Chemically Speaking LLC

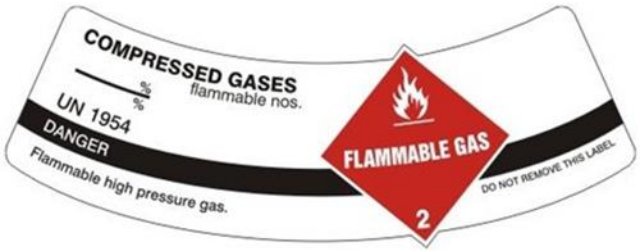
What's In That Cylinder?

March 2022

Some are easy

- Recently filled
- Label and Markings intact
- Name of supplier very clear
- No damage or corrosion
- Not leaking

It may not be what you think it is



A 15% Silane/Hydrogen mixture is classified as a Compressed Gas, Flammable, N.O.S. UN 1954
Pyrophoric gases do not have a separate hazard class unlike liquids or solids which do
As a result, pyrophoric gas mixtures are labelled as flammable gases
Disilane for example is Liquefied Gas, Flammable, N.O.S., UN 1954 the same as the mixture
Unknown Cylinder

Can be extremely dangerous
Even if properly identified
Most dangerous are explosive gas mixture or unstable reactive where the inhibitor has expired. Reaction can be caused by simply opening the cylinder valve and causing:
Adiabatic compression
Ignition and backflash
These can only be handled by waste disposal companies equipped and trained to do so.

Unstable Reactive Gases

Can violently polymerize or decompose, most have inhibitor which has a shelf life of a few years

- Bromotrifluoroethylene
- 1,2 Butadiene
- 1,3 Butadiene
- Cyanogen
- Cyanogen Chloride
- 1,1 Difluoroethylene
- Chlorotrifluoroethylene
- Ethylene oxide
- Hydrogen cyanide
- Tetrafluoroethylene
- Trifluoroethylene
- Tetrafluorohydrazine
- Vinylacetylene
- Vinyl bromide
- Vinyl chloride
- Vinyl Fluoride

Cylinder Worksheet, Cylinder ID _____	
Markings & Labels	
Shipping Name, UN#	
Specification/Pressure	
Hydrotest Date (first & last)	
Serial Number	
Cylinder Manufacturer	
Cylinder Owner	
Water Capacity (WC)	
Tare Weight (TW) /Total Weight	
DOT Hazard Labels/PG/Zone	
Sidewall Markings	
Collar Marking	
Color Cylinder Body/Code	
Marking on Cylinder Cap	
Other Labels/Tags	
Supplier	

Labels and Markings

DOT

- Shipping Name
- UN or NA #
- Reportable Quantity
- Inhalation Hazard (if required)
- Hazard Zone or Packing Group (if required)
- Technical Name (If not same as Shipping Name)
- Name and Address of Shipper
- DOT Hazard Labels

UN - International number established by UN to identify common chemicals in commerce. A chemical may have more than 1 number to reflect its' physical state e.g. for Carbon Dioxide:

- UN 1013 Carbon Dioxide, Compressed
- UN 2187 Carbon Dioxide, Refrigerated
- UN 1845 Carbon Dioxide, Solid

Transportation Hazard Classifications

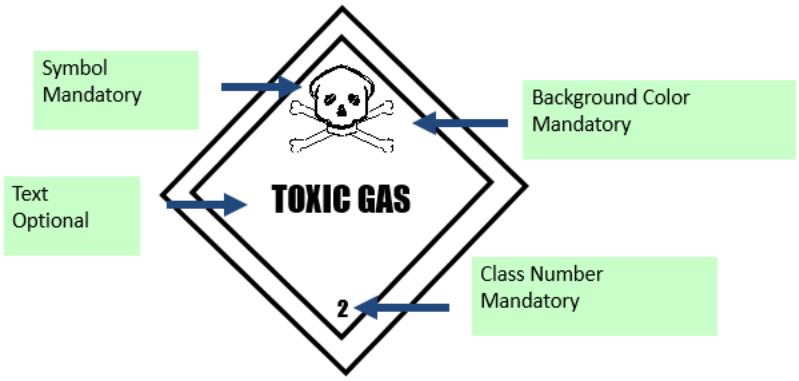
23 Hazard Classes with the most common for Compressed Gases being:

- Toxic Gas - 2.3
- Flammable Gas - 2.1
- Nonflammable Gas - 2.2

Hazard Warning Labels must be applied to Hazardous Material packages:

- Minimum - 3.9" (100mm) Diamond
- Placed point on square
- Near Shipping Name
- Only one set required for cylinders

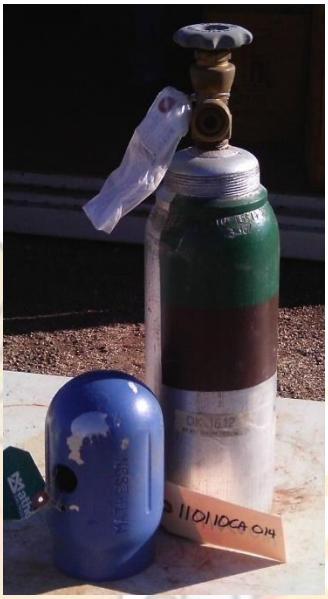
Hazard Warning Labels for cylinders containing >1000 kgs must be a Placard with UN# on both sides



