SAN DIEGO
HAZARDOUS INCIDENT RESPONSE TEAM

STANDARD OPERATING GUIDELINES

COMPRESSED, REFRIGERATED, AND LIQUIFIED GASES

	ITEM	DESCRIPTION:
☐	**BACKGROUND INFORMATION**	Compressed gases represent a wide range of chemical hazards and physical properties. The Hazardous Material Technician will need to complete an incident action plan for the specific hazards and scenario present. This is a generic guide to help with basic protocols.
☐	**INITIAL SIZE UP**	▪ Stay UPWIND/UPHILL. ▪ Monitor with an all hazards approach. ▪ Establish Zones and/or Shelter in Place. Continuously monitor to ensure zones are appropriate. ▪ When cylinders are involved with a fire, consider a 200 meters public evacuation zone. ▪ When vapors are suspected of penetrating a building, evacuate the building and shut down any HVAC systems that may draw vapors or gases into the building(s). ▪ PPE selection will be based on the primary chemical hazards. ▪ Consideration should also be given to the physical property of extreme cold & frostbite if dealing with a liquefied gas. If wearing turnouts consider using a Level B or an apron, face shield, and cryogenic gloves on the outside to prevent liquefied gas from getting caught in the folds of the turnouts. ▪ Turnouts may adsorb/trap gases. Responders should not remove their breathing apparatus until turnouts are doffed, set aside for 30 min and monitor for hazards. ▪ Some gases/odorants (i.e. ethyl mercaptan, hydrogen sulfide) can fade or diminish when filtered through water or soil. ▪ Prolonged exposure to a gas/odorant may cause olfactory fatigue preventing you from smelling the continued release. **Fires** ▪ Consider letting a tank or cylinder that is venting flame to self-mitigate. Use water to cool the outside of tanks or cylinders that are venting flame or have flame impingement. ▪ Place hose lines to protect entry personnel. ▪ Be aware of BLEVE potential. Keep personnel away from ends of tanks/cylinders. ▪ Tanks and cylinders under direct flame/torch impingement have a greater likelihood to BLEVE during and after a fire. ▪ Keep area isolated until tanks have cooled. If needed cool tanks/cylinders using water stream for 1 Hr., then monitor for 1 HR with a TIC. ▪ Eliminate all ignition sources if possible.
☐	**TACTICAL ACTIONS**	▪ Site Safety / Incident Action Plan ▪ Determine Control Zones ▪ Determine rescue if applicable ▪ Determine extent of contamination, if applicable ▪ Chemical Identification: HazCat ▪ Determine quantity and location of leak ▪ Estimate plume projections ▪ Thoroughly ventilate enclosed spaces. Check adjacent buildings that may have had gas intrusion/ hazards before allowing re-occupancy.

		▪ If the leaking cylinder is indoors, consider moving outdoors. ▪ If safely possible, shut off flow of gas. ▪
☐	**MONITORING & DETECTION**	▪ CGI ▪ PID ▪ Multi Rae Pro ▪ GAS ID ▪ pH paper ▪ Fluoride paper Oxidizer paper
☐	**CHEMICAL INFORMATION (if available)**	▪ DOT Hazard Class - Chemical Hazards- Compressed gases will present one or more chemical or health hazard(s): Flammable, Pyrophoric, Simple Asphyxiant, Reactive, Oxidizer, Corrosive, Toxic ▪ Physical properties: Compressed gasses may be stored in several physical states; Solid, Gas/Vapor (non-liquefied), Liquefied Gas, Refrigerated Liquefied Gas. ▪ Vapor Pressure(s)-Compressed gases most often have high vapor pressures; >1 atm, or 760mm/Hg Liquefied. ▪ Low Temperatures- Refrigerated Liquefied Gases represent a frostbite hazard. Operating temperatures are often well below zero degrees Fahrenheit. ▪ Venting cylinders will ice/frost up due to Adiabatic Decompression. ▪ Expansion Ratios- Liquefied gases have large expansion ratios from 250 to 900, which will greatly expand the chemical hazard zone. ▪ Water Solubility- Indicates how much of gas may be adsorbed in water. This may help in emergency mitigation. If a compressed gas has a water solubility of 10% or greater a water fog may be used to adsorb large gas cloud releases. Gases that are very hydroscopic may adsorb with humidity in the atmosphere. This could cause buoyant gases to behave more like a dense gas.
☐	**TECHNICAL REFERENCES**	▪ WISER https://wiser.nlm.nih.gov/ ▪ Cameo Chemicals https://cameochemicals.noaa.gov/ ▪ Safety Data Sheets (SDS) ▪ BOC Gases http://www.boconline.co.uk/en/sheq/safety-data-sheets/index.html ▪ DOT ERG ▪ Chlorine Institute Documents, Handbook of compressed Gases (Compressed Gas Assoc.) ▪ OSHA https://www.osha.gov/SLTC/compressedgasequipment/standards.html
☐	**DECONTAMINATION**	Determine based on technical references for decon: ▪ Water ▪ Water and detergent ▪ Citric acid ▪ Soda ash
☐	**MITIGATION AND CONTAINMENT**	▪ Absorbents / absorbent pads ▪ Plug and patch ▪ Fog stream
☐	**USEFUL CONTACTS**	Airgas: (855) 524-7427, (866) 734-3438, or (800) 224-7427 AERO Team: 562-480-9456; https://www.airgas.com/company/careers/employee-focus CHEMTRECT: 800-424-9300. CHEMTRECT can assist in locating the closest AERO Team member for emergency response situations. Air Products and Chemicals, Inc. (800) 523-9374 or (760) 931-9555 Amerigas (858) 578-6513 Parsons (858) 278-2050 PraxAir (800) 225-8247 or (800) 645-4633 or (619) 232-7341 Petrolane (aka Amerigas) (760) 728-1424 Stoody Industrial Welding & Supply Inc. (619) 234-6750 Westair Gases & Equipment (619) 239-7571 Responsible Party: Compressed gas distributors are responsible for cylinders they own.

		Note compressed gas cylinders may be privately owned yet have labels from a distributor or supplier. Some newer cylinders have barcodes that can indicate ownership.
☐	**CLEAN UP & DISPOSAL**	▪ Responsible Party ▪ Licensed clean up contractor ▪ Waste manifests ▪ Photographs / sampling ▪ Monitoring ▪ If the cylinder or Tank is determined to be empty, mark as "Empty" or MT" ▪ Cylinders should be capped, chained, and secured when not in use and during transport.
☐	**INCIDENT TERMINATION**	▪ Safe to reoccupy ▪ Enforcement ▪ ICS forms ▪ Inspection forms

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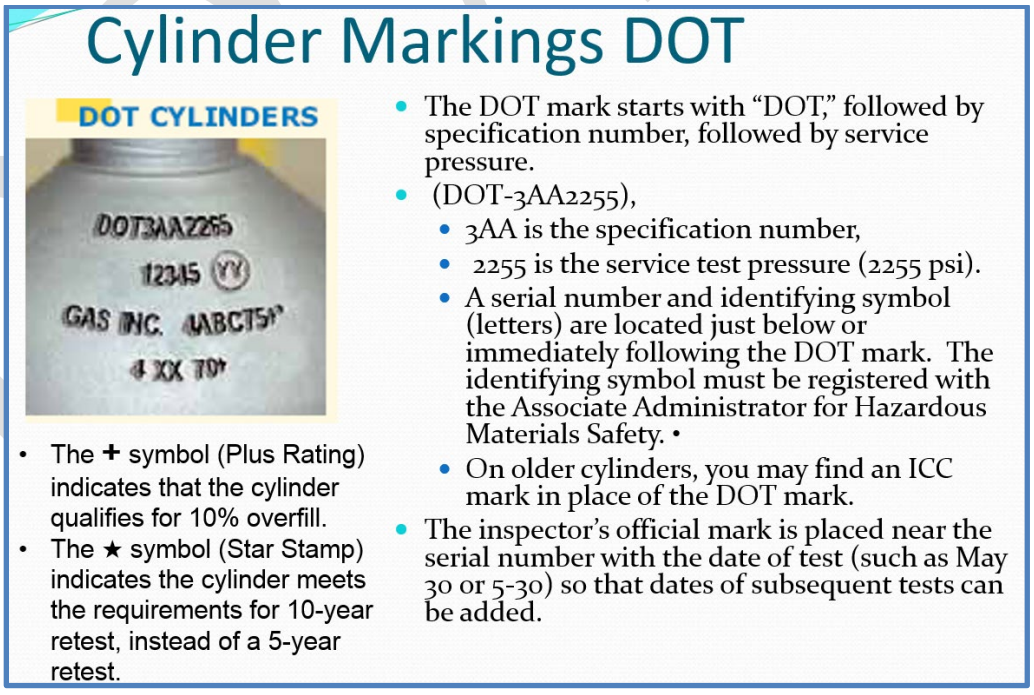
UNKNOWN CYLINDERS WORKSHEET

EXTERIOR EVALUATION

STOP if the contents are suspect to be explosive or reactive, or too dangerous to approach or move.

Cylinder Size Up

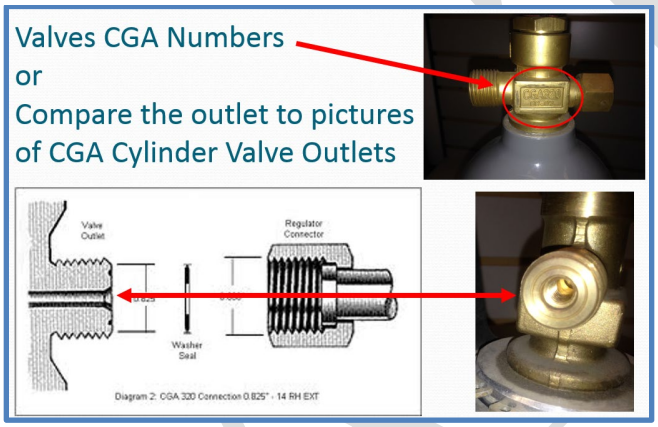
1) Cylinder colors are not standardized across distributors and are not a reliable way to identify contents.
2) Use proper PPE for any cylinder assessment or mitigation.
3) Look for any markings or labels that may identify the owner or responsible party.
4) Cylinder Type: See Table(s) 6
   i) Low Pressure: 90 to 400 PSI, Gas Types: Flammable (propane, butane, MAPP) Refrigerant, Helium, Ammonia,
   ii) High Pressure: 2400 psig most common inert gases, some Ultra High pressure 6000+psig
5) Cylinder Material (See Table(s) 6): Steel or Al or Other .
6) Type of valve material: Brass, Stainless Steel, Ni/Cr Plated, Other .
7) Cylinder Labels/Markings: See US DOT Guidance Cylinders What You Need to Know
   a) Cylinder Label .
   b) Hydro stamp/mark. *Be advised, if abandoned, a cylinder may be well past hydro.* .
   c) Tare Weight (TW) stamped on the cylinder, .
      i) Weigh the Cylinder [ ] - TW [ ]= Contents [ ]
   d) DOT Specification Number & Service Presure .



