

Tanks, Tubing, and Fittings

Modern Techniques in Heterogeneous Catalysis Research

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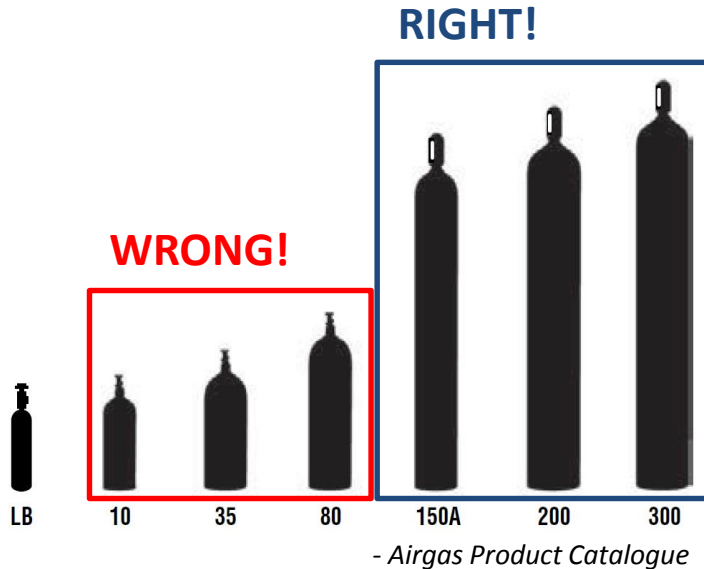
Updated 2-4-16



Tanks

The most dangerous property of tanks is... **HIGH PRESSURE!**

Even air and nitrogen tanks are extremely dangerous!



The “myths” are true... gas tanks have enough force to break through brick walls!
<https://youtu.be/ejEJGNLTo84>

LN2 tank explosions:

Liquid tank explosions can be even more devastating



Figure 1 -Effect of Explosion on Dewar Cylinder Compared to unaffected cylinder



Figure 2 - Hallway Outside Laboratory Showing Explosion Damage



Figure 3 - Inside the Laboratory after Explosion

Tanks

Know your gasses!

1ppm = 0.0001%

Methane (CH₄)

A colorless, odorless, flammable compressed gas.

Product Specifications	Minimum Purity	O ₂	H ₂ O	CO ₂	CO	C ₂ H ₆	Other HC	H ₂	N ₂	C ₃ H ₈	C ₃ H ₆
Research	99.999%	≤ 1	≤ 2	≤ 2	≤ 1	≤ 5	≤ 1	1	≤ 5	≤ 1	≤ 1
Ultra High Purity (UHP)	99.99%	≤ 5	≤ 5			≤ 20	≤ 20		≤ 70		
Chemically Pure (CP)	99.5%	≤ 50	≤ 10			≤ 1000			≤ 4000		

Concentrations given are ppm by volume unless otherwise specified.

Carbon Dioxide (CO₂)

A colorless, odorless, nonflammable liquefied gas or A colorless, odorless, nonflammable cryogenic liquid.

Product Specifications	Minimum Purity	H ₂ O	THC (C ₁ -C ₆)	THC(C ₇ -C ₂₀)	Ar+O ₂ +CO	Ar+O ₂	Halocarbons	N ₂	O ₂
SFE	99.9995%	≤ 1	≤ 0.5	≤ 10 ppb	≤ 1		≤ 1 ppb	≤ 5	
SFC	99.999%	≤ 3	≤ 1		≤ 1		≤ 10 ppb	≤ 5	
Research	99.999%	≤ 3	≤ 1		≤ 1			≤ 5	
Pure Clean	99.995%	≤ 5	≤ 5						
Instrument/Coleman	99.99%	≤ 10	≤ 10					≤ 70	≤ 20
Refrigerant Grade (R744)	99.99%	≤ 10							
Anaerobic	99.9%					≤ 10			
Bone Dry	99.9%	≤ 10							

Concentrations given are ppm by volume unless otherwise specified.

Hydrogen (H₂)

A flammable, colorless, odorless, compressed gas.

Product Specifications	Minimum Purity	O ₂	H ₂ O	THC	Ar	CO	CO ₂	N ₂
Research	99.9999%	≤ 0.5	≤ 0.5	≤ 0.1	≤ 0.5	≤ 0.1	≤ 0.1	≤ 0.5
Ultra Pure Carrier (UPC)	99.9995%	≤ 1	≤ 1	≤ 0.5		* ≤ 1	* ≤ 1	≤ 3
Ultra High Purity (UHP)	99.999%	≤ 1	≤ 2	≤ 0.5		* ≤ 1	* ≤ 1	≤ 5
Zero	99.998%	≤ 5	≤ 3	≤ 0.5				
High Purity / High Pressure	99.995%	≤ 4	≤ 3					
Prepurified	99.99%	≤ 10	≤ 5					

Concentrations given are ppm by volume unless otherwise specified.

