# Square One Presents – "The Pipeliner"

One Chemist's Quest for the Holy Grail of Compressed Gas Design Information for High Purity Installations.

Educational Brochure

Architects & Engineers

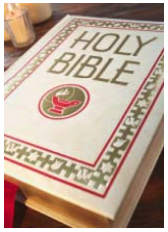
**Design Guidelines for High Purity Gas Delivery Systems**

**The Pipeliner**

SQUARE ONE
GAS & CRYOGENIC EQUIPMENT LLC

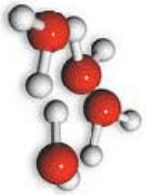
*« It's Always Preferable to Start From Square One! »*

# What is *"The Pipeliner"*?




The "design bible" of high purity compressed gas delivery systems???

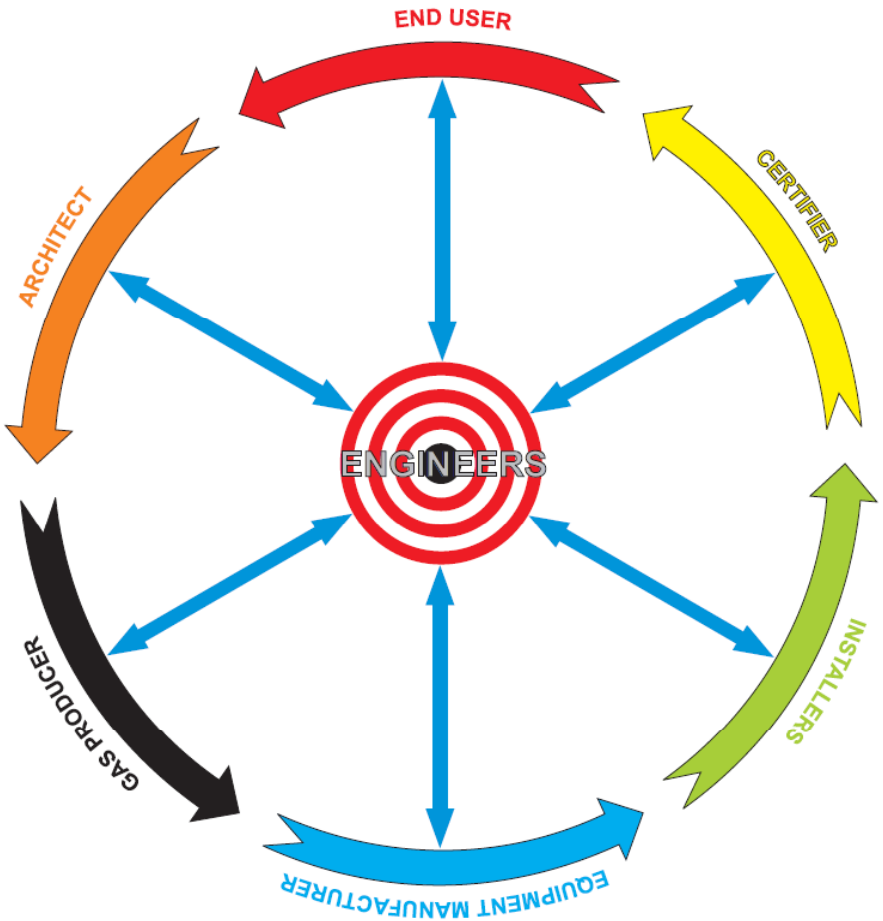

Your personal road map to the successful design and installation of high purity gas delivery systems???



Everything you always wanted to know about compressed gases and equipment, but didn't know who to ask!

Your journey on the quest for the "*Holy Grail*" of compressed gas knowledge has just begun.

# How do we achieve a successful project?




# Keys to Success

- Asking the right questions!

- The goal of the presentation is to teach you how to ask the right questions.

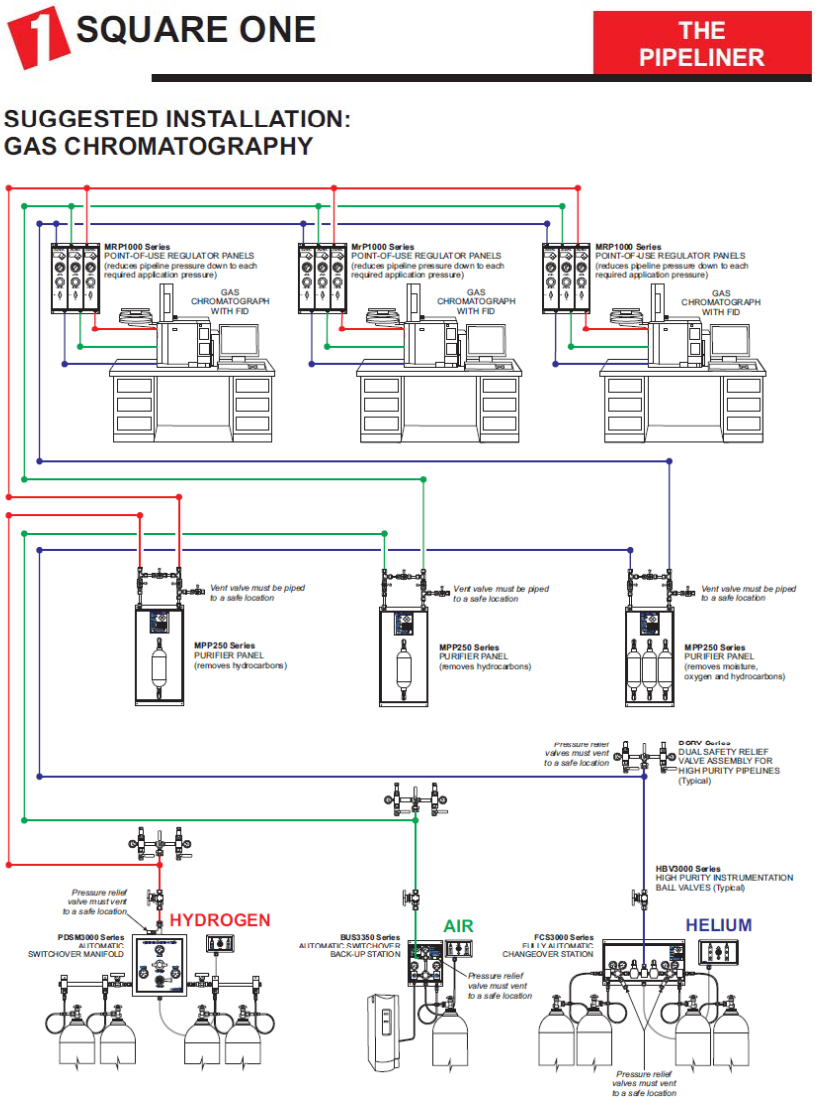
# What are the right questions?