8) Pressure Relief Devices (PRD's): .
   a) Rupture Disk Device (Type CG-1): Air, Argon, Helium, Hydrogen, Nitrogen, Oxygen, CO2, Nitrous Oxide, Small Medical Cylinders

b) Fusible Plug Devices: Typically found on Cylinders with <500 psi
   i) (Type CG-2) Rated at 165°F
   ii) (Type CG-3) Rated at 212°F: Acetylene
c) Combination Rupture Disk/ Fusible Alloy:
   i) Combination Rupture Disk/ Fusible Alloy Rated at 165°F (Type CG-4): Hydrogen, Small Medical
   ii) Combination Rupture Disk/ Fusible Alloy Rated at 212°F (Type CG-5): Hydrogen
   iii) Pressure-Relief Valve (Type CG-7:)- Spring loaded typically will reset. Propane

2) Look for a CGA # stamp on the valve_____.
   If marked compare to Tables (7) below to identify the gas(s)/hazards.
   a) If no CGA # stamp? Compare the valve outlet to the pictures of standard valves Tables (7) to identify the gas(s)/hazards:_____.



3) Examine the valve for discoloration; green indicates acid gas, blue indicates ammonia.
   a) Wipe the valve outlet with wetted pH paper, _____.
   Low pH indicates acid gas, pH ~11 indicates ammonia.
   b) Wipe the valve outlet with fluoride paper, _____.
   If positive suspect hydrogen fluoride.
   c) Conduct an oxidizer test _____.
   (Potassium Iodide Starch Paper wetted with 3N HCl)

4) Examine the valve hand wheel. Is it Up/Open? To close a valve, turn the hand wheel clockwise.
5) Make no attempt to open or manipulate a valve until responders are on Proper PPE full mitigation measures are planned and in place.

What is the suspected Gas, Hazard Properties?

ID THE CYLINDER "CONTENTS"

1. Location- choose a location that offers adequate space for the isolation zones.
2. Prior to opening the valve:
    a. Attach CGA fittings, external valves, gauges and regulators to the valve outlet to help control the gas flow, and for sampling.
    b. Have an Emergency Mitigation option plan in place prior to opening the valve, in the event the valve will not reseat/stop the gas flow.
    c. Based on the Cylinder Size Up select the proper level of PPE.

3. Opening the Valve:
    a. First turn the valve clockwise toward the closed position, it is possible the valve may already be open.
    b. Open the valve by turning counterclockwise in small increments 1/8 of a turn at a time. Stop at the first sign of gas flow is detected/observed.

4. Hazcat the Gas Flow:
    a. Fluoride Paper Test Result ____Pos____Neg___ Other_____.
    b. Wetted pH paper Result _____Pos____Neg___ Other_____.
        i. Low pH indicates acid gas, pH ~11 indicates ammonia.

    c. Oxidizer in Air test Result __Pos____Neg___ Other_____.
    If fluoride, pH and Oxidizer in Air are all negative proceed

    d. CGI Results: O2_____, HEX_____, CO_____, H2S_____.
    e. PID Results: _____.
        i. Use Tedlar Bag attachment to collect a sample for further analysis.
    f. Other test results using Hazmat Cad, Drager Tubes, Gas ID:

    _____

    _____

    _____

Re Assess: PPE, mitigation and disposal options based on the findings.

Different gases have different densities. Cylinder valves are designed for use with specific gases and fittings Regulators

Return know cylinders to the manufactures with verified contents.

Notes Page

REFERENCE MATERIALS

Installing a Regulator:

- Regulators should be chosen based on the type of gas. Note acetylene, MAPP, Oxygen may react with regulators not designed for their use.
- Make sure it has the correct CGA fitting for the cylinder.
- Clean the threads of the cylinder with a brass brush or dry Kim wipe, ensure that they are in good shape.
- Inspect the regulator CGA fitting threads to make sure they are also in good shape.
- Make sure that all threads are grease, solvent and Teflon tape free.
- Hand tighten the regulator, be certain to not cross thread it or strip it.
- Use a proper wrench to tighten down, do not over tighten (use a proper box wrench as crescent wrenches tend to strip the regulator fitting).
- Ensure that all valves on the regulator are closed, then stand so that you are not in the path of any objects should they fly off of the regulator and open the cylinder.
- Check for leaks using soapy water.

Removing a regulator:

- Close the cylinder valve first
- Blead off the gas in the regulator
- Unscrew the regulator.

Cylinder Relocation/Transport for Mitigation.

1. For assent and mitigation purposes it may be necessary relocate the cylinder to a place with adequate an isolation zone, e.g. SDSO Bomb range.
2. Use the Salvage Cylinder, or Capping Kit(s) Chlorine A, B, C, Midland Kits while in transport.
3. If necessary, reduce the cylinder vapor pressure by surround the cylinder with ice or dry ice.
4. Cylinders should be fitted with a cylinder cap and secured while in transport.
5. Use a DEH Truck for transport. Cylinders should not be transported inside of a response vehicle.
6. A Law Enforcement escort while in transport may be necessary for safety and traffic control.
7. Responder(s) driving the DEH Truck shall ware proper PPE.

Containment & Mitigation Options:

1. Containment Kits Chlorine, Propane, Kits
2. Salvage Cylinder
3. Venting
4. Flaring
5. Sparging/ Adsorption using Water Fog

1) Containment Kits Chlorine, Midland
   a) Chlorine Institute See current edition of Chlorine Institute A, B, or C Kits:
      i) Are intended for use of Chlorine and Sulfur Dioxide Gas.
      ii) Chlorine Vapor Pressure; ~100psi at 80oF, ~200psi at 120oF
      iii) The Chlorine A, B, and C Kits are rated for =<400psi. Note capping a release at >225 psi is difficult.

   b) Midland Kit- Intended for use on Rail Car Fittings (See Midland Kit Manuel & Chlorine Institute Pamphlets)

      i) Fits Rail Car Valves from chlorine to LPG, AA, Vinyl Chloride, Hydrogen Chloride (refrigerated) and next generation rail tank car valves.

      ii) Designed to work on all pressure cars that are designed to be capped

      iii) Midland Capping Kit and Anhydrous Hydrogen Chloride (AHCL) Chlorine Institute Pamphlet 170 - All AHCL tank car valves (angle valve and relief valve) can be capped with the Midland kit. It is designed for a maximum of 500 psig. The capping kit may not be able to contain leaks at a pressure of 250 psig and above. The kit's primary value is to divert the leak to a scrubber (or just away from the dome area) until the car can be emptied. Capping kit guidelines:

         (1) Do not attempt to cap a car above 250 psig or one with a significant leak below 250 psig. Experience has shown capping a car at pressures above 200 psig is very difficult.

         (2) Use the cap to divert the leak to a scrubbing source until the car can be emptied or transloaded. Avoid moving a car that has been capped. Only consider this if the car is liquid-free or the distance to a handling/producing or other chemical site is very small.

         (3) If capping of the pressure relief device is required, pressure monitoring is also required, and the tank car should be emptied (by transloading or to the process). The time in which a pressure relief device is capped must be minimized, because pressure will rise as AHCL warms. Capping the relief device eliminates the design overpressure protection.

2) **Salvage Cylinder Considerations**:
   a) Verify the Cylinder Size will fit into the Containment Vessel
   b) Verify the Cylinder/Gas working pressure is below the Containment Vessel working pressure.
   c) Never Place a leaking Acetylene Cylinder in the Containment Vessel. *If the acetylene gas pressure inside the Containment Vessel exceeds 30 Psi there is a risk of detonation.*
   d) Place a Cap the cylinder prior to placing in the containment vessel to protect the valve
   e) Maybe necessary to tie a rope around the cylinder to make removal easier.
   f) May be necessary to open an outlet valve on the containment vessel to vent gas while closing the vessel.
   g) Make sure all valves on the containment vessel are closed after the containment vessel is closed.
   h) Prior to opening:
   i) Check the pressure gauges on the containment vessel for pressure. If there is pressure it may be necessary to do vent or adsorb the contents of the vessel prior to opening the door.

Emergency Response Containment Vessel, Model 5502

SAP #56167 EQ_Vessel_Containment_ER_5502

Specifications

- DOT Exemption for Transportation of Leaking Gas Cylinders DOT #E10504
- ADR approval for Europe can be obtained at an additional fee for inspection in Belgium

Pressure Vessel

- Designed and fabricated to ASME Pressure Vessel, Section 8, Div 1 Specifications
- Painted SA 106 Grade C Carbon Steel
- Quick Opening Flange by Tube Turns with Double O Ring Seal (Viton inner and Buna N outer)
- Crank Handle Flange Closure
- 12" diameter x 78 3/4" long (Overall Pressure Vessel) (30.5 cm dia x 200 cm)
- Cylinder Slide Rails
- Usable Inside diameter of 10 ½" (26.7 cm)
- Working Pressure - 1100 psig @ 130^{0}F (76.8 bar)
- Internal Volume – 33 gallon (131 liter)
- Can safely contain a leak from a 2400 psig 50-liter cylinder
- 2 Stainless Steel Diaphragm Valves (Vent & Purge)
- 2000 psig (138.9 bar) Stainless Steel Pressure Gauge

Cart

- Empty Weight - 900 lbs (408 kg)
- Normally On Disk Brakes
- Foam Filled Tires (2 fixed and 2 steer able casters)
- Tow Hook
- Two Forklift Channels
- Two Lifting Lugs

3) Venting Cylinder Contents to Atmosphere
   a) Venting the contents of a cylinder to atmosphere may be a suitable option. Considerations:
   b) The leak from the cylinder cannot be stopped, and other mitigation options are not suitable.
   c) The location is suitable for this mitigation option. Air modeling and real-time air monitoring should be done to estimate/verify the downwind impact.
   d) The gas hazard properties are nominal: Inert, Simple Asphyxiations, weak Oxidizers Nitrous Oxide(s), Toxicity is low e.g. CO2, Non-flammable, Non-Corrosive.

4) Flaring (Flammable Gases: Propane or Butane)
   a) DEH HIRT has a portable flare (Red Dragon) intended use for propane, use with butane is suitable based on HIRT experience.
   b) Flare gas vapor only, "not liquids". Despite the manufacture claims the equipment can be used on liquids experience has shown flaring of vapor is most appropriate.
   c) Follow the Manufacture Assembly and Operations Instructions.
   d) The flare should be set up upwind of the flammable tank(s) are located
   e) Flaring should be done is a suitable location that provides for adequate control of isolation zones.