* CO + CO₂ ≤ 1 ppm

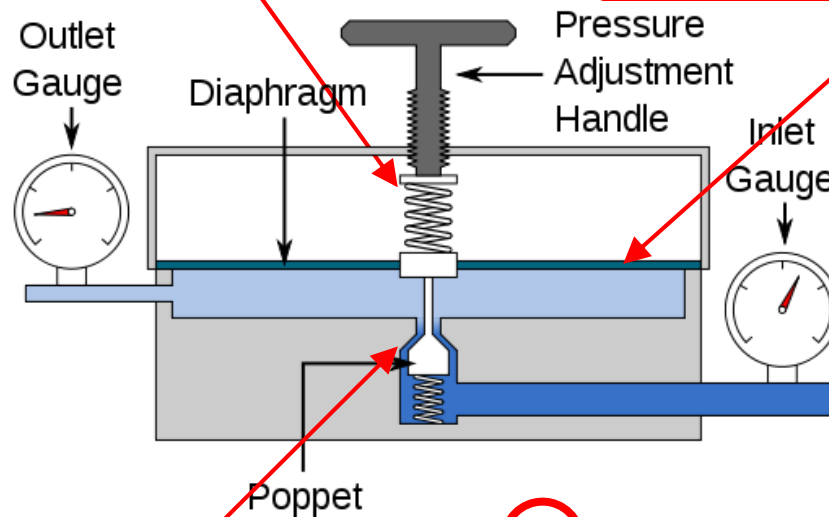
Regulators

1

When you tighten down on the regulator, the tension in the spring increases...

3

...as pressure builds in the low pressure side, the gas applies a force against the diaphragm, which works to close the poppet valve...



2

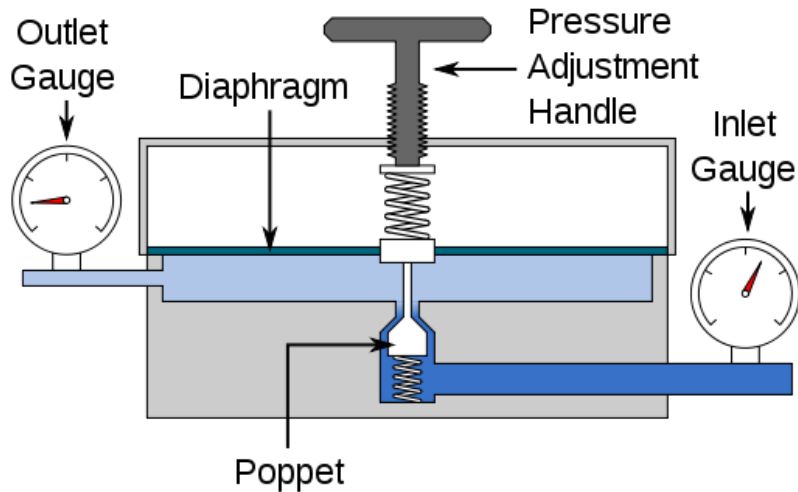
...this opens the poppet valve which allows gas from the high pressure side to enter the low pressure side...