In US Toxic can be interchanged with Poison
Internationally if text is used must be Toxic
US requires Inhalation Hazard Label

Shoulder labels now authorized in place of 4" hazard labels

GHS is a recent hazard classification effort It not be applicable for older cylinders
Where a transportation hazard label is visible to users, there is no need to apply an additional pictogram
Gas cylinder colors differ from one manufacturer or supplier to another
A universal color code does NOT exist except for a few medical and diving gases in the US
It is essential that a gas be identified by the name stenciled and the label on the cylinder, not by the color of the cylinder
Matheson was the only gas company that had a color code
Used 2-3 colors to denote the gas contained, no loner used



Praxair had a much simpler system with broad classification of toxic, flammable, corrosive using a number

US Medical Gas Color Code

	United States Color	Canada Color[1]
Single gases		
Oxygen USP	Green	White[2]
Carbon dioxide USP	Gray	Gray
Nitrous oxide USP	Blue	Blue
Cyclopropane	Orange	Orange
Helium USP	Brown	Brown
Nitrogen NF	Black	Black
Medical air USP	Yellow[2]	Black and white quadrants
Gas mixtures of oxygen USP and nitrogen NF		
19.5% to 23.5% oxygen	Yellow[2]	Black and white quadrants
All other oxygen concentrations	Black and green	Pink
Other gas mixtures[3]		
Oxygen USP and nitrous oxide USP: 52.5% oxygen USP, 47.5% nitrous oxide USP	Not assigned [4]	White and blue quadrants
Oxygen USP and carbon dioxide USP: ≥ 93% oxygen USP, remainder carbon dioxide USP	Green and gray	White and gray quadrants
Oxygen USP and helium USP: ≥ 20% oxygen USP, remainder helium USP	Green and brown	White and brown quadrants

Oxygen USP	Green		
Carbon dioxide USP	Gray		
Nitrous oxide USP	Blue		
Helium USP	Brown		
Nitrogen NF	Black		
Medical air USP	Yellow		
Oxygen USP and nitrogen NF mixtures other than Medical air USP	Black	&	Green
Oxygen USP and carbon dioxide USP	Green	&	Gray
Oxygen USP and helium USP	Green	&	Brown

Diving Gas Color Code, IMCA D043-07

Gas	Symbol	Typical shoulder colours	Cylinder shoulder	Quad upper frame/ frame valve end
Helium	He		Brown	Brown
Medical oxygen	O_2		White	White
Oxygen and helium mixtures	O_2/He		Brown and white quarters or bands	Brown and white short (8in/20cm) alternating bands
Nitrogen	N_2		Black	Black
Oxygen/helium/ nitrogen mixtures	O_2/He/N_2		Black, white and brown quarters or bands	Black, white and brown short (8in/20cm) alternating bands
Air (breathing) Oxygen/nitrogen mixtures	Air N_2/O_2		Black and white quarters or bands	Black and white short (8in/20cm) alternating bands
Carbon dioxide	CO_2		Grey	Grey
Calibration gases [1]	As appropriate		Pink	Pink

Notes:

1 The colour coding of cylinders containing calibration gases may vary from the above. In addition, some are marked with yellow shoulders for toxic contents and red shoulders for flammable contents. Labels and marking should be carefully checked before use.

Gas Mixtures for Medical or Inhalation Purposes

Gas type		Example cylinder shoulder colours
Air or synthetic air 20%≤O_2≤23%		 White RAL 9010 Black RAL 9005
Helium/oxygen	He/O_2	 White RAL 9010 Brown RAL 8008
Oxygen/carbon dioxide	O_2/Co_2	 White RAL 9010 Grey RAL 7037
Oxygen/nitrous oxide	O_2/N_2O	 White RAL 9010 Blue RAL 5010

Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Guideline N, Assignment of Refrigerant Container Colors, specifies that all refrigerant containers should have one uniform paint color, a light-green/grey (RAL 7044), and that existing individually assigned container paint colors should be transitioned to the new standard color by 2020.

Refrigerants that are flammable shall have a red stripe or top of the cylinder painted red.