5) Adsorption or Sparging- Based on the gas's physical property of water solubility, it may be possible to dissolve/adsorb into a liquid.
   a) Use SDS's or other Tech Ref data to determine the solubility in water or other solution.
   b)

Chemical	Solubility
Anhydrous Ammonia	34% in Water, Adsorption is water is suitable.
Arsine	20% in Water, Adsorption is water is suitable.
Chlorine	Soluble in Sodium Hydroxide
Ethylene Oxide	Miscible in water, forms Ethylene Glycol
Propylene Oxide	Miscible in water, forms Propylene Glycol
Florine	Reacts with Water
Hydrogen Chloride	Miscible water up to ~35% forms Hydrochloric Acid
Hydrogen Fluoride	Miscible water form Hydrofluoric Acid
Hydrogen Sulfide	0.4%, Not Soluble in Water
Methyl Bromide	2.0 % Water
Sulfur Dioxide	10% Water
Sulfuryl Fluoride (Vikane)	0.2%, Not Soluble in Water

   c) Location- May be necessary to relocate to area that offered adequate standoff distances and control.
   d) Equipment- Gather the necessary supplies equipment to complete the entire operation.
      i) CGA Fittings, Regulators, Valves, Hoses, waste Drums, Chemicals to make up adsorption solutions.
   e) Diagram????
   f) Operations????

Chlorine gas Absorption using an Alkaline Solution (See Chlorine Institute Chlorine Manuel and World Chlorine Counsel CHLORINE SAFETY SCRUBBING SYSTEMS)
A simple absorption system consists of a suitable tank capable of holding the required alkaline solution. After the solution is prepared, the chlorine can be passed from the container into the solution through a connection weighted to hold the outlet of the transfer hose or pipe beneath the level of the solution. Do not immerse the container. See Tables 4.1A for recommended solution (the recommended alkali quantities provide 20% excess).

On a weight basis, one kg (2.2 lbs.) of chlorine plus 1.13 kg (2.48 lbs.) of sodium hydroxide will produce 1.05 kg (2.31 lbs.) of sodium hypochlorite.

Recommended Alkaline Solutions for Absorption
U.S. UNITS

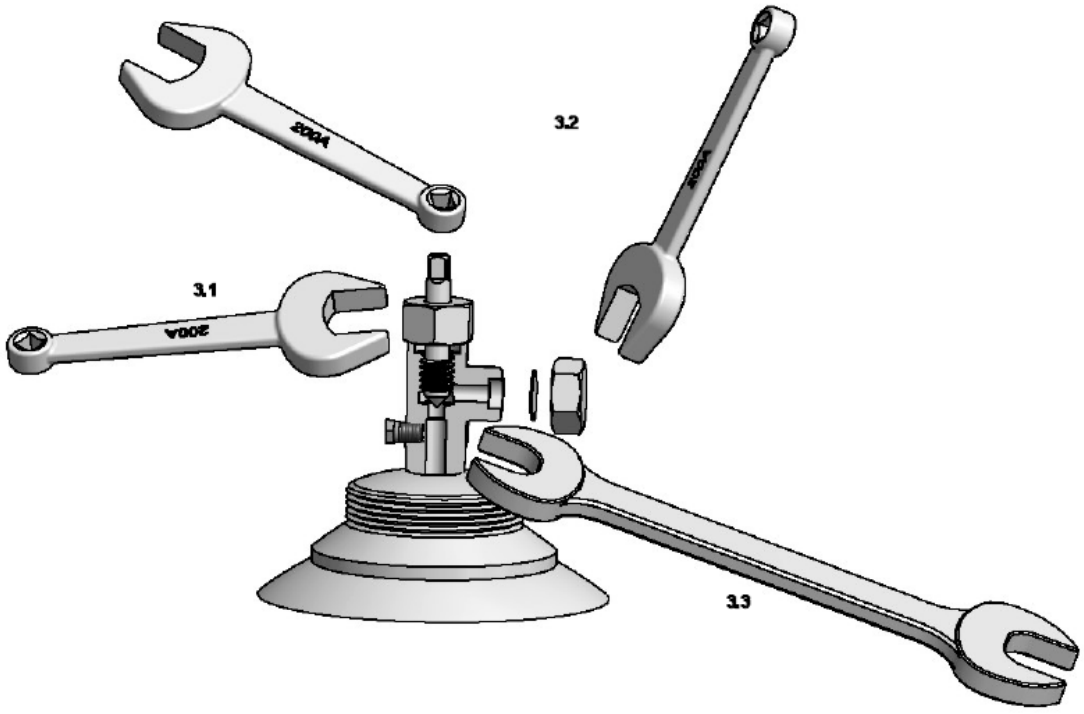
Chlorine Container Capacity	20 Weight % Sodium Hydroxide Solution		10 Weight % Sodium Carbonate Solution	
lb. (net)	100% NaOH lb.	Water gal.	100% Na_2CO_3 lb.	Water gal.
100	135	65	359	390
150	203	98	538	585
2000	2708	1300	7176	7800

Chlorine Institute

Mitigating a Leaking Cylinders/Tanks- (Excerpts from AirGas ER Doc, and Chlorine A Kit)

1) Most leaks occur at the valve in top of the cylinder. Areas that may be involved are the valve threads, valve stem and packing, valve outlet, or pressure relief device.
2) If the leaking cylinder is still connected to a fill manifold, valve off the remaining cylinders. and slowly vent down the leaker through the manifold vent, before attempting
3) Determine the source of the leak. Use a squirt bottle of soapy water to identify the location of the leak.
4) Close the valve "turn the hand wheel clockwise".
   a) LEAK: THROUGH VALVE SEAT (WILL NOT COMPLETELY CLOSE)
      i) If disconnecting from a process, reconnect and gently open and close valve stem to dislodge foreign matter from seat with WRENCH 200A, then disconnect and apply outlet cap and GASKET 2B with WRENCH 200A; or
      ii) If the leak is from an unconnected cylinder, apply outlet cap and GASKET 2B, then tighten with WRENCH 200A.
5) Tighten the packing gland nut around the valve stem.
6) Pressure Relief Devices (PRD):
   a) Never cap, seal, plug, restrict, or remove any relief device.
   b) Ice or frost buildup on a pressure relief valve can be removed with a damp cloth, spray bottle of water.
   c) Be aware that frost buildup can freeze open a pressure relief valve, which can then lead to the complete venting of the entire contents of the cylinder, Dewar, tank.
   d) If leaking from the threads of the PRD gently tighten.
7) LEAK: VALVE INLET THREADS
   a. Tighten valve into cylinder slowly with steady pressure using WRENCH 201;

IDENTIFYING AND STOPPING LEAKS



CRYOGENIC LIQUID SPILLS General Guidelines

Assess the risks

- All cryogenic liquids have large expansion ratios as such will produce large volumes of gas when released/vaporize.
- Evac and Isolation Zones will extend will past any vapor clouds. The cold vapors may settle in low-lying areas and cause localized areas of oxygen deficiency. Establish downwind monitoring.
- Contact with cryogenic liquids or vapor streams can cause severe frostbite.

Response Considerations:

- Approach from upwind, continuous monitoring.
- PPE selection will be based on the primary chemical hazards. Consideration should be given to the physical hazard of extreme cold & frostbite
    - Use a shield/ barrier like an umbrella to prevent liquefied gas from contact with responders.
    - If wearing turnouts consider using a Level B or apron, and Face Shield on the outside to act as a rain jacket to prevent liquefied gas from getting caught in the folds of the turnout.
    - Turnouts may adsorb/trap gases. Responders should not remove their BA until turnouts are removed. Let turnouts air out for 30 min, then monitor for hazards.
- Do not walk thru liquid or frozen puddles of liquefied gas.
- If possible, shut off the source of the cryogenic liquid. Whenever possible, accomplish this with a remotely operated valve.
- Does the process have an Emergency Stop Buttons, or emergency shut off valves?
- For minor releases of cryogenic liquids warm water may be used to melt ice/frost formed as the result of leaks.
- Loss of vacuum- in vacuum jacketed tanks will increase evaporation rates causing increased venting and activation of the PRD. These tanks should be moved outside or properly vented to the outside atmosphere.
- Dowers come in two types: pressurized and non-pressurized.

LIQUID OXYGEN (LOX) GUIDELINES, In addition to the General Guidelines.

Assess the Risks

- Do not allow oxygen cylinder contact with fuels, grease, oils or other Combustibles to
- Although the vapor cloud reveals the presence of a leak, the oxygen-rich area usually extends beyond its boundaries and may exist significantly downwind. Always approach an oxygen leak from upwind.
- Explosive, Shock and Friction Sensitive- Liquid or frozen puddles of oxygen in contact with organic matter/fuels (asphalt, fuel, wood, oil-soaked concrete…) can be explosive. Per fire code fixed tanks are surrounded by concrete however it is not uncommon to have algae build up due to chronic excessive moisture due to evaporation from for evap. coils. Do not allow any movement of personnel or vehicular, on or near the affected area for at least 30 minutes after the frost disappears. In cases of large spills penetrating into the ground, this can take days. Monitor for oxygen in cracks and crevasses in the ground/ area.
- Monitor the air to determine the perimeters:
    - 0% oxygen, at edge of Warm Zone
    - 23.5% oxygen content edge of hot zone.
- Shut off all sources of ignition such as electrical equipment, open flames, machinery, and No Smoking.
- If anyone has been exposed to an oxygen-rich area, do not get near any sources of high heat or open flame for at least 30 minutes. Open your clothes and turnouts ventilate, monitor to verify safe.

LIQUID CARBOI\ DIOXIDE (LCO2) Spill Guidelines in addition to general guidelines.

- Generally, a snow-like substance spraying from a vessel or line will reveal the presence of a LCO2 spill. This snow-like substance is solid CO2 (dry ice). The CO2 converts directly from the liquid phase to the solid phase as the system depressurizes due to the leak. The solid CO2 will then transform directly to the vapor phase (sublimes without passing through the liquid phase).
- Because CO2 vapors are denser than air, the vapors do not readily disperse in the atmosphere. The vapors may accumulate in low-lying or confined areas. Ventilate such areas to prevent the formation of harmful concentrations of CO2.
- If vapors are suspected of having penetrated a building, evacuate the building. Keep ventilators operating on any equipment which withdraws air from the building.
- A leaking CO2 cylinder may cause the contents to solidify.

Disposal

DTSC has published a revamped webpage on compressed gas waste; please look at the webpage, it has lots of information. http://dtsc.ca.gov/HazardousWaste/cgc.cfm

Significant guidance includes:
It is the position of DTSC that if a compressed gas cylinder valve is closed and has residual pressure, it is not considered empty. Thus, if a cylinder valve is left open, it is an "empty cylinder". A generator cannot open the valve to discard the contents; that would be illegal disposal to air of a hazardous waste if the substance was hazardous to begin with.

Are discarded compressed gas cylinders waste? Title 22 of the California Code of Regulations (22 CCR) defines waste and hazardous waste. If an item meets the definition in 22 CCR 66261.2, then it is a waste. The gases need to be characterized to know if they are a hazardous waste. A hazardous waste is defined in 22 CCR 66261.3, and included acutely hazardous waste, extremely hazardous waste, non-RCRA hazardous waste, RCRA hazardous waste, special waste and universal waste.