**Let's start with an application –**

**GAS CHROMATOGRAPHY**

## QUESTION #1:

**What is the application?**

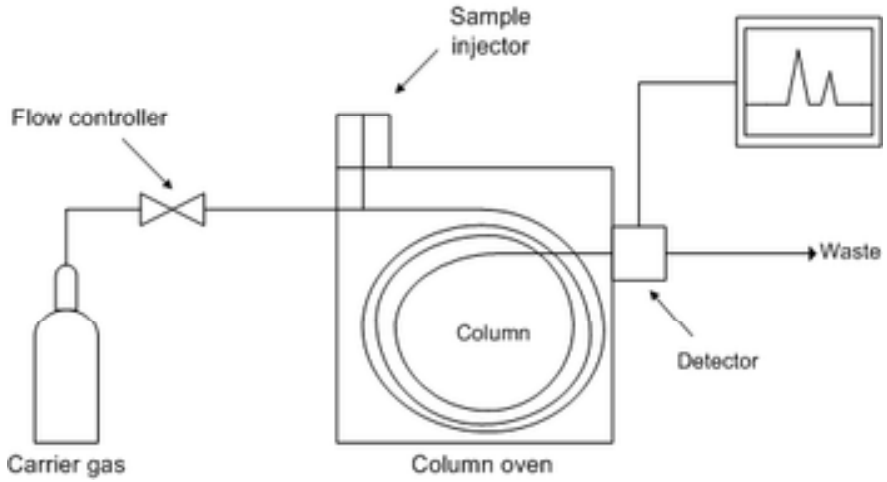



See Pg. 18

# What is a GC and How does it work?

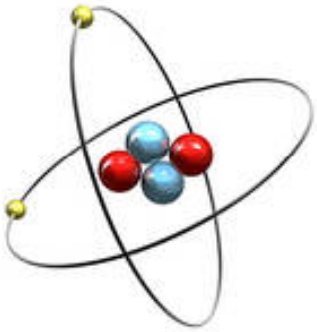
A gas chromatograph is an analytical instrument used to separate and identify individual gases/compounds in a sample.

It generally requires a carrier gas, such as helium or nitrogen and a process gas, such as hydrogen and air.




# What are the right questions?

- **Question #2:**
  - What are the gases required?
  - In our GC Example…
    - Helium = Carrier Gas
    - Hydrogen & Air = Process Gases



- In general, an application may require 3 different "kinds" of gases…
  - Carrier, Process & Purge Gases
  - Can also have calibration gas

# What are the right questions?

- **Question #3.**

What are my materials of construction?

- Gas service/Materials Compatability & Gas purity

**See Pg. 10 & 20**

Can I use brass or stainless steel? (HARD)

What types of soft materials can I use?

**Why can't I use a medical manifold for my specialty gas application???**

# Gas Purity Levels

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## PURITY LEVELS AND CHOICE OF MATERIALS

### GENERAL PURPOSE APPLICATIONS

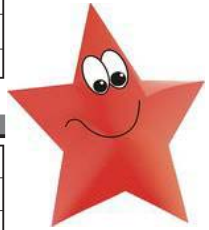
**Level 4**

**(99.99% +)**

Contamination Protection
- This has the least stringent purity requirements

Applications
- Atomic absorption (AA)
- Inductively Coupled Plasma (ICP)
- General Gas Chromatography (GC)

| CHARACTERISTICS | |
|---|---|
| Pipe or Tube | Copper, stainless steel, steel, any soft |
| Joints | Threaded, silver brazed, compression |
| Metals | All metals |
| Soft Materials | All plastics, all polymers |
| Valves | All types of valves |
| Regulators | All types of regulators |
| Hoses | All types of hoses |



### HIGH PURITY APPLICATIONS

**Level 5**

**(99.999% +)**

Contamination Protection
- Requires a higher level of protection against contamination

Applications
- Gas chromatography where capillary columns are used and system integrity is important

| CHARACTERISTICS | |
|---|---|
| Pipe or Tube | Copper, stainless steel (no soft tubing) |
| Joints | Threaded, silver brazed, compression |
| Metals | All (except steel) CFOS |
| Soft Materials | Preference for plastics like Teflon |
| Valves | All types of valves as long as CFOS |
| Regulators | Forged Body w/ SS Diaphragm |
| Hoses | All types of hoses (cleaning is critical) |

CFOS = Cleaned For Oxygen Service

### ULTRA HIGH PURITY APPLICATIONS

**Level 6**

**(99.9999% +)**

Contamination Protection
- This needs the highest level of purity

Applications
- Trace measurement in gas chromatography, ICP-MS

| CHARACTERISTICS | |
|---|---|
| Pipe or Tube | Electropolished SS or copper |
| Joints | Orbitally welded (avoid silver brazing) |
| Metals | First choice: stainless steel |
| Soft Materials | Teflon (minimize quantity of soft mat'l) |
| Valves | Diaphragm (minimize ball valve) |
| Regulators | Barstock Body w/ SS Diaphragm |
| Hoses | Rigid pigtail (SS preferably) |

See Pg. 10 ⟶

# Materials Compatibility Chart

Pay attention to three (3) areas:

1. Metals
2. Plastics
3. Elastomers

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## MATERIAL COMPATIBILITY CHART AND USEFUL GAS PROPERTIES

| Gas | Primary Hazards | | | | | Metals | | | | | Plastics | | | | | Elastomers | | Explosive Limits | | Toxicity Levels | | Physical Properties | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Asphyxiant | Toxic | Flammable | Corrosive | Oxidizer | Aluminum | | | | Steel | | | | | | | Neoprene | LEL (% in Air) | UEL (% in Air) | TLV-TWA (ppm in Air) | TLV-STEL (ppm in Air) | SPECIFIC VOLUME (ft³/lb) | BOILING POINT @ 1 atm (°F) | SPECIFIC GRAVITY (Air = 1) |
| ACETYLENE | X | | X | | | S | | | | | | | | | | | S | 2.5 | 100 | - | - | 14.77 | -119.6 | 0.899 |
| AIR | | | | | X | S | | | | | | | | | | | S | - | - | - | - | 12.55 | -317.8 | 1.000 |
| AMMONIA | | X | X | X | | S | | | | | | | | | | | S | 15.0 | 28.0 | 25 | 35 | 22.49 | -28.3 | 0.588 |
| ARGON | X | | | | | S | | | | | | | | | | | S | - | - | - | - | 9.68 | -302.5 | 1.379 |
| ARSINE | | X | X | | | - | | | | | | | | | | | S | - | - | 0.05 | - | 4.91 | -79.9 | 2.691 |
| BORON TRICHLORIDE | | X | | X | | U | | | | | | | | | | | - | - | - | - | - | 3.10 | 55.1 | 4.045 |
| BORON TRIFLUORIDE | | X | | X | X | - | | | | | | | | | | | - | - | - | 1C | - | 5.68 | -147.5 | 2.341 |
| BROMINE TRIFLUORIDE | | X | | X | | D | | | | | | | | | | | U | - | - | - | - | 415.1 | 258.2 | 4.727 |
| 1,3-BUTADIENE | | X | X | | | S | | | | | | | | | | | S | 2.0 | 12.0 | 2 | - | 6.98 | 23.7 | 1.868 |
| n-BUTANE | X | | X | | | S | | | | | | | | | | | S | 1.8 | 8.4 | 800 | - | 6.45 | 31.0 | 2.007 |
| 1-BUTENE | | | X | | | S | | | | | | | | | | | S | 1.6 | 10.0 | - | - | 6.70 | 21.1 | 1.937 |
| cis-2-BUTENE | | | X | | | S | | | | | | | | | | | S | 1.7 | 9.7 | - | - | 6.61 | 53.1 | 1.937 |
| trans-2-BUTENE | | | X | | | S | | | | | | | | | | | S | 1.7 | 9.7 | - | - | 6.62 | 47.3 | 1.937 |
| CARBON DIOXIDE | X | | | | | S | S | S | S | S | S | S | S | S | S | D | D | - | - | 5000 | 30000 | 8.74 | -126.5 | 1.519 |
| CARBON MONOXIDE | | X | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 12.5 | 74.0 | 25 | - | 13.80 | -312.7 | 0.967 |
| CHLORINE | | X | | X | X | U | U | U | S | S | S | S | S | S | U | U | U | - | - | 0.5 | 1 | 5.39 | -28.8 | 2.448 |
| CHLORINE TRIFLUORIDE | | X | | X | | U | - | - | S | S | D | D | S | U | U | U | U | - | - | - | - | 4.09 | 53.1 | 3.192 |
| DEUTERIUM | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 4.9 | 75.0 | - | - | 96.00 | -417.0 | 0.139 |
| DICHLOROSILANE | | X | X | X | | U | - | - | S | S | S | S | S | S | - | - | - | 4.1 | 98.8 | - | - | 3.72 | 46.7 | 3.487 |
| DI-, MONO-, AND TRIMETHYLAMINES | | X | X | X | | U | U | U | S | S | S | S | S | S | U | U | - | - | - | - | - | - | - | - |
| DISILANE | | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 6.01 | 6.7 | 2.148 |
| ETHANE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 3.0 | 12.4 | - | - | 12.76 | -127.5 | 1.038 |
| ETHYL CHLORIDE | | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 3.8 | 15.4 | 100 | - | 5.82 | 54.0 | 2.227 |
| ETHYLENE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 2.7 | 36.0 | - | - | 13.71 | -154.8 | 0.969 |
| FLUORINE | | X | | X | X | D | D | D | S | S | D | D | D | D | U | U | U | - | - | 1 | 2 | 10.18 | -306.8 | 1.312 |
| HALOCARBON- 14 | | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | - | - | - |
| HALOCARBON- 23 | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 5.48 | -115.9 | 2.917 |
| HALOCARBON-116 | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 2.77 | -108.7 | 4.765 |
| HELIUM | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 96.67 | -452.0 | 0.138 |
| HYDROGEN | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 4.0 | 75.0 | - | - | 191.95 | -423.2 | 0.070 |
| HYDROGEN BROMIDE | | X | | X | | U | U | U | S | S | S | S | S | S | S | U | U | - | - | 3C | - | 4.74 | -88.0 | 2.794 |
| HYDROGEN CHLORIDE | | X | | X | | U | U | U | S | S | S | S | S | S | U | U | U | - | - | 5C | - | 10.55 | -120.8 | 1.259 |
| HYDROGEN FLUORIDE | | X | | X | | U | U | U | S | S | S | S | S | S | U | U | U | - | - | 3C | - | 5.65 | -108.7 | 4.765 |
| HYDROGEN SULFIDE | | X | X | X | | S | S | - | S | S | S | S | S | S | U | S | S | 4.0 | 44.0 | 10 | 15 | 11.26 | -74.9 | 1.176 |
| ISOBUTANE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 1.8 | 8.4 | - | - | - | - | - |
| ISOBUTYLENE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 1.8 | 9.8 | - | - | - | - | - |
| KRYPTON | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 4.61 | -244.1 | 2.893 |
| METHANE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 5.0 | 15.0 | - | - | 24.06 | -258.7 | 0.554 |
| METHYL CHLORIDE | | X | X | | | U | S | S | S | S | S | S | S | S | S | U | U | 7.0 | 17.4 | 50 | 100 | 4.83 | -11.2 | 1.740 |
| METHYL FLUORIDE | | X | X | | | S | S | S | S | S | S | S | S | S | - | - | - | - | - | - | - | 11.23 | -109.0 | 0.170 |
| NEON | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 19.18 | -410.9 | 0.697 |
| NITROGEN | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 13.80 | -320.4 | 0.967 |
| NITROGEN DIOXIDE | | X | | X | X | S | U | U | U | S | S | S | - | - | U | U | U | - | - | 3 | 5 | - | - | - |
| NITROGEN TRIFLUORIDE | | X | | | X | - | S | S | S | S | S | S | S | S | S | - | - | - | - | 10 | - | 5.43 | -200.2 | 2.451 |
| NITROUS OXIDE | | | | | X | S | S | S | S | S | S | S | S | S | S | S | S | - | - | 50 | - | 8.74 | -128.3 | 1.520 |
| OCTAFLUOROCYCLOBUTANE | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 1.87 | 21.2 | 6.906 |
| OCTAFLUOROPROPANE | X | | | | | S | S | S | S | S | S | S | S | S | - | S | S | - | - | - | - | 2.01 | -34.3 | 6.491 |
| OXYGEN | | | | | X | D | S | S | S | D | S | S | S | S | S | D | U | D | - | - | - | 12.08 | -297.4 | 1.105 |
| PHOSPHINE | | X | X | | | S | - | - | S | S | S | S | S | - | - | - | - | - | - | 0.3 | 1 | 11.30 | -126.0 | 1.174 |
| PROPANE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 2.1 | 9.5 | - | - | 8.62 | -43.7 | 1.522 |
| PROPYLENE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | U | 2.4 | 11.0 | - | - | 9.06 | -53.8 | 1.453 |
| SILANE | | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | 5 | - | 11.98 | -170.4 | 1.109 |
| SILICON TETRACHLORIDE | | X | | X | | U | U | U | S | S | S | S | S | S | U | U | U | - | - | - | - | 8.25 | 136.6 | 5.866 |
| SILICON TETRAFLUORIDE | | X | | X | | U | U | U | S | S | S | S | S | S | U | U | U | - | - | - | - | 3.69 | -148.3 | 3.593 |
| SULFUR DIOXIDE | | X | | X | | S | U | S | S | S | S | S | S | S | S | U | U | - | - | 2 | 5 | 5.95 | 13.8 | 2.212 |
| SULFUR HEXAFLUORIDE | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | 1000 | - | 2.62 | -90.8 | 5.042 |
| SULFUR TETRAFLUORIDE | | X | | X | | U | U | U | S | S | S | S | S | S | U | U | U | - | - | - | - | 3.53 | -53.5 | 3.731 |
| TUNGSTEN HEXAFLUORIDE | | X | | X | | U | U | U | S | S | S | S | S | S | U | U | U | - | - | - | - | 1.26 | 63.0 | 10.283 |
| XENON | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 2.93 | -162.6 | 4.533 |