Cylinders

Compressed gases must be packaged in DOT/TC (Dept of Transportation, Transport Canada) Specification cylinders

Material of Construction

- Carbon Steel
  - Chrome/Molybdenum Alloy (3AA)
  - Light weight - high strength (HC series)
  - Open Hearth, electric or basic oxygen process steel (low pressure welded)
- Aluminum
- Fiber Wrapped Aluminum
- Stainless Steel
- Specialty Alloy (Nickel or Monel)

Types

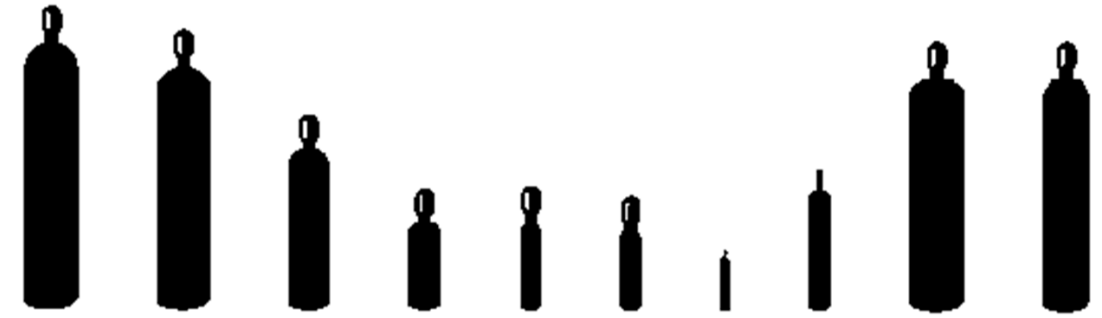
- Returnable
- Disposable (Nonrefillable)

Construction

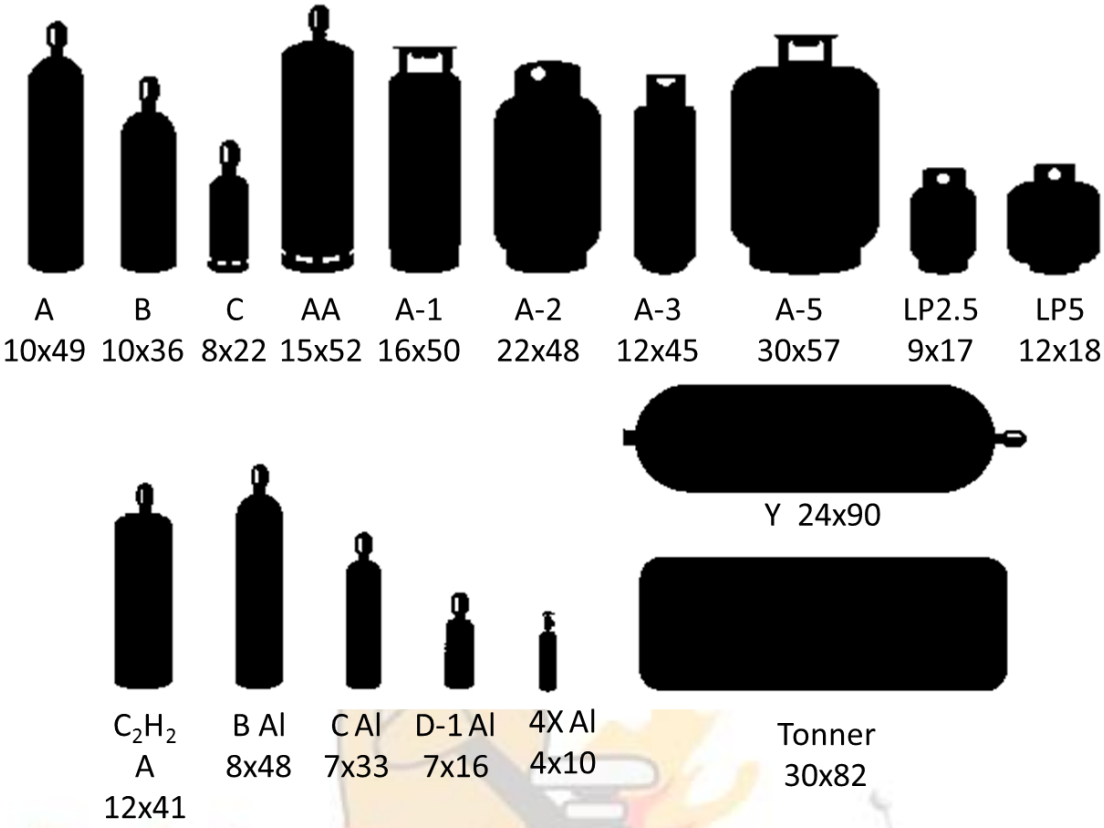
- Seamless
  - Forged
  - Spun
- Welded
- Fiberwound
- Composite

Sizes

Variety of sizes available. Following are from Air Products



A	B	C	D-1	D	4X	LB	E	BX	BY
9x55	9x51	7x33	7x19	4x17	4x13	2x12	4x26	10x51	9x51



Low Pressure Cylinders

Low pressure cylinders are typically constructed using plate steel or aluminum that are rolled into cylindrical pieces and assembled by welding.
Wide shoulder, almost flat
Pressure rating <480 psig
May have a foot ring
May have a weld seam

High Pressure Cylinders

Seamless carbon steel or aluminum
Round shoulder
Small diameter (Typically <10")
Concave bottom (Aluminum is flat)

Lecture Bottle

2" dia X 16" long (body is 12")
0.10" thick wall
DOT Spec 3E (178.42)
Holds up to 220 gms of Liquefied Gas or 1800 psig of Gas. (approx. 0.44 liters)
Commonly referred to as Lecture Bottle which has valve outlet CGA 160 or 170. No relief device.
Also known as 7X which has standard valve CGA outlet and a relief device.
Carbon, Stainless Steel or Monel
While they are reusable, most become a waste disposal problem

Disposable cylinders are designed to be filled once, DOT 39 or 2P specification

Typical Cylinder Specifications

High Pressure (150-6000 psig)

DOT 3A DOT 3AAX (Tube Trailer) DOT 3AX (Tube Trailer)

DOT 3AA DOT 3AL

Seamless cylinders typically used for Nitrogen, Hydrogen, etc..