Residual gases in a cylinder transported with minimum pressure as a matter of safety are not regulated as hazardous waste because it has not been discarded if going back to the cylinder supplier. The material is not discarded until the cylinder reaches the supplier and a decision is made whether to discard the residual gas. Returning the cylinder to the supplier does not make the customer a hazardous waste generator.

How do I manage the compressed gas cylinders?
Once a cylinder is empty and is to be discarded, it should be recycled. Scrap metal recycling companies sometimes have restrictions on the types of cylinders that they will take or require that they be cut in half or for the cylinder valve be removed to prove that they are empty. Others will require that it be punctured prior to acceptance. As stated previously, if you are returning your cylinders to a location for refilling, they are not considered hazardous waste. Contact the receiving facility to determine their requirements prior to shipping compressed gas cylinders for reuse, recycling, or disposal.

Empty cylinders being recycled as scrap metal should be clearly marked as “Empty” or “MT”. If possible, remove the valve to clearly show the cylinder is empty.

Acetylene (Ethyne): C2H2, UN1001

Cylinder Operating pressure= 200-300 psig.
Vapor Pressure= 635 psi
LEL/UEL= 2.5%/100%
V.D= 0.907
Melting/Freezing Point = 114F
Autoignition= 581F
Dissolved in acetone. A matrix inside cylinder holds liquid/gas. Acetylene is unstable when not dissolved in acetone Dimethylformamide (DMF), Do Not place a leaking Acetylene Cylinder in a containment vessel. Confining an acetylene gas vapors above gas above 15psi can cause self-detonation.

Leaking cylinder: Establish safe distances, isolate/remove ignition sources, stop flow of gas if possible, using spark proof tools. Vapor pressure can be reduced by placing container in dry ice (sublimation temp = 109F). Cylinders with small leaks can possibly be transported to safe area for venting/destruction. A CalEPA/DTSC notification may be required depending on the situation.

- Never open an acetylene cylinder valve more than one turn.
- Do not use copper or silver based fittings
- The porous contents may contain **Asbestos,** Empty acetylene cylinders may be returned to the AirGas Facility in San Marcos. Or disposed of as a Special Waste "Non-Friable Asbestos".
- These cylinders should *always* be stored with the valve up.
- Should a cylinder fall over or accidentally be laid down, it should be placed upright prior to use.
-

Propane (LP) C3H8; UN 1075; UN 1978

Cylinder Operating pressure= 10-200 psig
Confined/under pressure= liquid below -44F
Vapor Pressure= 109 psi @STP
LEL/UEL= 2.1% / 9.5%
V.D= 1.6
Melting/Freezing Point = -306F
Boiling Point= -44F
Autoignition= 842F
Flashpoint= -155F
Expansion= 270/1
Pressure Relief Device 375/250 psi (cylinder/tank)
Cylinders fall into two groups of propane service, liquid and vapor. Cylinders in liquid service are commonly found on forklifts while bottles in vapor service are easily spotted fueling a gas grill. Commercially available "propane" fuel, or LPG, is not pure. Typically in the United States and Canada, it is primarily propane (at least 90%), with the rest mostly ethane, propylene, butane, and odorants including ethyl mercaptan
Abandoned Container: Contact manufacturer/supplier. It is possible a supplier can reuse or reclaim the acetylene. Ensure it can be safely transported prior to removing from location.
Leaking Container: Establish safe distances, isolate/remove ignition sources, stop flow of gas if possible, using spark proof tools. Contact propane dealer if possible. Do not stop leak in a way that eliminates the pressure relief device, such as using a wet cloth in poor location. Best solution may be to allow slow venting. Be advised auto-refrigeration may occur and leak may stop and restart.

Anhydrous hydrogen chloride, AHCL, is a colorless gas with a sharp, irritating odor. It is readily absorbed in water to form hydrochloric acid. It is very hydroscopic (attracts moisture) and in moist air, forms white fumes which are a mist of hydrochloric acid.

- Because of its low boiling point (-85°C, -121°F) and high vapor pressure (603 psia at 20°C) AHCL is shipped in pressure containers as a refrigerated liquid.
- The boiling point of AHCL at one atmosphere pressure (14.7 psia, 760 mmHg) is -85°C (-121°F) and the vapor pressure of AHCL at ambient temperature of (20°C, 68°F) is 603 psia. Because of these extreme values, the pressure in equipment containing liquefied AHCL must be closely monitored and controlled.
- If the temperature of the liquid AHCL is allowed to rise too high, the rise in vapor pressure could cause leaks at valves and flanges and could actuate the pressure relief system.

WHAT ARE SOME DIFFERENCES BETWEEN UN PRESSURE RECEPTACLES AND DOT CYLINDERS?

DOT CYLINDERS

- Are acceptable for transport to, from, or within the United States
- Aluminum oxygen cylinders must have straight threads only
- Markings
  - Marks conform to applicable requirements of §178.35
  - Service pressure shown
  - Markings expressed in conventional units

UN PRESSURE RECEPTACLES

- Must have "USA" country of approval marking to be acceptable for transport to, from, or within the United States
- Aluminum oxygen cylinders may have straight or tapered threads
- Markings
  - Required Part 178 markings displayed in 3 rows in accordance with §178.71
  - Test pressure shown
  - Markings expressed in metric units
  - Thread type must be marked on each receptacle and valve

ALUMINUM CYLINDERS IN OXYGEN SERVICE

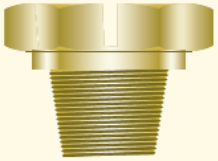
The openings on aluminum alloy UN oxygen cylinders may be configured with straight (parallel) or taper threads. The thread type must be marked on the cylinder and on the valve. Any person who installs a valve into a UN aluminum alloy cylinder in oxygen service must verify the valve and the cylinder have the same thread type.

For example:

Typical straight thread: 25P
Typical tapered thread: 25E


Straight (parallel) thread

The openings on aluminum alloy DOT specification oxygen cylinders must be configured with straight threads only.


Taper thread

Note: A thread mismatch can lead to an unintentional release of product or a violent expulsion of the valve which can cause personal injury or death. Improper valve torquing can lead to cylinder damage. The correct amount of torque applied to a valve must be obtained from the cylinder manufacturer.

WHAT ARE THE FILLING REQUIREMENTS?

Filling limits for UN pressure receptacles are outlined in §173.302b and §173.304b. UN pressure receptacles may be filled with a gas by using the numerical limits or the formulas provided in P200 of the UN Model Regulations unless otherwise provided.

WHAT ARE THE REQUALIFICATION FREQUENCY AND MARKINGS?

UN pressure receptacles must be requalified at least once every ten years, except that composite cylinders and pressure receptacles used for certain specialized service must be requalified every five years (see §180.207). The requalification markings must conform to the requirements in §180.213.

HOW ARE UN PRESSURE RECEPTACLES REQUALIFIED?

UN pressure receptacles may be requalified by a hydraulic pressure test or ultrasonic examination (UE). The hydraulic pressure test may be either the volumetric expansion or the proof pressure test. UN seamless steel pressure receptacles with a tensile strength ≥950 MPa must be requalified by UE in accordance with ISO 6406 by a requalifier authorized to requalify UN pressure receptacles by UE. Alternative requalification methods may be used if prior approval has been obtained from PHMSA's Associate Administrator for Hazardous Materials Safety.

WHERE TO LEARN MORE

For information about other Hazmat Publications

Visit our web site:
http://hazmat.dot.gov

Write:
U.S. Department of Transportation
Pipeline and Hazardous Materials Safety Administration
1200 New Jersey Avenue, SE, PHH-50
Washington, DC 20590-0001

Fax: (202) 366-7342
E-mail: training@dot.gov
Or Phone: (202) 366-2301

For information about Hazmat Regulations

Contact our Hazmat INFO-LINE:

GOT A HAZMAT QUESTION?
http://hazmat.dot.gov
INFO-LINE
1-800-467-4922

E-mail: infocntr@dot.gov

SafeTravel
SAFETY TIPS FOR TRAVELERS
HTTP://SAFETRAVEL.DOT.GOV

EFFECTIVE SEPTEMBER 11, 2006,

PHMSA adopted standards into the Hazardous Materials Regulations (49 CFR Parts 171-180) for the design, construction, and use of UN pressure receptacles based on the standards contained in the United Nations Recommendation on the Transport of Dangerous Goods (UN Model Regulations).

WHAT DOES HM-220E DO?

The HM-220E final rule:

- Authorizes the design, construction, testing, and use of UN cylinders, tubes, and multiple-element gas containers (MEGCs)
- Specifies requalification methods and intervals for UN pressure receptacles
- Establishes filling requirements for UN pressure receptacles conforming to the UN Model Regulations
- Promotes greater flexibility and permits the use of advanced technology for the manufacture of pressure receptacles
- Provides for a broader selection of pressure receptacles
- Reduces the need for special permits
- Facilitates international transportation

DOES HM-220E AFFECT THE CURRENT REQUIREMENTS FOR DOT SPECIFICATION CYLINDERS?

No. HM-220E allows a shipper to use either a DOT specification cylinder or a UN standard pressure receptacle, as appropriate for individual gases and circumstances.

WHAT ELSE SHOULD I KNOW?

Definitions:

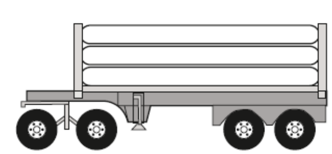
ISO—International Organization for Standardization

UN Cylinder—Transportable pressure receptacle with a water capacity generally not exceeding 150 L (37.5 gal.)

UN Tube—Transportable pressure receptacle with a capacity exceeding 150 L (37.5 gal.) but not more than 3000 L (750 gal.)

UN Pressure Receptacle—A UN cylinder or a UN Tube

Multiple-Element Gas Container (MEGC)—Assemblies of UN cylinders, tubes, or bundles of cylinders interconnected by a manifold and assembled within a framework. The term includes all service equipment and structural equipment necessary for the transport of gases.



Multiple-Element Gas Container (MEGC)

WHAT ARE THE UN PRESSURE RECEPTACLE DESIGN TYPES?

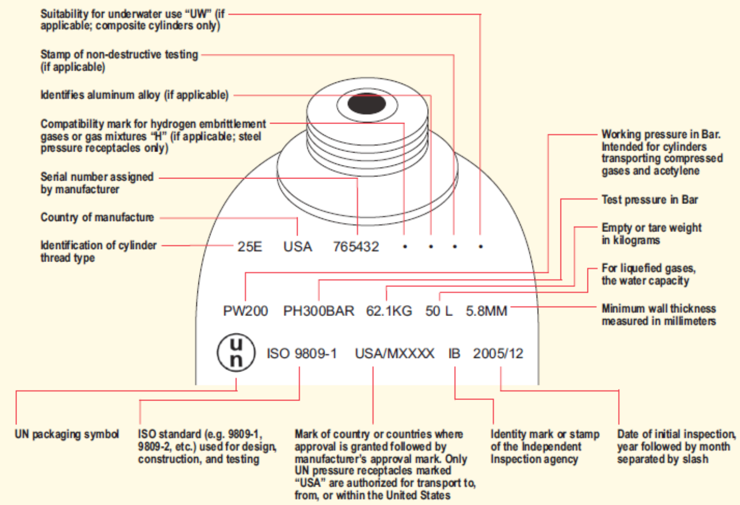
- Acetylene Cylinders: shells in accordance with ISO 9809-1 or -3; Porous mass must conform to ISO 3807-2; must contain a suitable quantity of solvent, and have fusible plugs. [§173.303, §178.71(k)]
- Refillable seamless aluminum cylinders conforming to ISO 7866

WHAT TYPES OF MARKINGS APPEAR ON UN PRESSURE RECEPTACLES?