4

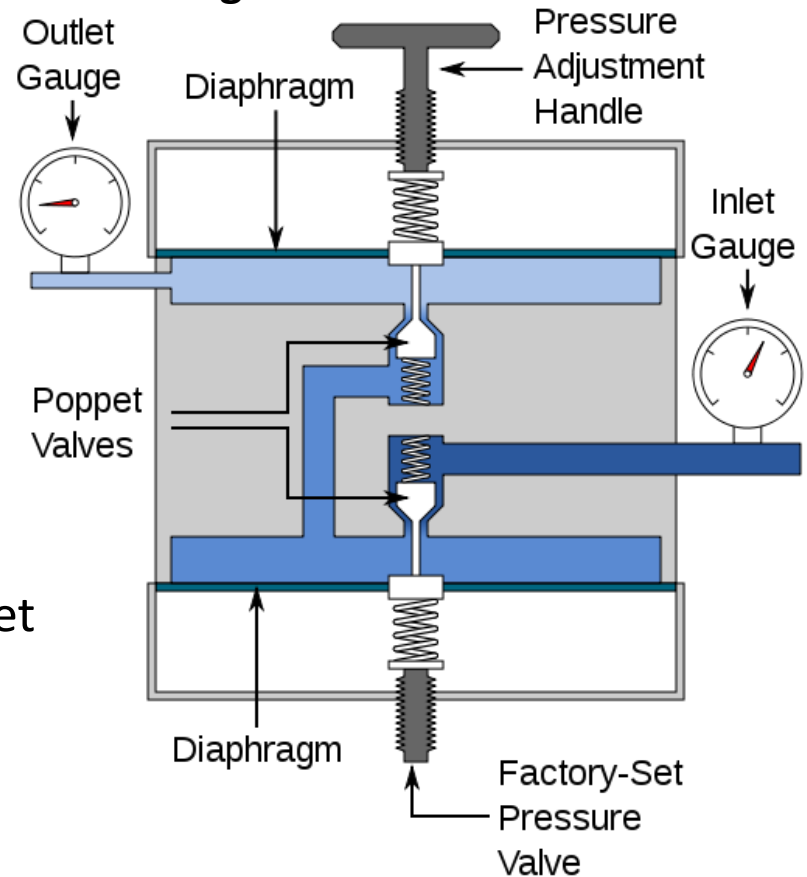
...the forces equilibrate to supply a constant pressure to the outlet

Regulators

Single Stage:



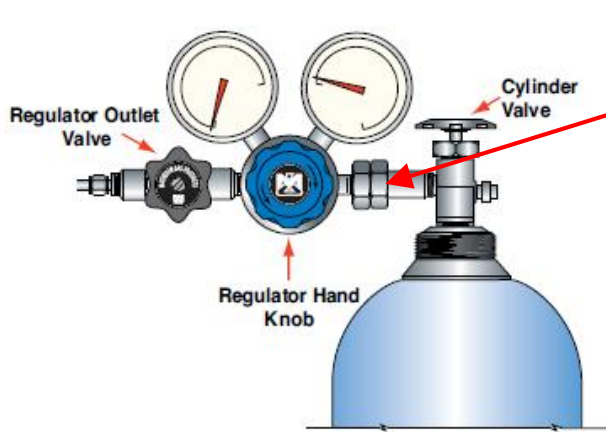
Double Stage:



- Regulators are rated by their inlet and outlet pressures
 - can be determined by looking at the gauges
 - Gauges and fittings should **NEVER** be changed from regulators
- High purity regulators are made from materials which minimize off-gassing

- Double stage regulators provide more stable pressure throughout the life of the tank (i.e. as the tank pressure drops)

Regulators

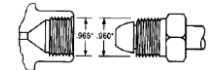


CGA fitting

- Tanks require various CGA fittings to ensure incompatible gases are never mixed
- Common CGA's

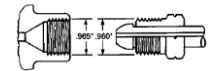
- Inerts – 580

CGA 580
.965"-14 NGO-RH-INT



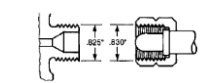
- O₂ (<21%) – 590

CGA 590
.965"-14 NGO-LH-INT



- Flammables – 350

CGA 350
.825"-14 NGO-LH-EXT (ROUND NIPPLE)



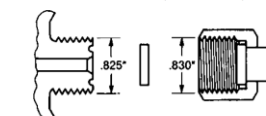
Compressed Gas Association Valve Outlet Listing

Gas	CGA Valve Outlet & Conn. No. CGA/UHP CGA
Acetylene	510
Air, Breathing	346
Air, Industrial	590*
Allene	510**
Ammonia, Anhydrous	705**
Ammonia, Electronic	660/720
Argon	580*/718
Argon-3500 psig	680***
Argon-6000 psig	677
Arsine	350/632
Boron Trichloride	660**/634
Boron Trifluoride	330**/642
1,3-Butadiene	510*
Butane	510*
Butenes	510*
Carbon Dioxide	320*/716
Carbon Monoxide	350*/724
Carbonyl Fluoride	660
Carbonyl Sulfide	330**

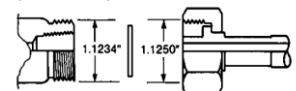
Gas	CGA Valve Outlet & Conn. No. CGA/UHP CGA
Hydrogen	350*/724
Hydrogen-3500 psig	695***
Hydrogen Bromide	330**/634
Hydrogen Chloride	330**/634
Hydrogen Fluoride	660**/638
Hydrogen Iodide	330**
Hydrogen Selenide	350
Hydrogen Sulfide	330**/722
Isobutane	510*
Isobutylene	510*
Krypton	580/718
"Manufactured Gas B"	350
Methane	350*
Methyl Bromide	330
3-Methyl-1-butene	510
Methyl Chloride	660*/510
Methyl Fluoride	350/724
Methyl Mercaptan	330**
Monomethylamine	705**