Medium Pressure (150-500 psig)

DOT 4BA DOT 4B DOT 3B

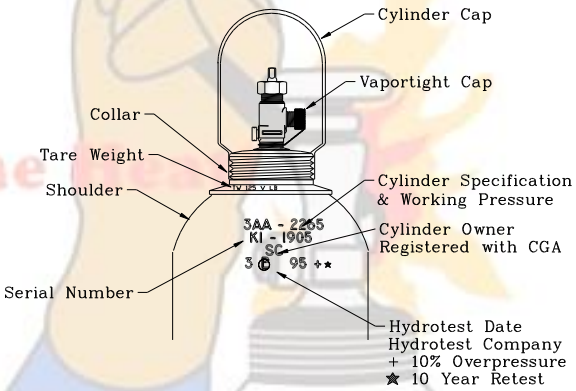
Welded cylinders typically used for liquefied gases such as Hydrocarbons

Disposable (260 -500 psig)

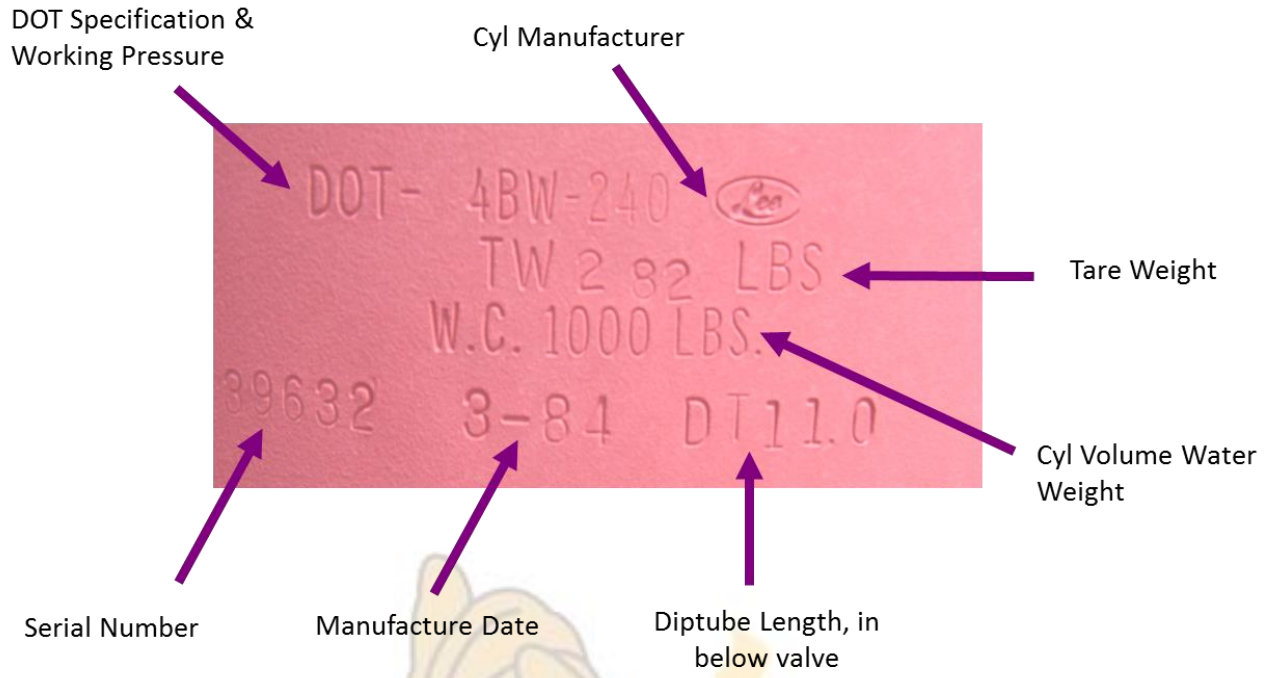
DOT 39 - Welded, used for Freon, Propane, etc..