TOP ROW
Contains manufacturing marks such as the cylinder thread type, the country of manufacture, and the serial number assigned by the manufacturer.

MIDDLE ROW
Contains operational marks such as the test pressure, the tare or empty weight, and the minimum wall thickness.

BOTTOM ROW
Contains certification marks such as the UN packaging symbol, the ISO standard, the country or countries of approval, and the manufacturer's approval mark.



Other markings are permitted in other low stress areas provided they are not on the side wall. Other markings must not conflict with the required markings.

- Refillable seamless steel cylinders conforming to ISO 9809-1, 9809-2, or 9809-3
- Non-refillable cylinders conforming to ISO 11118
- Composite cylinders conforming to ISO 11119-1, 11119-2, or 11119-3
- Refillable tubes conforming to ISO 11120

COMMON GASES CONVERSION TABLE

Table 1. Compressed Gas Unit Conversion.

1. Find the name of the compressed gas you want to convert.
2. If you know the quantity in **pounds**, multiply by the number in Column A to get cf
3. If you know the quantity in **gallons**, multiply by the number in Column B to get cf
4. If you know the quantity in gallons, multiply by the number in Column C to get #

x A= cf
Gal x B= cf
Gal x C = #

		Column A	Column B	Column C
GAS NAME	**FORMULA**	**cf per Pound**	**cf per Gal**	**Pounds per Gal**
Acetylene (Ethyne)	C2H2	13.7	43.7	3.19
Air	0.8N2-0.2O2	12.2	88.9	7.29
Ammonia	NH3	20.9	118.8	5.68
Argon	Ar	9.6	112.5	11.72
Arsine	AsH3	4.6	_____	_____
Butane	C4H10	6.1	29.8	4.89
Carbon Dioxide	CO2	8.7	74	8.51
Carbon Monoxide	CO	13.8	93.5	6.78
Chlorine	Cl2	5.1	61.5	12.06
Ethane	C2H6	11.8	35.4	3.00
Ethylene (Ethene)	C2H4	12.7	60.1	4.73
Ethylene Oxide	C2H4O	8.1	60.5	7.47
Fluorine	F2	9.4	117.9	12.54
Forane 134a (Freon134a)	C2H2F4	3.5	_____	_____
Freon-12 (Dichloro-difluoromethane)	CCl2F2	2.9	32.5	11.21
Freon-22 (Chloro-difluoromethane)	CHClF2	4.1	41.5	10.12
Freon-113 (Trichloro-trifluoroethane)	C2Cl3F3	1.9	21.8	11.47
Helium	He	69.7	38.4	0.55
Hydrogen	H2	192	113.4	0.59
Hydrogen Chloride	HCl	9.8	96.8	9.88
Hydrogen Fluoride	HF	17.7	_____	_____
Hydrogen Sulfide	H2S	10.4	79.6	7.65
Isobutane	C4H10	5.9	_____	_____
Krypton	Kr	0.45	92.69	205.98
Methane	CH4	22.2	78.7	3.55
Methyl Bromide	CH3Br	3.7	_____	_____
Methyl Mercaptan	CH3SH	7.4	_____	_____!
Neon	Ne	19.2	193.2	10.06
Nitrogen	N2	13.8	93.1	6.75
Nitrogen Dioxide	NO2	4.3	_____	_____
Nitrous Oxide	N2O	8.1	82.7	10.21
Oxygen	O2	12	115.1	9.59
Ozone	O3	8.1	84.3	10.41
Propane	C3H8	8.1	34.1	4.21
Propylene	C3H6	8.9	38.2	4.35
Silane	SiH4	11.1	_____	_____
Sulfur Dioxide	SO2	5.6	64.1	11.45
Complete list at https://www.sfdph.org/dph/files/EHSdocs/ehsHMUPAdocs/GasConversionTable.pdf				

Table 2. Physical Properties (Reference: Air Liquid Industrial and Specialty Gas data Book)

PHYSICAL PROPERTIES (ENGLISH)

Substance	Chem. Symbol	Molecular Weight	Liquid Phase Liquid @ B.P. & @1 atm		Boiling Point @ 1 atm		Gaseous Phase Gas @ 32°F & @1 atm			Triple Point		Critical Point			Thermal Conductivity
			Specific Gravity	Specific Heat Cp	Temp.	Latent Heat of Vaporization	Specific Gravity	Specific Heat Cp	Density	Temp.	Pressure	Temp.	Pressure	Density	@ 80° F
			Water=1	BTU/lb °F	° F	BTU/lb	Air=1	BTU/lb°F	lb/cu. ft	°F	psia	°F	psia	lb/cu ft	BTU/ft h °F
Helium	He	4.00	0.124	1.086	-452.06	8.72	0.139	1.25	0.01114	NONE	NONE	-450.31	33	4.347	0.0906
Neon	Ne	20.18	1.207	0.4483	-410.9	37.08	0.701	0.25	0.05621	-415.4	6.29	-379.8	384.9	30.15	0.01385
Argon	Ar	39.95	1.4	0.2575	-302.6	69.8	1.39	0.125	0.11135	-308.8	9.99	-188.1	711.5	33.44	0.01035
Krypton	Kr	83.80	2.41	0.1273	-244	46.2	2.887	0.06	0.2315	-251.3	10.6	-82.8	798	56.7	0.0055
Xenon	Xe	131.30	3.06	0.08121	-162.6	41.4	4.55	0.038	0.365	-169.2	11.84	61.9	847	68.67	0.00317
Hydrogen	H_2	2.02	0.071	2.309	-423	191.7	0.06998	3.425	0.005611	-434.6	1.045	-399.93	190.8	1.88	0.1081
Nitrogen	N_2	28.01	0.808	0.4877	-320.4	85.6	0.9737	0.249	0.07807	-346.0	1.81	-232.4	493	19.6	0.01503
Oxygen	O_2	32.00	1.14	0.4058	-297.3	91.7	1.113	0.2197	0.089212	-361.8	0.02147	-181.43	731.4	27.22	0.0152
Ozone	O_3	47.99	1.352	-	-168.3	6530	1.656	9.41	-	-314.5	1.65	10.13	808.1	33.71	-
Air	-	28.98	0.873	0.4454	-317.8	88.2	1	0.241	0.08018	-352.1	-	-221.1	547	21.9	0.0151
Carbon Monoxide	CO	28.01	0.79	-	-312.7	92.79	0.9736	0.2478	0.07806	-337.1	2.2	-220.4	507.5	18.79	0.01445
Water	H_2O	18.02	0.95855	1.007	212	970.6	-	0.6784****	0.0368****	32.0	0.088	705.182	3200.5	20.1	0.01081
Hydrogen Sulfide	H_2S	34.08	0.9136	-	-76.4	235.6	1.198	0.245	0.09608	-	-	212.9	1306.5	21.6	0.0844
Sulfur Dioxide	SO_2	64.06	1.46	-	14	167.5	2.279	0.149	0.18272	-103.9	0.2429	315.4	1143	32.6	0.00555
Carbon Dioxide	CO_2	44.01	1.18***	-	-109.3*	245.5**	1.524	0.199	0.12341	-69.9	75.1	87.9	1070.6	29.2	0.00971
Ammonia	NH_3	17.03	0.6819	-	-28	589.3	0.6003	0.520	0.04813	-107.9	0.88	271.4	1657	14.7	0.0141
Methane	CH_4	16.04	0.425	0.8314	-258.68	219.22	0.559	0.593	0.0448	-296.5	1.69	-115.78	673.1	10.09	0.0197
Ethane	C_2H_6	30.07	0.546	-	-127.53	210.41	1.056	0.386	0.08469	-297.9	14.70	86.96	708.35	12.67	0.0123
Ethylene(Ethene)	C_2H_4	28.05	0.567	-	-154.8	208	0.978	0.399	0.07868	-272.5	1.0146	49.82	745	14.2	0.0119
Acetylene	C_2H_2	26.04	0.613	-	-118.4*	264***	0.906	0.383	0.07314	-116.0	17.7	96.8	907	14.4	0.0124
Propane	C_3H_8	44.10	0.58	-	-43.67	183.05	1.573	0.388	0.1261	-	-	206.01	616.3	13.5	0.0104
Propylene	C_3H_6	42.08	0.61	-	-53.9	188.18	1.481	0.355	0.11249	-	-	197.2	670	14.5	0.0104
Methanol	CH_3OH	32.04	0.795	0.6055	148.2	473	-	0.3274	49.44****	-143.4	-	464.1	1154.2	16.981	0.0081

*Sublimation point ** Sublimation Enthalpy *** Triple point **** Boiling point

PRESSURE CONVERSION FACTORS

Pressure	Multiply units in left column by proper factor below:						
	lb/sq in	int atm	kg/cm^2	mm Hg at 32°F	in Hg at 32°F	ft water at 39.2°F	bar
1 pound/sq in	1	0.06804	0.0703	51.713	2.0359	2.307	0.06896
1 int atmosphere	14.696	1	1.0333	760	29.921	33.90	1.01325
1 kilogram/sq cm	14.223	0.9678	1	735.56	28.958	32.81	0.9806
1 mmHg (Torr)	0.0193	0.00132	0.00136	1	0.0394	0.0446	0.00133
1 inch mercury	0.4912	0.0334	0.0345	25.400	1	1.133	0.03386
1 foot water	0.4335	0.0295	0.0305	22.418	0.8826	1	0.02989
1 bar	14.5	0.987	1.0198	750.06	29.529	33.455	1

Table 3. VP Unit Conversion, VD, Water Soluability

Vapor Pressure		Vapor Density & Molecular Weight
Will chemical come get me? 0 mm/Hg = Rock 25 mm/Hg = Water 180 mm/Hg = Acetone 760 mm/Hg = Gas/Vapor	Other ways you see mm/Hg 1 atm = 760 mm/Hg 1 Torr = 1 mm/Hg 1 kPa = 7.5 mm/Hg 1 psi = 50 mm/Hg 1 psi = 6.895 kPa	**Tells us if chemical goes up or down** Vapor Density of air = 1 Greater than 1 VD = goes down Less than 1 VD = goes up Molecular Weight of air = 30 Greater than 30 MW goes down Less than 30 MW goes up
Water Solubility		
<10% Use fog stream to push like a smoke ejector. Decon with soap and water. >10% Use fog stream to absorb BE AWARE OF RUNOFF. Decon with water.		