S = Satisfactory
- = Insufficient Data or Not Applicable
U = Unsatisfactory
D = Suitability depends on condition of use
C = Ceiling value
X = Indicates primary hazard

**See Pg. 20** →

# What are the right questions?

- **Question #4:**
  - What are the pressure and flow requirements?
    - A. Inlet pressure
    - B. Delivery Pressure and/or Point-of-Use Pressure –
    - C. Flow, generally expressed in SCFH (standard cubic feet per hour)
    - D. Pipe vs. Tube… Pressure & Flow Calc's

# What are the right questions?

- Question #4A:
  - What is the inlet pressure?

-  **<u>Question #5:</u>**
  - What is the source of supply of the gas/liquid?
  - What is the CGA connection?

# Gas Supply Modes – The answer to Questions 4A. And 5.

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## GAS SUPPLY MODES - CRYOGENIC

### CRYOGENIC PLANTS (AIR SEPARATION)

| CHARACTERISTICS | |
|---|---|
| Manufacturers | Primarily major gas companies |
| Products | Mainly $N_2$, $O_2$, Ar, He, $H_2$, $CO_2$ |
| Capacity | Several tons per day |
| Location | Independent site near major user |
| Pressure | In general below 200 psig |
| Purity | Commercial grade (can be purified) |
| Purpose | Merchant Plant |
| Typ. Industry | All industries |

### CRYOGENIC LIQUID TANKERS

| CHARACTERISTICS | |
|---|---|
| Manufacturers | Original Equipment Manufacturers |
| Products | Mainly $N_2$, $O_2$, Ar, He, $H_2$, $CO_2$ |
| Capacity | Generally around 15,000 gallons |
| Location | Road tankers and ISO Containers |
| Pressure | Cryo: up to 60 psig - $CO_2$ is diff. |
| Purity | Commercial grade (can be purified) |
| Purpose | Hauling product from ASP to tanks |
| Typ. Industry | All industries |

### CRYOGENIC STORAGE VESSELS

| CHARACTERISTICS | |
|---|---|
| Manufacturers | Chart, Taylor Wharton, Tomco |
| Products | Mainly $N_2$, $O_2$, He, Ar, $H_2$, $CO_2$ |
| Capacity | From 525 to 20,000 gallons |
| Location | End user sites |
| Pressure | Cryo: up to 500 psig - $CO_2$ : 350 psig |
| Purity | Commercial grade or better |
| Purpose | Product storage in liquid state |
| Typ. Industry | All industries |

### MICRO-BULKS

| CHARACTERISTICS | |
|---|---|
| Manufacturers | Chart |
| Products | Mainly $N_2$, $O_2$, Ar, $CO_2$ |
| Capacity | Up to 2000 liters (liquid content) |
| Location | End user sites |
| Pressure | Cryo: up to 500 psig - $CO_2$ : 350 psig |
| Purity | Commercial grade or better |
| Purpose | Product storage in liquid state |
| Typ. Industry | Welding, restaurants, laboratories |

### PORTABLE LIQUID CYLINDERS

| CHARACTERISTICS | |
|---|---|
| Manufacturers | Chart, Taylor Wharton |
| Products | Mainly $N_2$, $O_2$, Ar, $CO_2$ |
| Capacity | Up to 230 liters |
| Location | End user sites |
| Pressure | Cryo: up to 500 psig - $CO_2$ : 350 psig |
| Purity | Commercial grade or better |
| Purpose | Product storage in liquid state |
| Typ. Industry | All industries |

**See Pg. 12 & 13**



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## GAS SUPPLY MODES - NON CRYOGENIC - ON-SITE PRODUCTION

### LARGE SIZE ON-SITES : APSA & VPSA

| CHARACTERISTICS | |
|---|---|
| Manufacturers | Primarily major gas companies |
| Products | Mainly $N_2$, $O_2$, $H_2$, $CO_2$, CO |
| Capacity | Several tons per day |
| Location | Mostly at customers' sites |
| Pressure | In general below 200 psig |
| Purity | Commercial grade (can be purified) |
| Purpose | Supply gas for one application |
| Typ. Industry | $O_2$ for pulp & paper, $N_2$ for electronics |

### MEDIUM SIZE ON-SITES : PSA - MEMBRANES

| CHARACTERISTICS | |
|---|---|
| Manufacturers | Majors, AirSep, Dow, Parker |
| Products | Mainly $N_2$, $O_2$, $H_2$, $CO_2$, CO |
| Capacity | Vary greatly (low to mid tons per day) |
| Location | Mostly at customers' sites |
| Pressure | In general below 200 psig |
| Purity | Commercial grade (can be purified) |
| Purpose | Supply gas for one application |
| Typ. Industry | Food packaging, bright annealing |

### SMALL GAS GENERATORS

| CHARACTERISTICS | |
|---|---|
| Manufacturers | Parker, Peak, Domnick Hunter |
| Products | $N_2$, Air, $H_2$ |
| Capacity | Very low (from lpm to 100 scfh) |
| Location | Only customers' sites |
| Pressure | In general below 200 psig |
| Purity | Both laboratory & commercial grade |
| Purpose | GCs MSs, light industrial applications |
| Typ. Industry | Pharmaceutical, tire inflation |

# Gas Supply Modes, cont…

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## GAS SUPPLY MODE - HIGH PRESSURE GAS

### TUBE TRAILERS

| CHARACTERISTICS | |
|---|---|
| Manufacturers | Fiba and a couple of others |
| Products | Mainly Air, He, $N_2$, $O_2$, Ar, $H_2$, $CO_2$ |
| Capacity | Up to 150,000 scfh |
| Location | Hauling products from plants to cust. |
| Pressure | Rarely above 2400 psig |
| Purity | Any purity |
| Purpose | Temporary supply or cascading |
| Typ. Industry | All industries |

### HYDRIL TUBES

| CHARACTERISTICS | |
|---|---|
| Manufacturers | Fiba and a couple of others |
| Products | Mainly Air, He, $N_2$, $O_2$, Ar, $H_2$, $CO_2$ |
| Capacity | Could be limitless |
| Location | Point of use sites |
| Pressure | Rarely above 2400 psig |
| Purity | Any purity |
| Purpose | High pressure gas storage (medium) |
| Typ. Industry | All industries |