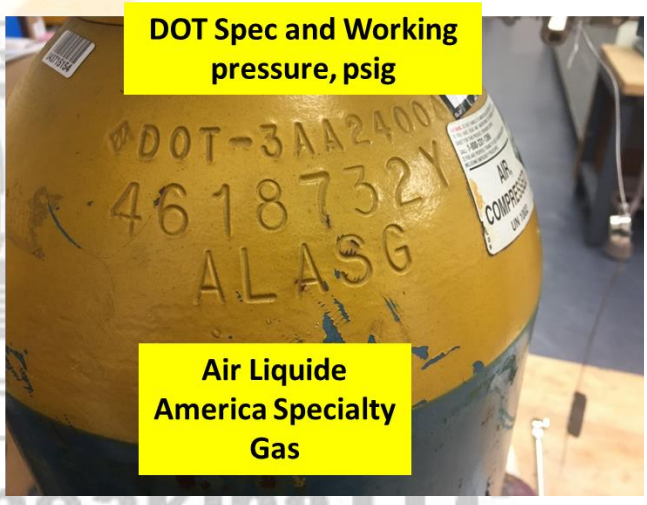
DOT 2P - Aerosol can

Common Markings On US Cylinders



- ICC – Interstate Commerce Commission
- SP – Service Pressure
- TP – Test Pressure
- TW – Tare Weight
- TW with a V – With valve
- CR MO – Chrome Moly
- REE – Rejection elastic expansion
- Non Shat – Shatterproof cylinder
- DOT – Dept of Transportation (1978)
- TC – Transport Canada
- USN – US Navy
- SPUN – High pressure cylinder fabrication method
- WC – Water capacity in lbs
- DP – Diptube length in inches





Cylinder Manufacturers

Formerly used symbols

ASAHI	ASAHI	
COMPRESSED GAS CYLS. INC.	CGC	
COYNE CYL.	COYNE	
CREAMERY PACKAGE	CP	
CUNEO PRESS	CTD	CTD
CYLINDERS INC.	INC	
GENERAL FIRE EXTINGUISHER	F	

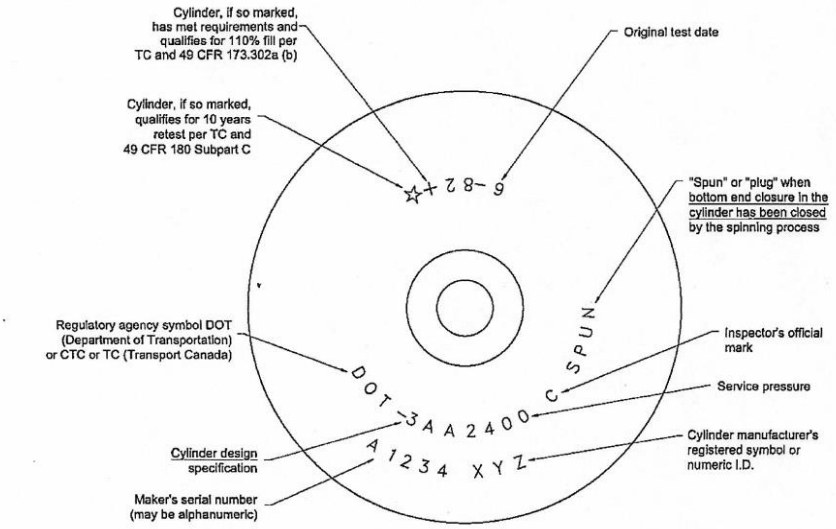
Now 4 digit iID registered with DOT

IDNO	COMPANY	IDNO	COMPANY
M4001	Worthington Cylinders	M4014	The Manchester Tank and Equipt. Co.
M4002	Catalina Cylinders Corporation	M4017	Systron Donner
M4004	Scientific Safety Technologym, Inc.	M4018	Pressed Steel Tank Company, Inc.
M4006	Harsco Corporation	M4020	Comdyne I, Inc.
M4008	Air-Lock, Inc.	M4040	Precision Fabricators, Inc.
M4009	Puritan Bennett	M4063	Compositek Engineering
M4010	Harsco Corporation	M4064	Wasson ECE

Cylinder Owners – refillable cylinders are typically stamped with the owners symbol. The cylinder owner retains liability for the cylinder. Since 1983, DOT no longer required the owners symbol to be placed on the cylinder, the Compressed Gas Association now maintains a cylinder owner symbol registration program

With all the constant changes in ownership it was not possible to provide a comprehensive update This was discussed in detail during the Cylinder Specification Committee meetings in 2020 and the decision by the committee was to leave it as is and reaffirm the 2014 edition.

CGA C-16 CGA Registration Program for Cylinder Owner Symbols, 12/01/2014



NOTE—Removal of these markings prohibited.