Table 4 Expansion Ratios of Various Gases

Gas	Expansion Ratio
Argon	1:835
Carbon dioxide	1:845
Carbon monoxide	1:764
Chlorine	1:521
Dichlorosilane	1:290
Ethylene	1:482
Hydrogen bromide	1:648
Hydrogen chloride	1:772
Hydrogen iodide	1:518
Hydrogen sulfide	1:638
Methane	1:630
Neon	1:1434
Nitrogen	1:691
Oxygen	1:854
Phosgene	1:337
Phosphine	1:510
Propane	1:311
Silane	1:412
Sulfur dioxide	1:535
Trifluoromethane (R23)	1:488
Vinylchloride	1:365
Xenon	1:550

Source: Adapted from AIR LIQUIDE, SA

Table 5. Characteristics of Gases

Characteristics of Specialty Gases Gas	Nonliquefied Compressed Gas	Liquefied Gas	Flammable Limits in Air (Vol. %) (1)	Oxidant	Inert	Corrosive	Toxic
Acetylene	(2)		2.5–100				
Air	X			X			
Allene		X	2.2–N.A.				
Ammonia		X	15–28			X	
Argon		X			X		
Arsine		X	5.1–78				(4)
Boron Trichloride		X				X	X
Boron Trifluoride	X			X		X	(4)
1,3-Butadiene		(5)	2.0–11.5				
Butane		X	1.8–8.4				
Butenes		X	1.6–10				
Carbon Dioxide		X			X		
Carbon Monoxide	X		12.5–74				X
Carbonyl Sulfide		X	11.9–28.5			(3)	X
Chlorine		X		X		(3)	(4)
Cyanogen		X	6.6–32				(4)
Cyclopropane		X	2.4–10.4				
Deuterium	X		4.9–75				
Diborane	X		0.8–98				(4)
Dimethylamine		X	2.8–14.4			X	
Dimethyl Ether		X	3.4–27				
Ethane		X	3.0–12.4				
Ethyl Acetylene		X	(7)				
Ethyl Chloride		X	3.8–15.4				
Ethylene	X		2.7–36				
Ethylene Oxide		(6)	3.6–100				X
Fluorine	X			X			(4)
Germane	X		(7)				(4)
Helium	X				X		
Hydrogen	X		4.0–75				
Hydrogen Bromide		X				(3)	(4)
Hydrogen Chloride		X				(3)	(4)
Hydrogen Fluoride		X				X	(4)

(1) Flammable limits are at normal atmospheric pressure and temperature. The flammable limits in air for some components vary in Europe – please refer to Chemiekaarten for specified limitations of each gas.
(2) Dissolved in solvent under pressure. Gas may be unstable and explosive above 15 psig (1 bar).
(3) Corrosive in presence of moisture.
(4) Toxic. It is recommended that the user be thoroughly familiar with the toxicity and other properties of this gas.
(5) Cancer suspect agent.
(6) Recognized human carcinogen.
(7) Flammable. However, limits are not known.

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Table 5. Characteristics of Gases Continued

Characteristics of Specialty Gases Gas	NonLiquefied Compressed Gas	Liquefied Gas	Flammable Limits in Air (Vol. %) (1)	Oxidant	Inert	Corrosive	Toxic
Hydrogen Sulfide		X	4–44			(3)	(4)
Iso-Butane		X	1.8–9.6				
Iso-Butylene		X	1.8–9.6				
Krypton	X				X		
Methane	X		5.0–15.0				
Methyl Chloride		X	10.7–17.4				
Methyl Mercaptan		X	3.9–22				(4)
Monoethylamine		X	3.5–14			X	
Monomethylamine		X	4.9–20.7			X	
Neon	X				X		
Nitric Oxide	X			X		(3)	(4)
Nitrogen	X				X		
Nitrogen Dioxide		X		X		(3)	(4)
Nitrogen Trioxide		X		X		(3)	(4)
Nitrosyl Chloride		X		X		(3)	(4)
Nitrous Oxide		X		X			
Oxygen	X			X			
Phosgene		X					(4)
Phosphine		X	1.6–99				(4)
Propane		X	2.1–9.5				
Propylene		X	2.0–11				
Halocarbon-12 (Dichlorodifluoromethane)		X			X		
Halocarbon-13 (Chlorotrifluoromethane)		X			X		
Halocarbon-14 (Tetrafluoromethane)	X				X		
Halocarbon-22 (Chlorodifluoromethane)		X			X		
Silane	X		1.5–98				
Sulfur Dioxide		X				(3)	(4)
Sulfur Hexafluoride		X			X		
Sulfur Tetrafluoride		X				X	(4)
Trimethylamine		X	2.0–12.0			X	
Vinyl Bromide		X	9–15				
Vinyl Chloride		(5)	3.6–33				
Xenon	X				X		

(1) Flammable limits are at normal atmospheric pressure and temperature. The flammable limits in air for some components vary in Europe – please refer to Chemiekaarten for specified limitations of each gas.
(2) Dissolved in solvent under pressure. Gas may be unstable and explosive above 15 psig (1 bar).
(3) Corrosive in presence of moisture.
(4) Toxic. It is recommended that the user be thoroughly familiar with the toxicity and other properties of this gas.
(5) Cancer suspect agent.
(6) Recognized human carcinogen.
(7) Flammable. However, limits are not known.

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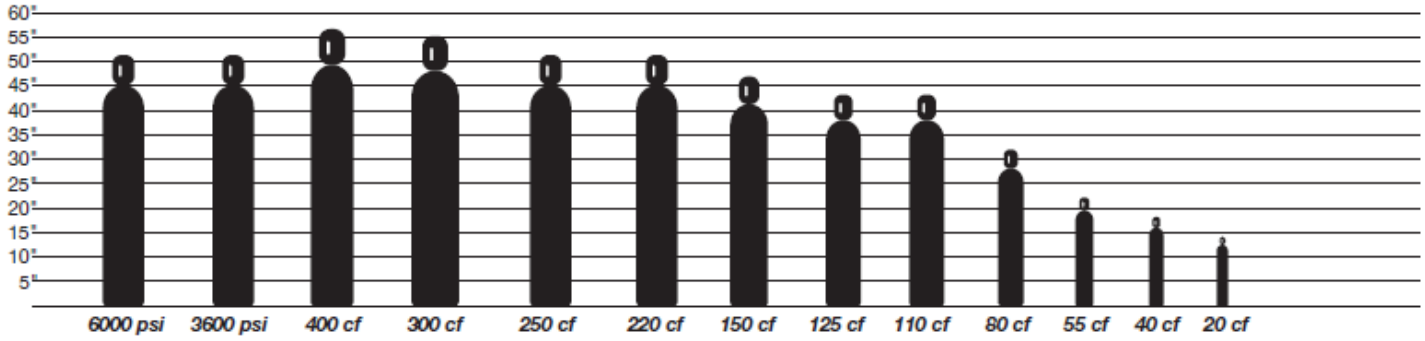
Table 6a. High Pressure Compressed Gas Cylinders, Steel

COMPRESSED GAS CYLINDERS

High Pressure Steel

Cylinder Model		6000 psi	3600 psi	400 cf	300 cf	250 cf	220 cf	150 cf	125 cf	110 cf	80 cf	55 cf	40 cf	20 cf
DOT Spec		3AA 6000	3AA 3600	3AA 2400	3AA 2400	3AA 2265	3AA 2015	3AA 2015	3AA 2265	3AA 2015	3AA 2015	3AA 2015	3AA 2015	3AA 2015
Dimentions	inches	9.28x51	9.31x51	10.51x56	9.27x55	9.04x51	8.99x51	7x46.25	7x43	7x43	7x32.38	7x22.88	7x18	5.27x14
	cm	23.5x129.5	23.6x129.5	26.7x142.2	23.5x139.7	23x129.5	22.8x129.5	17.8x117.5	17.8x109.2	17.8x109.2	17.8x82.2	17.8x58.1	17.8x45.7	13.4x35.6
Nominal Weight	lbs.	267	180	190	135	115	114	59	55	55	42	30	23	10.1
	kg.	121.1	81.6	86.2	61.2	52.2	51.7	26.76	24.94	24.94	19.05	13.61	10.43	4.58
Service Pressure	psi	6000	3600	2400	2400	2265	2015	2015	2265	2015	2015	2015	2015	2015
	bars	413.7	248.2	165.5	165.5	156.2	138.9	138.9	156.2	138.9	138.9	138.9	138.9	138.9
Water Capacity	cu. in.	2285	2640	3960	2980	2640	2640	1660	1345	1345	985	644	495	221
(volume)	liters	37.4	43.3	64.9	48.4	43.3	43.3	27.2	22.0	22	16.1	10.6	8.1	3.6



Reference: Air Liquid Industrial and Specialty Gas data Book

Table 6b. High Pressure Compressed Gas Cylinders, Steel

COMPRESSED GAS CYLINDERS

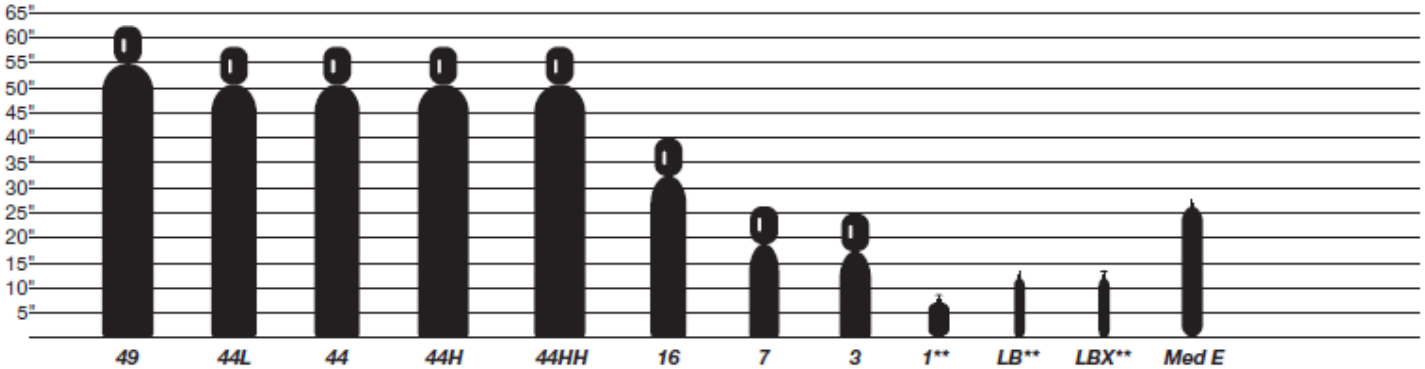
High Pressure Mild Steel

Cylinder Size		49	44L	44	44H	44HH	16	7	3	1"	LB"	LBX"	Med E
Service Pressure	psig	2400	2015	2265	3500	6000	2015	2015	2015	2200	1800	1800	2015
Approximate Capacity*	liters	8071	5976	6740	9487	13990	2181	934.6	396.5	147	53.8	53.8	566
	cu. ft.	285	211	238	335	494	77	33	14	5.2	1.9	1.9	20
Outside Diameter	inches	9.25	9	9	10	10	7	6.25	4.25	4.2	2	2	4
Height w/o Valve	inches	55	51	51	51	51	32.5	18.5	16.75	7.25	12	12	26
Tare Weight w/ Valve	lbs.	143	112	133	189	303	63	28	11	6	3.5	4.5	14
Internal Water Volume	liters	49	44	44	44	42.9	16	7	3	0.98	0.44	0.44	4.5
	cu. in.	2990	2685	2685	2607	2383	976	427	183	60	27	27	275

* Ideal Gas at STP

** Non-returnable cylinder. Price of cylinder included in the price of the gas.

Note: LBX is an LB cylinder with a CGA valve other than 170 or 180



Reference: Air Liquid Industrial and Specialty Gas data Book

Table 6c.