- Some fittings have a notch in the nut... the notch indicates a reverse thread! (e.g. 350 and 590)
- Some CGA fittings require washers!
 - e.g. 320 (CO₂) and 705 (NH₃)

CGA 320
.825"-14 NGO-RH-EXT (FLAT NIPPLE)



CGA 705
1.125"-14 UNS-2A-RH-EXT (FACE WASHER)



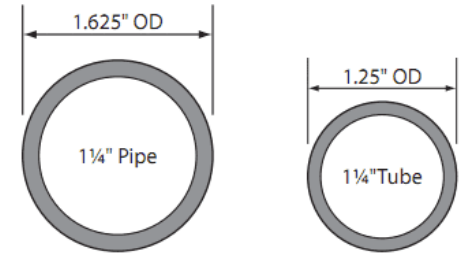
- **NEVER** use Teflon tape on ANY CGA fitting!!!

- Gauges and fittings should **NEVER** be changed from regulators

- Complete listing available in the Matheson Guide to Regulators

Pipe vs. Tube

- The main difference is their characteristic measurement
 - Tubing -> Outer Diameter
 - Pipe -> Nominal Diameter (close to inner diameter)
- Pipe is often threaded, tube is never threaded



- Consider the application when Choosing your tubing:

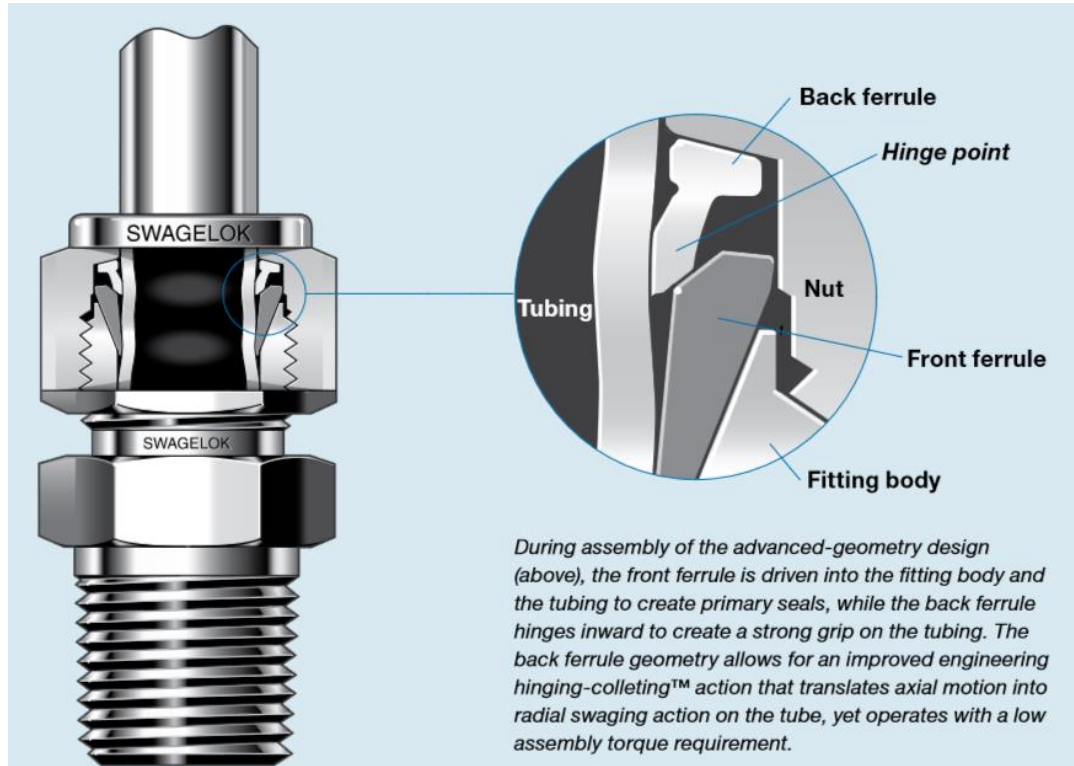
Tubing: 0.25" OD, 0.18" ID

Material	Max P @ 22°C (psig)	Temp range (°C)	Comment
316 Steel	4300	-198 to 815	Requires Bending Tool
Copper	1500	-254 to 93	Bend by hand
Teflon	165	-268 to 260	Flexible

Fittings

Compression

- Swagelok
 - Valco/VICI
 - Lor-lok
-
- Be sure materials are compatible!