Figure 1—Example of required cylinder markings

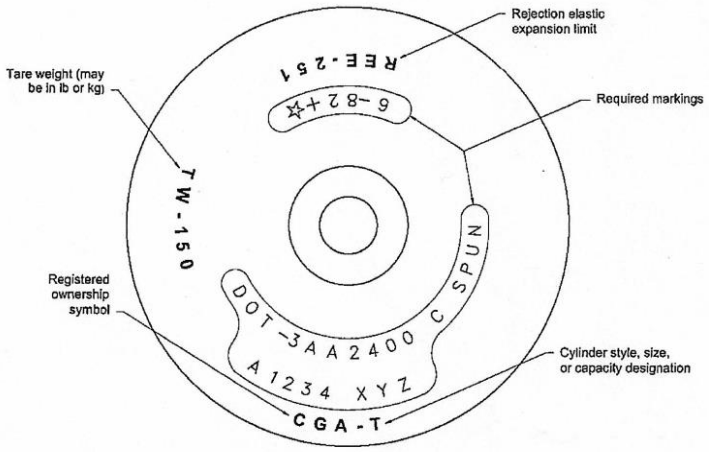


Figure 2—Example of additional cylinder markings

CGA C-16.1 Cylinder Owner's Registration Symbols and Company Names, 5/2015

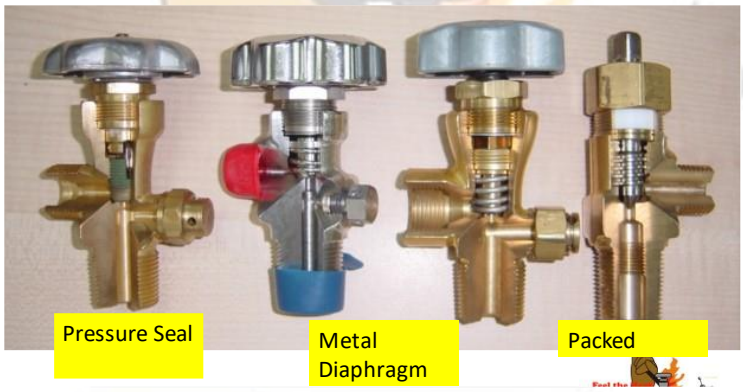
Table 1—Cylinder symbols registered with CGA—sorted by registered symbol

Table 2—Cylinder symbols registered with CGA—sorted by company

Table 3—Names and addresses of registered cylinder owners

Company	Registered symbol
LaRoche Industries Inc.,	A & CO
American Compressed Gases, Inc.	A - In a badge shape.
O. E. Meyer Co.	A819
Oxygen & Welding Supply Co., Inc.	A828
Liquid Carbonic Specialty Gas	ABC
Adirondack Bottled Gas Corp.	ABGC
ABSCO Distributing	ABSCO
Amarillo Coca-Cola Bottling Co.	ACCBC
Liquid Carbonic Specialty Gas	ACCORP
Allied Corp. Engd. Matls. Sector	ACC-SCD
Allied-Signal Inc.	ACC-SCD
American Compressed Gases, Inc.	ACG
Airco Gases	ACME
Liquid Carbonic Specialty Gas	ACME OX
Airco Gases	ACMEGAS
General Welding Supply Co.	ADAM
Airco Gases	AEM
Airco Gases	AEMM
AETNA Gas Products, Inc.	AETNAGAS
Approved Fire Protection Co.	AFPCO
Acetylene Gas Company	AG - G in the lower half of the "A".
AGA Gas, Inc.	AGA
AGA Gas, Inc.	AGA USA
AGA Gas, Inc.	AGAGAS
AGA Gas, Inc.	AGAS
Air Products & Chemicals, Inc.	AGCD
Liquid Carbonic Inc.	AGS

Cylinder Valves



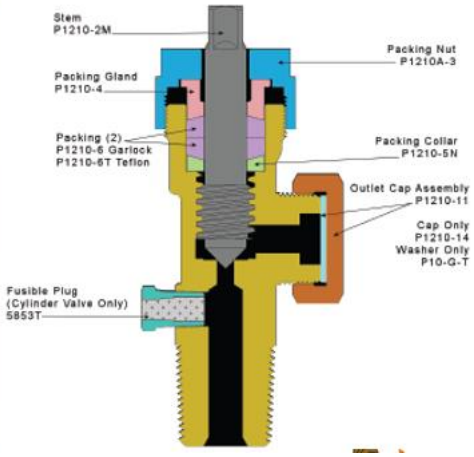
Pressure seal valves are used for cryogenic dewars and high pressure non toxic, corrosive gases such as SCBA

Packed valves are used for corrosive gases such as HCl, NH_3, BCl_3.

Ammonia has carbon steel packed valve. Magnetic. Female thread

Acid gases have Aluminum Silicon Bronze valve which looks like brass. Not magnetic. Male thread

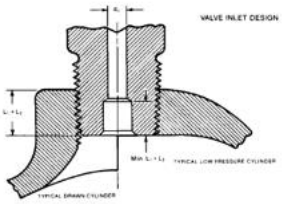
Chlorine valve



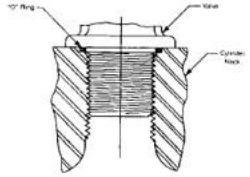
Metal diaphragm valve must be used for highly toxic, only exception is a packed valve with a stem cap

The method of screwing the cylinder valve into the cylinder

Tapered thread must be used for toxic or corrosive gases. There are threads showing above the cylinder