### HIGH PRESSURE CYLINDERS

| CHARACTERISTICS | |
|---|---|
| Manufacturers | Norris, Taylor Wharton, Catalina... |
| Products | All |
| Capacity | Vary greatly upon size and gas |
| Location | Point of use sites |
| Pressure | Up to 6000 psig |
| Purity | Any purity |
| Purpose | Individual or small applications |
| Typ. Industry | All industries |

### Specialty Gas Cylinder Size Comparison Chart

| Approximate Dimensions (inches) | Air Products | AGA | Airgas | BOC (Airco) | Alphagaz (Liquid Air) | Praxair | Matheson | MG | Solkatronics | Scott Specialty Gases |
|---|---|---|---|---|---|---|---|---|---|---|
| High Pressure Steel | | | | | | | | | | |
| 24 x 90 | Y | — | — | — | — | T0 | — | — | — | — |
| 9 x 55 | A | 649 | 300 | 300 | 89 | T | 1L | 300 | 89 | K |
| 9 x 51 | B | 644 | 200 | 200 | 44 | K | 1A | 200 | 44 | A |
| 7 x 33 | C | 616 | 80 | 80 | 16 | Q | 2 | 80 | 16 | B |
| 7 x 19 | D-1 | 607 | 35 | 30 | 7 | G | 3 | 35 | 7 | C |
| 4 x 17 | D | 603 | 7 | 12 | 3 | F | 4 | 10 | 3 | D |
| 2 x 12 | L.B. | LBR | L.B. | L.B. | L.B. | L.B. | L.B. | L.B. | — | L.B. |
| 4 x 28 | E | 605 | E | E | MEDE | ANE | 3L | E | — | ER |
| 10 x 51 | BX | 485 | 3HP | 500 | 44H | 6K | 1U | 3HP | — | — |
| 9 x 51 | BY | — | — | — | 44H | 3K | 1H | 2HP | — | — |
| Aluminum | | | | | | | | | | |
| 10 x 52 | A(Al) | — | — | — | AT | — | — | — | — | — |
| 8 x 48 | B(Al) | A31 | 150A | 150A | 36AL | AS | 1R | 150AL | 29A | AL |
| 7 x 33 | C(Al) | A16 | 80A | 80A | 22AL | AQ | 2R | 80AL | — | BL |
| 7 x 16 | D-1(Al) | A07 | 33A | 30A | 7AL | AG | 3R | 33AL | — | CL |
| M size cylinder 7 x 43 inches | | | | | | | | | | |

Source: Air Products & Chemicals Specialty Gas Catalog

See Pg. 14 →

# Common Gases – Reference Info

- Typical “A” size cylinder of Helium, Nitrogen, Argon, Air, Oxygen or Hydrogen
  - 9” x 55”
  - 3,000 psig rated, actual ~ 2,640 psig @ 70$^{o}$F
  - ~250-350 cubic feet
- Typical “A” size cylinder of Nitrous Oxide Gas
  - 9” x 55”
  - 3,000 psig rated, actual ~ 745 psig @ 70$^{o}$F
  - 65 Lbs. or ~ 570 cubic feet

# Common Gases – Reference Info

- Typical “B” size cylinder of Carbon Dioxide Gas
  - 9” x 51”
  - 3,000 psig rated, actual ~ 830 psig @ 70$^{o}$F
  - ~39 Lbs. or ~341 cubic feet
- Typical dewar of **Carbon Dioxide Liquid**
  - Size ~ 20” x ~ 62”
  - 350 psig rated, actual will vary
  - ~375 Lbs. or ~3,200 cubic feet

# Common Gases – Reference Info

**Gases & CGA Connections**

- Air, Compressed/Medical = CGA 346
- Air, Industrial = CGA 590
- Argon = CGA 580
- Carbon Dioxide = CGA 320
- Helium = CGA 580
- Hydrogen = CGA 350
- Nitrogen = CGA 580
- Nitrous Oxide = CGA 326
- Oxygen = CGA 540

- Mixtures **ASK YOUR GAS SUPPLIER!**

# What are the right questions?

- **Question #4:**
  - What are the pressure and flow requirements?
    - A. Inlet pressure – determined by the source of supply. Check with the gas supplier if you are unsure.
    - B. Delivery Pressure and/or Point-of-Use Pressure
    - C. Flow, generally expressed in SCFH (standard cubic feet per hour)

Check with the end user or consult installation and operating manual for given piece of analytical equipment.

# Pipes & Tubes & Calc's – OH MY!!!

## PRESSURE

SQUARE ONE — THE PIPELINER

### PRESSURE RATING CALCULATIONS FOR TUBING AND PIPING

**Formula**

$$tm = \frac{P * Do}{2\,(SE + P*y)} + A$$

Where:

| | | |
|---|---|---|
| tm | = | Minimum Wall Thickness |
| P | = | Design Pressure |
| Do | = | Outlet Diameter of Tube or Pipe |
| SE | = | Allowable Stress |
| y | = | Temperature Coefficient |
| A | = | Threading Allowance |

**Stress Value for Common Tubes & Pipes**

| Material | | SE |
|---|---|---|
| Copper Pipe or Tube | ASTM B280 | 5,000 |
| Copper Pipe or Tube | ASTM B75 | 6,000 |
| Brass | ASTM B16 | 13,000 |
| Aluminum 6061-T6 | ASTM B210 | 14,000 |
| Steel | ASTM A179 | 15,700 |
| Monel Alloy 400 | ASTM B175 | 18,700 |
| Stainless Steel 304/316 | ASTM A269 | 20,000 |

As listed in ASME B31.3

Above are stress values as published in ASME B31.3 for temperature between -20°F to 100°F.

For welded and drawn tubing, a derating factor must be applied for weld integrity:
- for double-welded tubing, multiply pressure rating by 0.85
- for single-welded tubing, multiply pressure rating by 0.80

The SE values must be derated to comply to ASME B31.1. The derating factors are different for each material.

**Example**

A material testing laboratory wants to use an existing pipeline to test concrete compression resistance. You are requested to verify if the existing pipeline is adequate for the application. Hereunder is the data you have been able to collect:

| | | |
|---|---|---|
| **Conduit type:** | Tube | |
| **Material:** | Stainless steel 304 (welded) | |
| **Outside diameter:** | 0.500" | Do = 0.500 |
| **Specification:** | ASTM A269 | SE = 20000 |
| **Operating temperature:** | 70°F | y = 0.4* |
| **Operating pressure:** | 3500 psig | P = 3500 |
| **Type of fittings:** | Compression | A = 0 |
| **Actual wall thickness:** | 0.035" | |

$$tm = \left[\frac{3500 \times 0.500}{2\,(20000 + 3500 \times 0.4)}\right] \times 0.8$$

$$tm = \left[\frac{1750}{42800}\right] \times 0.8$$

$$tm = \left[0.041\right] \times 0.8$$

$$tm = 0.032$$

Existing wall thickness = 0.035"

0.032" < 0.035"

Conclusion, the existing tubing is not adequate for the application.