CARBON DIOXIDE CYLINDER SPECIFICATIONS

Cylinder Model		50 LBS.	20 LBS.	15 LBS.	10 LBS.	5 LBS.	2.5 LBS.	10 OZ.
DOT Spec		3AA 1800	3AA 1800	3AA 1800	3AA 1800	3AA 1800	3AA 1800	3E 1800
Dimentions	inches	8.625 x 45.38	7.75 x 23.25	7.0 x 22.88	7.0 x 18.0	5.73 x 14.0	3.56 x 14.62	1.94 x 11.88
	cm	21.908 x 115.2	19.685 x 59.0	17.78 x 58.115	17.78 x 45.72	13.385 x 35.6	9.042 x 37.135	4.928 x 30.175
Nominal Weight	lbs.	84.9	31.2	30	23	10.1	5.25	2.3
	kg.	38.5	14.95	13.61	10.43	4.58	2.38	1.04
Service Pressure	psi	1800	1800	1800	1800	1800	1800	1800
	bars	124.1	124.1	124.1	124.1	124.1	124.1	124.1
Water Capacity (volume)	cu. in.	2160	840	644	495	221	108	25.5
	liters	35.4	13.77	10.55	8.11	3.62	1.77	0.418

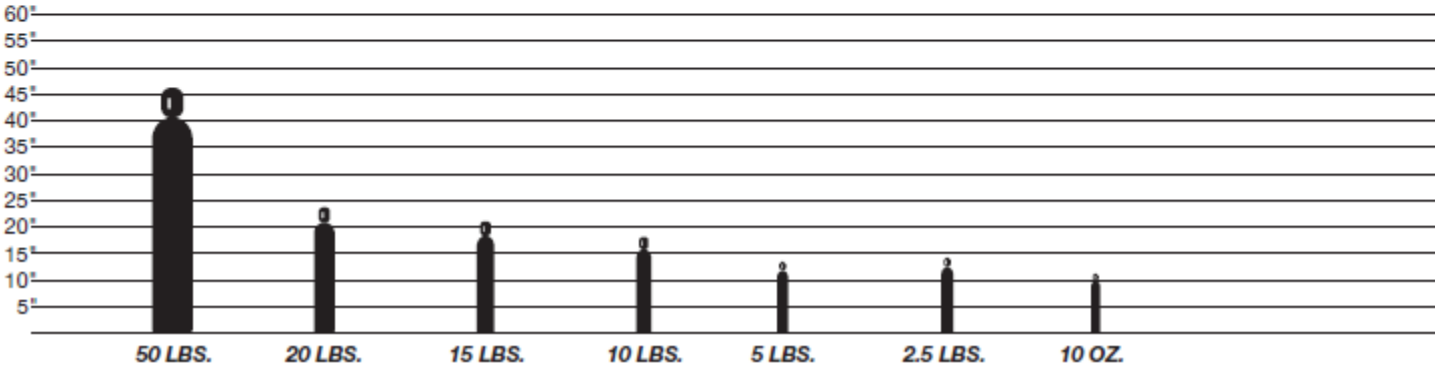


Table 6d. High Pressure Compressed Gas Cylinders, Aluminum

Reference: Air Liquid Industrial and Specialty Gas data Book

COMPRESSED GAS CYLINDERS

High Pressure Aluminum

Cylinder Size		30 AL	16 AL	7 AL	3 AL**	1 AL**
Service Pressure	psig	2015	2216	2216	2216	2216
Approximate Capacity*	liters	4088	2350	934.6	595	195
	cu. ft.	144	83	33	21	6.9
Outside Diameter	inches	8	7.25	6.9	5.2	4.4
Height w/o Valve	inches	47.9	33	15.6	17.1	9.3
Tare Weight w/ Valve	lbs.	48.5	31	15.6	9.7	4.8
Internal Water Volume	liters	29.4	15.7	6.6	3.9	1.3
	cu. in.	1800	840	360	244	80

* Ideal Gas at STP
** Resale Cylinder Only

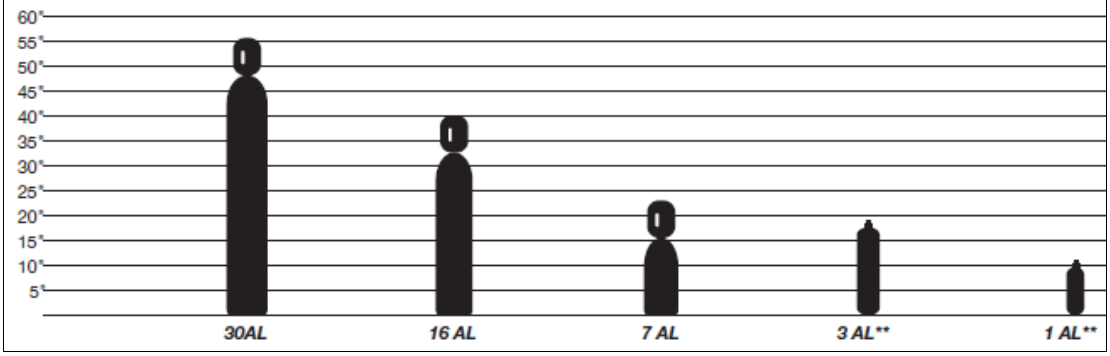
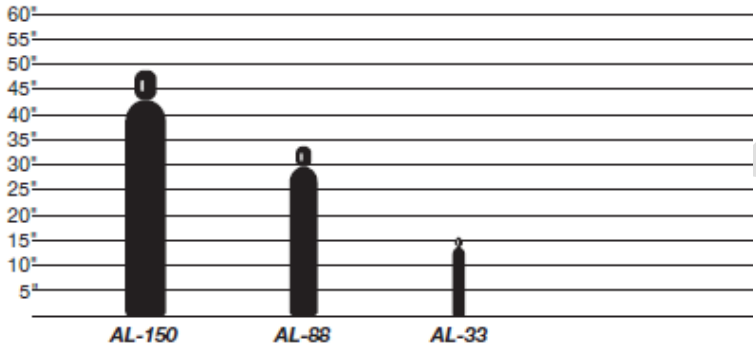


Table 6d. High Pressure Compressed Gas Cylinders, Aluminum Continued

COMPRESSED GAS CYLINDERS

High Pressure Aluminum				
Cylinder Model		**AL-150**	**AL-88**	**AL-33**
DOT Spec		3AL 2015	3AL 2216	3AL 2216
Dimentions	inches	8 x 48	7 x 33	7 x 16
	cm	22 x 122	18 x 84	18 x 41
Nominal Weight	lbs.	50	32	16
	kg.	23	15	7
Service Pressure	psi	2015	2216	2216
	bars	139	153	153
Water Capacity (volume)	cu. in.	1831	976	366
	liters	30	16	6



Reference: Air Liquid Industrial and Specialty Gas data Book

Table 6e. Low Pressure Compressed Gas Cylinders

Low Pressure Cylinders										
Cylinder Size		**125**	**110**	**70****	**55**	**22 UP**	**22 LP AL**	**11 LP**	**11 LP AL**	**4D*****
Service Pressure	psig	480	260	250	300	240	240	240	240	240
Approximate Capacity*	liters	4076	1982	11894	1121	368	368	200	200	20
	cu. ft.	144	70	420	39.6	13	13	7	7	0.7
Outside Diameter	inches	15	15	12	10	12	12	9	10	3
Height w/o Valve	inches	54.5	45	43..5	51	18	21	17	16	12
Tare Weight w/ Valve	lbs.	159	73	187	56	21	14	16	11	2.5
Internal Water Volume	liters	125	110	70	55	22	22	12	12	1.16
	cu. in.	7628	6712	4271	3356	1342	1342	732	732	71

* Ideal Gas at STP
** Acetylene Cylinder with acetone
*** Non-returnable cylinder

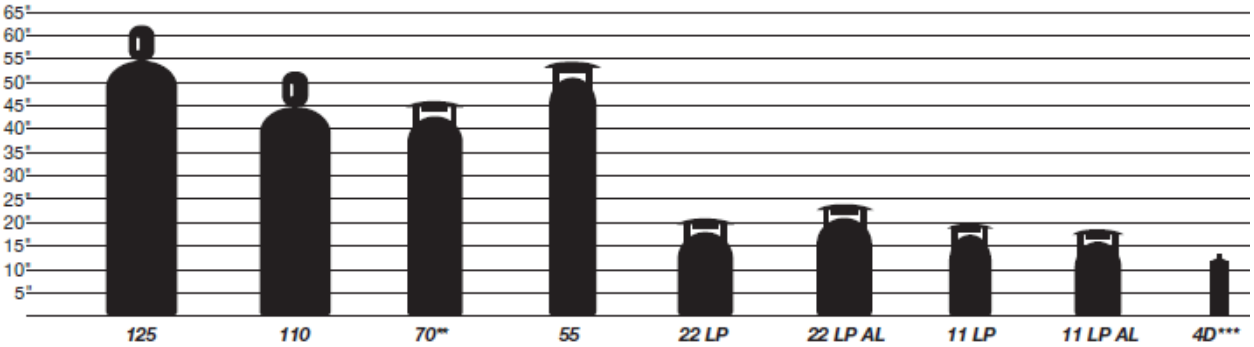


Table 7a. Scott Specialty Gases Design and Safety Handbook 4th Edition

Cylinder Valve Outlets and Connections

Scott supplies gases in cylinders with valves having BS, CGA, DIN and NEN standard outlet connections. In some cases, alternate connections may be used, and upon customer's request, will be supplied instead of the standards shown below.