If there are no threads showing below the valve, it is a straight thread. Is sealed using gasket or O Ring. Cannot be used for toxic or corrosive gases



Cylinder valve with a vapor and liquid outlet. Typically used for refrigerant gases

Valve Outlet Connection

Standards established by CGA

Types:

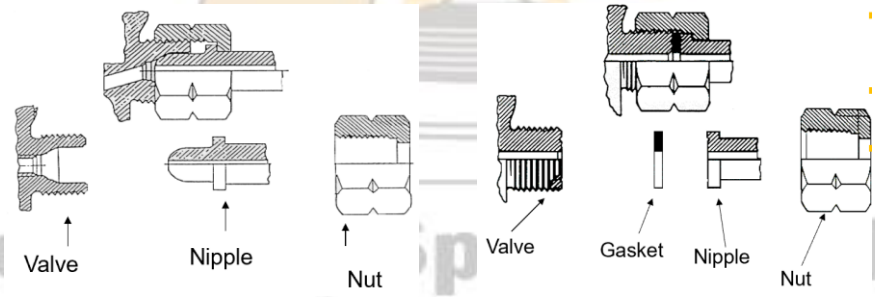
- Industrial
- Medical
- Semiconductor

Prevent connection of incompatible or excessive pressure gases

Required under 29CFR1910.101(b) which references CGA P-1 for user in US

Summarized in CGA Pamphlets V-1 for pure gases and V-7 for Mixtures

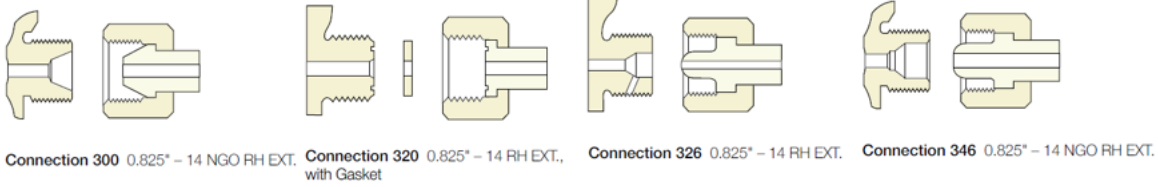
- Male or female
- Right or left handed threads (notch in nut)
- Flat gasket, bullet, pipe thread
- Gasket material



Bullet **Gasket**

CGA Outlets Using 0.825” dia Nut

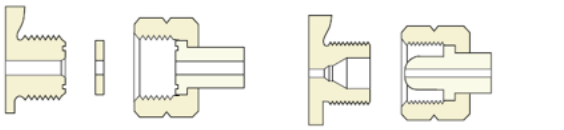
Right Handed Thread



Connection 300 0.825" – 14 NGO RH EXT. Connection 320 0.825" – 14 RH EXT., with Gasket Connection 326 0.825" – 14 RH EXT. Connection 346 0.825" – 14 NGO RH EXT.

Ethyl chloride **Carbon dioxide** **Nitrous oxide** **Air**

Left Handed Thread

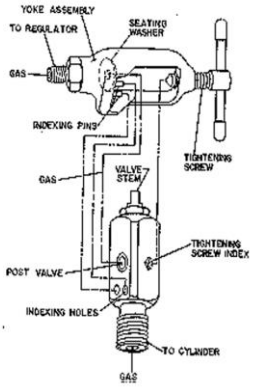


Connection 330 0.825" – 14 LH EXT., with Gasket Connection 350 0.825" – 14 LH EXT.

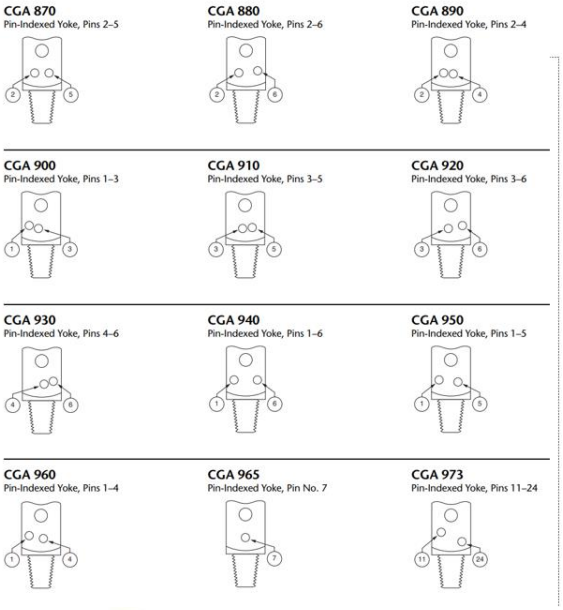
Hydrogen chloride
Boron trifluoride

Hydrogen
Methane

Medical Gas Cylinder Valves, Pin Index



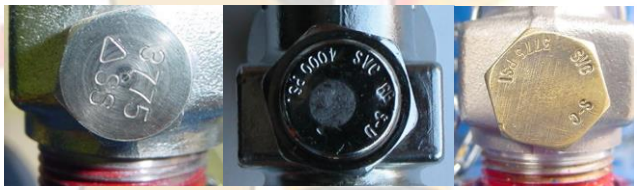
- To Prevent Incorrect Medical Gas From Being Connected
- Non Threaded & Non Indexed Yoke
- SCUBA uses non pin indexed yoke CGA-850 with “O” Ring
- Pin Index is yoke type utilizing a flat gasket and a series of pins and holes to prevent interchange