**See Pg. 22**



## FLOW

SQUARE ONE — THE PIPELINER

### FLOW CALCULATIONS FOR TUBING

**Undersized Lines**
- An undersized line will result in high pressure drops, making it difficult or impossible to consistently supply the required gas pressure to the instrument

**Oversized Lines**
- An oversized line, by contrast, will ensure adequate pressure but will be unnecessarily expensive to install

**Accurate Flow Calculations**
- Accurate flow calculation is an art as it has several parameters to consider:
  a) Mechanical: tees, pipes, elbows
  b) Fluid: Molecular weight, viscosity, compressability
  c) Operating conditions: Temperature, pressure
- Most accurate flow calculations are conveniently made by computers

**Flow Chart**
- The table on the following page provides a good estimate of potential flow through a given tube diameter
- Both inlet pressure and length of the pipeline have an impact on outlet flow of air

**Gas & Temperature Compensation**
- The type of gas molecule could greatly affect the flow: the heavier the molecules are, the slower they move in a pipe
- The temperature also plays an important role in the output flow: the warmer the molecules are the faster they move in a pipe

**Specific Gravity of Common Gases**

| Gas | Specific Gravity |
|---|---|
| Air | 1.00 |
| Argon | 1.38 |
| Carbon Dioxide | 1.52 |
| Carbon Monoxide | 0.97 |
| Helium | 0.14 |
| Hydrogen | 0.07 |
| Nitrogen | 0.97 |
| Oxygen | 1.11 |

**Formula**
**Correction Factor for Gases Other than Air (CFg)**

$$Cg = \left[\sqrt{\frac{1}{g}}\right]$$

**Formula**
**Correction Factor for Temperatures other than 60°F**

$$Ct_F = \frac{[460 + T]}{520}$$

**Formula**
**Correction Factor for Temperatures other than 16°C**

$$Ct_C = \frac{[273.15 + T]}{288.71}$$

**Example**

Calculate distribution line size for carbon dioxide of 2000 SCFH at inlet pressure of 150 psig and a maximum pressure drop of 5 psig per 100 feet at 80°F.

Specific Gravity of Carbon Dioxide:..... 1.52

$$Cg = \left[\sqrt{\frac{1}{g}}\right] = \left[\sqrt{\frac{1}{1.52}}\right] = 0.811$$

$$\frac{2000\ SCFH\ CO_2}{0.811} = 2466\ SCFH\ of\ Air\ at\ 60°F$$

$$Ct_F = \frac{[460 + T]}{520} = \frac{[460 + 80]}{520} = 1.038$$

2466 SCFH of Air at 60°F X 1.038 = 2562 SCFH of Air at 80°F

**See Pg. 26**

# Pipes & Tubes & Calc's – OH MY!!!

## COPPER PIPE & TUBE

SQUARE ONE — THE PIPELINER

PRESSURE RATING OF COPPER PIPES & TUBES

Pipe - Copper - ASTM B280 - Type K

| O.D. | NOMINAL | WALL | I.D. | MAX. PRESSURE (IN PSIG) at 150°F |
|---|---|---|---|---|
| 0.375" (3/8") | 1/4" | 0.035" | 0.305" | 913 |
| 0.500" (1/2") | 3/8" | 0.049" | 0.402" | 960 |
| 0.625" (5/8") | 1/2" | 0.049" | 0.527" | 796 |
| 0.750" (3/4") | 5/8" | 0.049" | 0.652" | 626 |
| 0.875" (7/8") | 3/4" | 0.065" | 0.745" | 724 |
| 1.125" (1-1/8") | 1" | 0.065" | 0.995" | 557 |
| 1.375" (1-3/8") | 1-1/4" | 0.065" | 1.245" | 452 |
| 1.625" (1-5/8") | 1-1/2" | 0.072" | 1.481" | 420 |
| 2.125" (2-1/8") | 2" | 0.083" | 1.959" | 370 |
| 2.625" (2-5/8") | 2-1/2" | 0.095" | 2.435" | 338 |
| 3.125" (3-1/8") | 3" | 0.109" | 2.907" | 328 |
| 3.625" (3-5/8") | 3-1/2" | 0.120" | 3.385" | 311 |
| 4.125" (4-1/8") | 4" | 0.134" | 3.857" | 306 |

Pipe - Copper - ASTM B280 - Type L & ACR

| O.D. | NOMINAL | WALL | I.D. | MAX. PRESSURE (IN PSIG) at 150°F |
|---|---|---|---|---|
| 0.375" (3/8") | 1/4" | 0.030" | 0.315" | 775 |
| 0.500" (1/2") | 3/8" | 0.035" | 0.430" | 662 |
| 0.625" (5/8") | 1/2" | 0.040" | 0.545" | 613 |
| 0.750" (3/4") | 5/8" | 0.042" | 0.666" | 537 |
| 0.875" (7/8") | 3/4" | 0.045" | 0.785" | 495 |
| 1.125" (1-1/8") | 1" | 0.050" | 1.025" | 420 |
| 1.375" (1-3/8") | 1-1/4" | 0.055" | 1.265" | 373 |
| 1.625" (1-5/8") | 1-1/2" | 0.060" | 1.505" | 347 |
| 2.125" (2-1/8") | 2" | 0.070" | 1.985" | 309 |
| 2.625" (2-5/8") | 2-1/2" | 0.080" | 2.465" | 285 |
| 3.125" (3-1/8") | 3" | 0.090" | 2.945" | 270 |
| 3.625" (3-5/8") | 3-1/2" | 0.100" | 3.425" | 258 |
| 4.125" (4-1/8") | 4" | 0.110" | 3.905" | 249 |

Tube - Copper - ASTM 280 - Refrigeration Type

| O.D. | NOMINAL | WALL | I.D. | MAX. PRESSURE (IN PSIG) at 150°F |
|---|---|---|---|---|
| 0.125" (1/8") | 1/8" | 0.030" | 0.065" | 2613 |
| 0.250" (1/4") | 1/4" | 0.030" | 0.190" | 1195 |
| 0.375" (3/8") | 3/8" | 0.032" | 0.311" | 836 |
| 0.500" (1/2") | 1/2" | 0.032" | 0.436" | 618 |
| 0.625" (5/8") | 5/8" | 0.035" | 0.555" | 525 |
| 0.750" (3/4") | 3/4" | 0.035" | 0.680" | 435 |
| 0.875" (7/8") | 7/8" | 0.045" | 0.785" | 495 |
| 1.125" (1-1/8") | 1-1/8" | 0.050" | 1.025" | 420 |
| 1.375" (1-3/8") | 1-3/8" | 0.050" | 1.275" | 373 |
| 1.625" (1-5/8") | 1-5/8" | 0.060" | 1.505" | 347 |