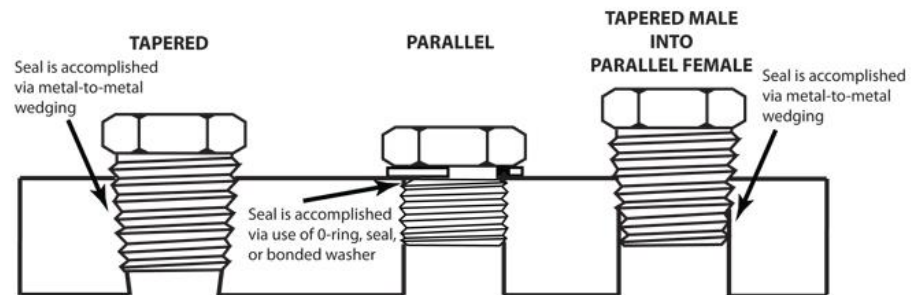


NEVER USE TEFLON TAPE!

- Swagelok Product Catalogue

National Pipe Thread Taper (NPT)

ALWAYS USE TEFLON TAPE!

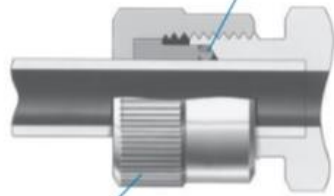


Fittings

Ultra-torr

Seal performance is maintained through repeated disconnects.

O-ring seals to glass, metal, or plastic tubing.



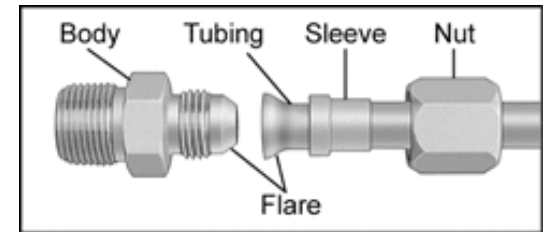
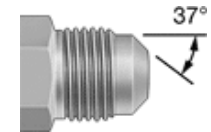
Knurled nut for easy, finger-tight assembly.

- Swagelok Product Catalogue

- My preferred fitting for glass to metal connections
- Be sure O-rings are compatible with process!

Other types of fittings you may encounter...

Flared Fittings



Assorted Flanged Fittings

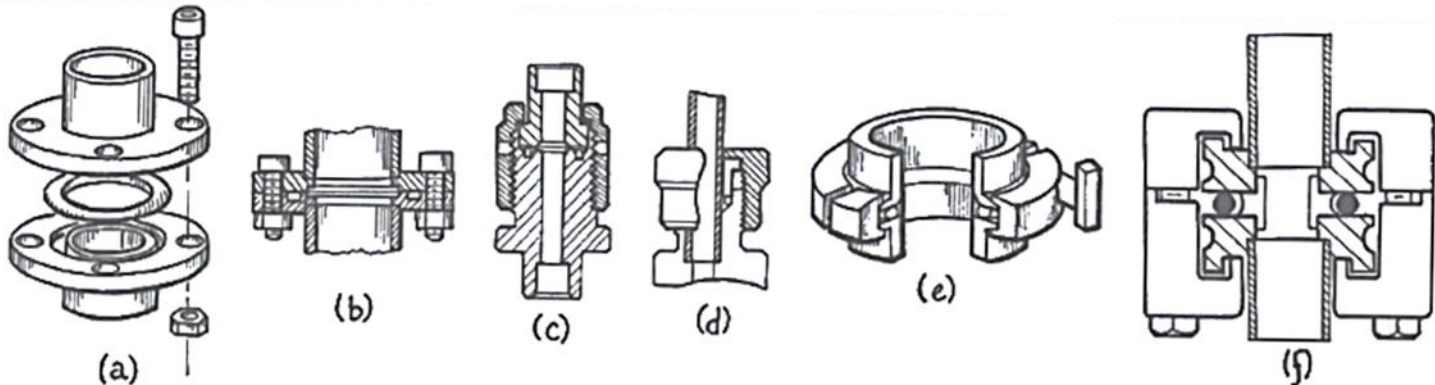


Figure 3.16 O-ring-sealed vacuum connections: (a) an exploded view of an O-ring-sealed flange joint; (b) assembled ASA-style flange joint; (c) O-ring tube coupling (Cajon VCO); (d) a quick connect; (e) QF(or KF) joint; (f) ISO joint with K-style flanges.

- John Moore, Christopher Davis, and Michael Coplan, "Building Scientific Apparatus" Cambridge University Press