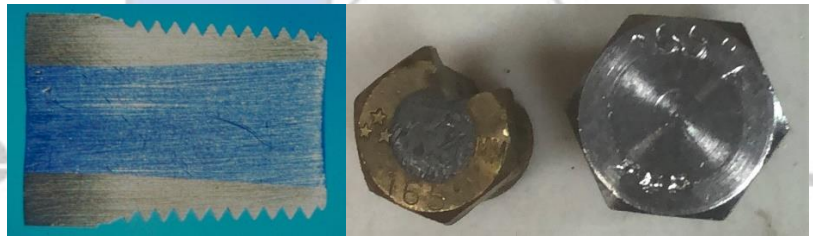
Pressure Relief Device (PRD)

Pressure Relief Devices will have the rupture disk pressure rating and/or the fuse metal temperature stamped on the back.

CG-1 Rupture disk, used for inert and oxidizing gases, oxygen, nitrogen, argon, helium

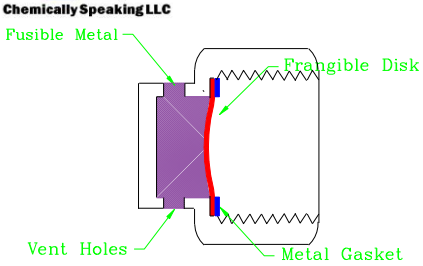


CG-2 165°F fuse metal, used for low pressure corrosive liquefied gases, ammonia, chlorine, boron trichloride



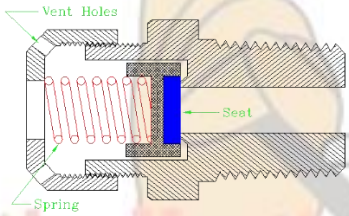
CG-3 212°F fuse metal, used for acetylene

CG-4 Rupture disk and 165°F fuse metal, used for boron trifluoride, hydrogen chloride, silicon tetrafluoride



CG-5 Rupture disk and 212°F fuse metal, used for silane, methane, hydrogen

CG-7 Springloaded PRD, Used for LPG gases, butane, propane, isobutane



No PRD – Highly toxic gas, phosgene, hydrogen cyanide, arsine. Optional for ammonia and amines less than 165 lbs and small cylinders such as lecture bottles.
Could also contain a liquid chemical

Old poison gas valve and cap

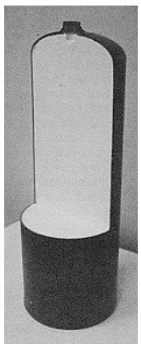
Corrosive highly toxic gas valve (Phosgene, Fluorine, etc) with vaportight stem cap

Highly toxic ton unit for Phosgene, Cyanogen Chloride on left. Has vapor tight dome cap and PRD seal cap.

Acetylene 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)

Safety practice is to use it at 15 psig or less

Cylinders are filled to 250 psig and contain a solid matrix formerly asbestos now clay which has microcavities to absorb Acetone and Acetylene. Will absorb the heat of decomposition to prevent runaway reaction

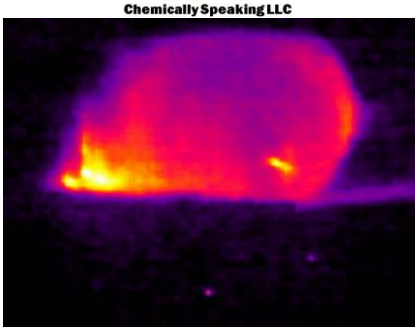


Due to Acetone hazard some companies are using DMF as the solvent

DOT (ICC old) Specification 8 or 8AL cylinders can only contain acetylene. They are welded carbon steel with fusible metal PRDs. MC cylinder has fuse metal in valve or should of the cylinder. Larger cylinders will have a removable PRD threaded onto shoulder of cylinder and in the bottom of the cylinder.

Cylinders larger than MC will also have PRDs threaded on shoulder and bottom. Many have 2 on top and 2 on bottom

Acetylene cylinder hot spot. Decomposition reaction in cylinder which can lead to rupture.



The decomposition reaction of acetylene will form copious amounts of soot which can plug the PRD and then build pressure and rupture. Opening the valve can draw more acetylene into the reaction zone, the soot could plug the valve and pressure will build.

Cooling using a hose stream for 1 hour is the most effective. If a hot spot is no longer found, immersion in a drum of water overnight is a best practice.

Brass valve in Ammonia, blue due to dezincification

A cylinder is never empty, it will contain at least one atmosphere of the gas. Must be purged of contents with inert gas. If no gas comes out. Test valve to prove it is open and not plgged