Technical Data

Values of allowable internal working pressure for copper tube in service are based on the formula from ANSI B31, Standard Code for Pressure Piping:

$P = \frac{2 S t_m}{D - 0.8 t_m}$

P = Allowable pressure
S = Allowable stress
$t_m$ = Wall thickness
Od = Outside diameter

@ 150°F S = 5100 PSIG annealed
@ 200°F S = 4800 PSIG annealed
@ 300°F S = 4700 PSIG annealed
@ 400°F S = 3000 PSIG annealed

All ratings listed for types K, L, M, DWV and refrigeration service tube in the preceding charts are calculated for tube in the annealed condition. These values should be used when soldering, brazing or welding is employed for joining components in a system. While the ratings for hard drawn tube are substantially higher, they should only be used for systems using properly designed flare or compression mechanical joints, since joining by any heating process might anneal (soften) the tube. In designing a system, careful consideration should also be given to joint ratings as well as those of the components.

See Pg. 23

## STAINLESS STEEL TUBE

SQUARE ONE — THE PIPELINER

PRESSURE RATING OF STAINLESS STEEL TUBES

UPPER VALUES : BURST PRESSURE (PSIG) — LOWER VALUES : WEIGHT PER FOOT (in Lbs.)

WALL THICKNESS

| O.D. IN INCH | .020" | .025" | .028" | .035" | .049" | .065" | .083" | .095" | .109" | .120" | .156" | .188" | .250" | .313" | .375" | .500" | .625" | .750" |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/8 | 24,000 .022 | 30,000 .026 | 39,000 .029 | 42,000 .033 | 58,000 .040 | | | | | | | | | | | | | |
| 3/16 | 15,998 .035 | 19,950 .043 | 22,463 .047 | 22,463 .057 | 39,203 .075 | 58,800 .040 | | | | | | | | | | | | |
| 1/4 | 12,000 .049 | 15,000 .063 | 16,800 .069 | 21,000 .080 | 29,400 .105 | 39,000 .128 | 49,800 .148 | 57,000 .157 | | | | | | | | | | |
| 5/16 | 9,600 .062 | 12,000 .078 | 13,440 .086 | 16,800 .103 | 23,520 .136 | 31,200 .172 | 39,780 .203 | 45,750 .221 | | | | | | | | | | |
| 3/8 | 8,003 .075 | 9,998 .093 | 11,998 .103 | 14,003 .127 | 19,598 .170 | 26,003 .215 | 33,203 .258 | 38,003 .284 | 43,596 .309 | 48,000 .326 | | | | | | | | |
| 1/2 | 6,000 .102 | 7,500 .129 | 8,400 .141 | 10,500 .173 | 14,700 .236 | 19,500 .302 | 24,900 .369 | 28,500 .418 | 32,700 .455 | 36,000 .487 | | | | | | | | |
| 5/8 | 4,800 .129 | 6,000 .160 | 6,720 .178 | 8,400 .221 | 11,760 .301 | 15,600 .388 | 19,920 .480 | 22,888 .537 | 26,160 .600 | 28,800 .647 | 37,440 .781 | 44,880 .877 | | | | | | |
| 3/4 | 3,998 .155 | 5,003 .193 | 5,603 .215 | 6,998 .267 | 9,803 .366 | 12,997 .475 | 16,598 .591 | 18,998 .654 | 21,803 .746 | 24,000 .807 | 31,200 .990 | 37,403 1.128 | | | | | | |
| 7/8 | 3,428 .183 | 4,283 .227 | 4,800 .253 | 6,000 .314 | 8,400 .432 | 11,145 .562 | 14,228 .702 | 16,283 .791 | 18,683 .891 | 20,573 .968 | 26,745 1.166 | 32,055 1.379 | | | | | | |
| 1 | 3,000 .209 | 3,750 .260 | 4,200 .290 | 5,250 .360 | 7,350 .497 | 9,750 .649 | 12,450 .812 | 14,250 .918 | 16,350 1.037 | 18,000 1.126 | 23,400 1.406 | 28,050 1.630 | 37,500 2.003 | | | | | |
| 1 1/8 | 2,663 .236 | 3,330 .294 | 3,735 .328 | 4,665 .407 | 6,533 .563 | 8,670 .736 | 11,070 .923 | 12,668 1.045 | 14,535 1.183 | 15,998 1.286 | 20,798 1.614 | 24,930 1.881 | 33,330 2.336 | | | | | |
| 1 1/4 | 2,400 .262 | 3,000 .324 | 3,360 .346 | 4,200 .454 | 5,880 .628 | 7,800 .822 | 9,960 1.034 | 11,400 1.172 | 13,080 1.328 | 14,400 1.502 | 18,720 1.832 | 22,440 2.132 | 30,000 2.670 | | | | | |
| 1 3/8 | | | 3,053 .402 | 3,818 .501 | 5,438 .694 | 7,087 .909 | 9,053 1.145 | 10,365 1.309 | 11,888 1.473 | 13,088 1.608 | 17,018 2.031 | 20,400 2.383 | 27,270 3.004 | | | | | |
| 1 1/2 | | | 2,948 .440 | 3,903 .547 | 4,898 .739 | 6,503 .996 | 8,303 1.256 | 9,503 1.433 | 10,899 1.619 | 12,000 1.769 | 15,600 2.239 | 18,698 2.634 | 24,998 3.338 | | | | | |
| 1 3/4 | | | | 3,000 .641 | 4,200 .890 | 5,573 1.170 | 7,118 1.478 | 8,145 1.679 | 9,345 1.910 | 10,283 2.160 | 13,373 2.856 | 16,028 3.136 | 21,428 4.005 | | | | | |
| 2 | | | | 2,625 .734 | 3,675 1.021 | 4,875 1.343 | 6,225 1.699 | 7,125 1.933 | 8,175 2.201 | 9,000 2.409 | 11,700 3.072 | 14,025 3.638 | 18,750 4.673 | 23,475 5.639 | 28,125 6.508 | 37,500 8.010 | | |
| 2 1/4 | | | | 2,333 .828 | 3,270 1.152 | 4,335 1.517 | 5,535 1.921 | 6,333 2.250 | 7,268 2.556 | 8,003 2.730 | 10,403 3.489 | 12,465 4.140 | 16,665 5.340 | 20,865 6.475 | 24,998 7.509 | 33,330 9.345 | | |
| 2 1/2 | | | | 2,100 .921 | 2,940 1.283 | 3,900 1.690 | 4,980 2.143 | 5,700 2.440 | 6,540 2.783 | 7,200 3.050 | 9,360 3.905 | 11,220 4.642 | 15,000 6.008 | 18,780 7.311 | 22,500 8.511 | 30,000 10.680 | 37,500 12.515 | |
| 2 3/4 | | | | 1,913 1.015 | 2,679 1.413 | 3,548 1.864 | 4,530 2.364 | 5,183 2.699 | 5,948 3.177 | 6,548 3.496 | 8,513 4.322 | 10,200 5.144 | 13,636 6.675 | 17,070 8.147 | 20,453 9.512 | 27,270 12.015 | 34,088 14.180 | 40,913 16.020 |
| 3 | | | | 1,748 1.108 | 2,453 1.544 | 3,248 2.037 | 4,148 2.586 | 4,748 2.947 | 5,453 3.393 | 6,000 3.691 | 7,800 4.739 | 9,383 5.646 | 12,503 7.343 | 15,653 8.982 | 18,759 10.513 | 24,998 13.390 | 31,253 15.853 | 37,500 18.020 |
| 3 1/4 | | | | | | 3,000 2.211 | 3,833 2.805 | 4,388 3.201 | 5,033 3.634 | 5,538 3.975 | 7,208 5.155 | 8,633 6.148 | 11,535 8.010 | 14,445 9.818 | 17,318 11.514 | 23,078 14.685 | 28,845 17.520 | 34,613 20.146 |
| 3 1/2 | | | | | | 2,783 2.385 | 3,560 3.029 | 4,073 3.455 | 4,673 3.976 | 5,145 4.385 | 6,693 5.571 | 8,018 6.650 | 10,718 8.678 | 13,418 10.650 | 16,073 12.515 | 21,428 16.020 | 26,783 19.191 | 32,827 22.007 |
| 3 3/4 | | | | | | 2,603 2.556 | 3,323 3.248 | 3,803 3.708 | 4,358 4.235 | 4,800 4.650 | 6,240 5.968 | 7,478 7.152 | 9,998 9.345 | 12,518 11.490 | 15,000 13.520 | 20,003 17.355 | 24,998 20.860 | 30,000 24.030 |
| 4 | | | | | | 2,438 2.715 | 3,112 3.473 | 3,563 3.962 | 4,088 4.530 | 4,500 4.975 | 5,850 6.464 | 7,013 7.654 | 9,375 10.045 | 11,738 12.330 | 14,063 14.530 | 18,750 19.490 | 23,438 23.530 | 28,125 26.700 |