Gas	BS	CGA	DIN	NEN	Gas	BS	CGA	DIN	NEN
Acetylene	2	510	–	LI2	Hydrogen Bromide	–	330	8	
Air	3	590	6		Hydrogen Chloride	6	330	8	
Allene	–	510	1		Hydrogen Sulfide	15	330	5	
Ammonia, Anhydrous	10	240, 660	8		Iso-Butane	4	510	1	
Argon	3	580	10		Iso-Butylene	4	510	1	
Arsine	4	350	5		Krypton	3	580	10	
1,3-Butadiene	4	510	1		Methane	4	350	1	
Butane	4	510	1		Methyl Chloride	7	660	5	
Butenes	4	510	1		Methyl Mercaptan	–	330	5	
Carbon Dioxide	8	320	6		Monoethylamine	11	240	5	
Carbon Monoxide	4	350	5		Monomethylamine	11	240	5	
Carbonyl Fluoride	–	660	8		Natural Gas	4	350	1	
Carbonyl Sulfide	–	330	5		Neon	3	580	10	
Chlorine	6	660	8		Nitric Oxide	14	660	8	
Cyanogen	–	660	8		Nitrogen	3	580	10	
Deuterium	4	350	1		Nitrogen Dioxide	14	660	8	
Dimethylamine	11	240	5		Nitrous Oxide	13	326	6	
Dimethyl Ether	–	510	1		Oxygen	3	540	–	RI2
Ethane	4	350	1		Phosgene	6	660	8	
Ethyl Acetylene	–	510	1		Phosphine	4	350	5	
Ethyl Chloride	7	510	1		Propane	4	510	1	
Ethylene	4	350	1		Propylene	4	510	1	
Ethylene Oxide	7	510	1		Silane	–	350	5	
Halocarbon-14					Silicon Tetrafluoride	–	330	8	
(Tetrafluoromethane)	6	580	6		Sulfur Dioxide	12	660	8	
Halocarbon-22					Sulfur Hexafluoride	6	590	6	
(Chlorodifluoromethane)	6	660	6		Trimethylamine	11	240	5	
Helium	3	580	10		Vinyl Chloride	7	510	5	
Hydrogen	4	350	1		Xenon	3	580	10	

Table 7b.

CGA Valve Outlets and Connections

The Compressed Gas Association (CGA) has established standards for cylinder outlet connections for the respective gases listed here. The outlets are designed to minimize the possibility of hazardous connections. Wherever possible, the CGA standards are used.

Gas	CGA Valve Outlet & Connection	Gas	CGA Valve Outlet & Connection
Acetylene	510	Helium	580
Air	590	3,500 psig	680
Ammonia	660 or 705	6,000 psig	677
Argon	580	Hydrogen	350
3,500 psig	680	3,500 psig	695
6,000 psig	677	6,000 psig	703
1,3-Butadiene	510	Hydrogen Bromide	330
n-Butane	510	Hydrogen Chloride	330
1-Butene	510	Hydrogen Sulfide	330
cis-2-Butene	510	Isobutane	510
trans-2-Butene	510	Isobutylene	510
Carbon Dioxide	320	Krypton	580
Carbon Monoxide	350	Methane	350
Chlorine	660	Methyl Acetylene	510
Deuterium	350	Methyl Mercaptan	330
Diborane	350	Monoethylamine	705
Dimethylamine	705 or 240	Monomethylamine	705
Dimethyl Ether	510	Neon	580
2,2-Dimethylpropane	510	Nitric Oxide	660
Ethane	350	Nitrogen	580
Ethyl Acetylene	510	3,300 psig	680
Ethylene	350	6,000 psig	677
Halocarbon 11	660	Nitrogen Dioxide	660
Halocarbon 12	660	Nitrous Oxide	326
Halocarbon 13	660 or 320	Oxygen	540
Halocarbon 13 B1	660	Perfluoropropane	660
Halocarbon 14	580 or 320	Propane	510
Halocarbon 21	660	Propylene	510
Halocarbon 22	660	Sulfur Dioxide	660
Halocarbon 23	660 or 320	Sulfur Hexafluoride	590
Halocarbon 113	660	Sulfur Tetrafluoride	330
Halocarbon 114	660	Trimethylamine	705
Halocarbon 115	660	Xenon	580
Halocarbon 116	660 or 320		
Halocarbon 142 B	510		
Halocarbon 152 A	510		
Halocarbon C-318	660		
Halocarbon 1132 A	350		

Table 7c

Compressed Gas Association (CGA) Cylinder Valve Fitting Specifications

All cylinder valve outlets and connections are designed and constructed to conform to the specifications established by the Compressed Gas Association (CGA).

CGA valve connections for converting cylinder valve outlets to 1/4' MNPT (CGA 180, 1/8" MNPT) are available in brass, stainless steel, and Monel metal.

The CGA connection numbers shown here are followed by a multi-part, sequentially listed descriptive code. This code generally includes:

- Outside diameter (O.D.) of valve threads
- Threads per inch and thread size
- Left-hand or right-hand thread
- External or internal threads

CGA Connection No. 110
.3125"-3UNEF-2B-RH-INT

CGA Connection No. 240
¾" - 18NGT-RH-INT

CGA Connection No. 326
.825" - 14NGO-RH-EXT (Small Round Nipple)

CGA Connection No. 350
.825" - 14NGO-LH-EXT (Round Nipple)

CGA Connection No. 580
.965" - 14NGO-RH-INT

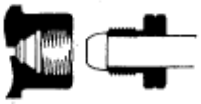
CGA Connection No. 670
1.030" - 14NGO-LH-EXT (Face Washer)

CGA Connection No. 500
.885" - 14NGO-RH-INT (Bullet Nipple)

CGA Connection No. 165
.4375"-20UNF-2A-RH-EXT (1/4" SAE Flare)

CGA Connection No. 290
.745"-14NGO-LH-EXT

CGA Connection No. 330
.825" - 14NGO-LH-EXT (Flat Nipple)



CGA Connection No. 510
.885" - 14NGO-LH-INT

CGA Connection No. 590
.965" - 14NGO-LH-INT

CGA Connection No. 677
1.030" - 14NGO-LH-EXT (Round Nipple)

CGA Connection No. 679
1.030" - 14NGO-LH-EXT (Tipped Nipple)

CGA Connection No. 180
.625"-18UNF-2A-RH-EXT

CGA Connection No. 320
.825"-14NGO-RH-EXT (Flat Nipple)

CGA Connection No. 346
.825" - 14NGO-RH-EXT (Large Round Nipple)

CGA Connection No. 540
.903" - 14NGO-RH-EXT

CGA Connection No. 660
1.030" - 14NGO-RH-EXT (Face Washer)

CGA Connection No. 678
1.030" - 14NGO-LH-EXT (Recessed Washer)

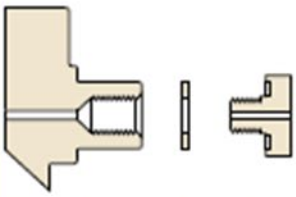
CGA Connection No. 705
1.125"-14 RH EXT. using Flat Seat with Washer

Airgas
Specialty Gases

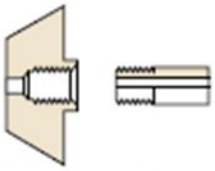
Table 7d CGA US Standards Outlets & Connections

Specialty Gases Design and Safety Handbook 4th Edition

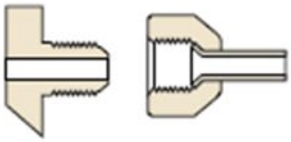
CGA U.S. Standards Cylinder Valve Outlets and Connections



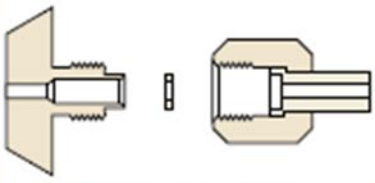
Connection 110 5/16" – 32 RH INT., with Gasket



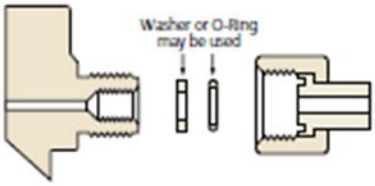
Connection 160 1/8" – 27 NGT RH INT.



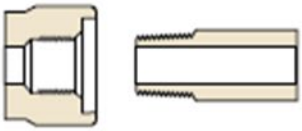
Connection 165 0.4375" – 20 UNF 2A RH EXT.



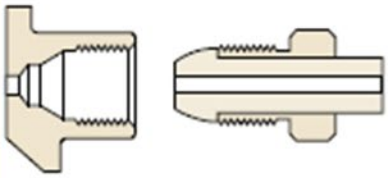
Connection 170 9/16" – 18 RH EXT. and 5/16" – 32 RH INT., with Gasket



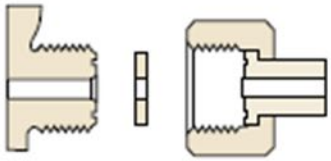
Connection 180 0.625" – 18 UNF 2A RH EXT., with Gasket



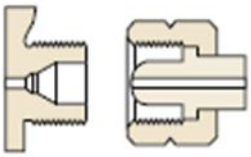
Connection 240 3/8" – 18 NGT – RH INT.



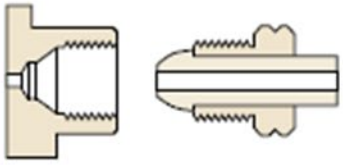
Connection 296 0.803" – 14 RH INT.



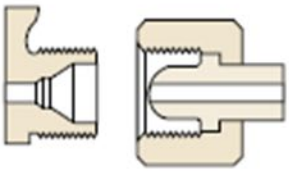
Connection 320 0.825" – 14 RH EXT., with Gasket
Connection 330 0.825" – 14 LH EXT., with Gasket



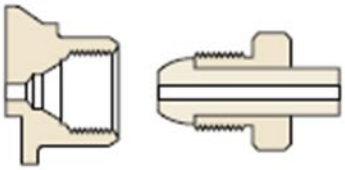
Connection 326 0.825" – 14 RH EXT.
Connection 350 0.825" – 14 LH EXT.



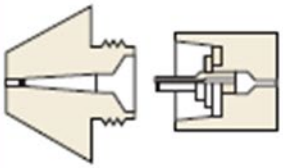
Connection 510 0.885" – 14 LH INT.



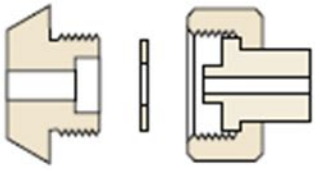
Connection 540 0.903" – 14 RH EXT.



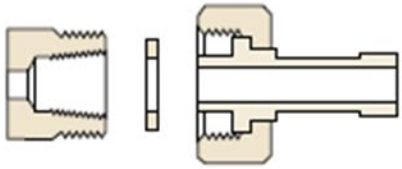
Connection 580 0.965" – 14 RH INT.
Connection 590 0.965" – 14 LH INT.



Connection 600 1.000" – 20 UNEF RH EXT., with Gasket



Connection 660 1.030" – 14 RH EXT., with Gasket



Connection 705 1.125" – 14 UNS 2A RH EXT., with Gasket