Figures and tables are for reference only. No implication is made that these values can be used for design work. Applicable codes and practices in industry should be considered.

See Pg. 24

## STAINLESS STEEL PIPE

SQUARE ONE — THE PIPELINER

PRESSURE RATING OF STAINLESS STEEL PIPES

UPPER VALUE: BURST PRESSURE (in PSIG) — LOWER VALUES : WALL THICKNESS ( in Inches) AND WEIGHT PER FOOT (in Lbs.)

SCHEDULE

| NOMINAL PIPE SIZE | O.D. IN INCH | 5's | 10's | 10 | 20 | 40 | STD. 40's | 80's | E.H. 80's | 160 | DBLE. E.H. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1/8 | .405 | | 18148 .049/.1863 | 18148 .049/.1863 | | 25185 .068/.2447 | 25185 .068/.2447 | 35185 .095/.3145 | 35185 .095/.3145 | | |
| 1/4 | .540 | | 18058 .065/.3297 | 18058 .065/.3297 | | 24444 .088/.4248 | 24444 .088/.4248 | 33056 .119/.5351 | 33056 .119/.5351 | | |
| 3/8 | .675 | | 14444 .065/.4235 | 14444 .065/.4235 | | 20222 .091/.5676 | 20222 .091/.5676 | 28000 .126/.7388 | 28000 .126/.7388 | | |
| 1/2 | .840 | 11607 .065/.5380 | 14821 .083/.6710 | 14821 .083/.6710 | | 19464 .109/.8510 | 19464 .109/.8510 | 26250 .147/1.088 | 26250 .147/1.088 | 33393 .187/1.304 | 52500 .294/1.714 |
| 3/4 | 1.050 | 9286 .065/.6838 | 11857 .083/.8572 | 11857 .083/.8572 | | 16143 .113/1.131 | 16143 .113/1.131 | 22000 .154/1.474 | 22000 .154/1.474 | 31143 .218/1.937 | 44000 .308/2.441 |
| 1 | 1.315 | 7417 .065/.8678 | 12433 .109/1.404 | 12433 .109/1.404 | | 15171 .133/1.679 | 15171 .133/1.679 | 20418 .179/2.172 | 20418 .179/2.172 | 28517 .250/2.844 | 40837 .358/3.659 |
| 1 1/4 | 1.660 | 5873 .065/1.107 | 9849 .109/1.806 | 9849 .109/1.806 | | 12651 .140/2.273 | 12651 .140/2.273 | 17259 .191/2.997 | 17259 .191/2.997 | 22590 .250/3.765 | 34518 .382/5.214 |
| 1 1/2 | 1.900 | 5132 .065/1.27 | 8605 .109/2.085 | 8605 .109/2.085 | | 11447 .145/2.718 | 11447 .145/2.718 | 15789 .200/3.631 | 15789 .200/3.631 | 22184 .281/4.859 | 31579 .400/6.408 |
| 2 | 2.375 | 4 .065/1.604 | 6884 .109/2.638 | 6884 .109/2.638 | | 9726 .154/3.653 | 9726 .154/3.653 | 13768 .218/5.022 | 13768 .218/5.022 | 21663 .343/7.444 | 27537 .436/9.029 |
| 2 1/2 | 2.875 | 4105 .065/1.604 | 6261 .120/3.531 | 6261 .120/3.531 | | 10591 .203/5.793 | 10591 .203/5.793 | 14400 .276/7.661 | 14400 .276/7.661 | 19365 .375/10.01 | 28800 .522/13.69 |
| 3 | 3.5 | 3557 .083/3.029 | 5143 .120/4.332 | 5143 .120/4.332 | | 9257 .216/7.576 | 9257 .216/7.576 | 12857 .300/10.25 | 12857 .300/10.25 | 18771 .438/14.32 | 25714 .600/18.58 |
| 3 1/2 | 4.0 | 3112 .083/3.472 | 4500 .120/4.973 | 4500 .120/4.973 | | 8475 .226/9.109 | 8475 .226/9.109 | 11925 .318/12.50 | 11925 .318/12.50 | | 23850 .636/22.85 |
| 4 | 4.5 | 2767 .083/3.915 | 4000 .120/5.613 | 4000 .120/5.613 | | 7900 .237/10.79 | 7900 .237/10.79 | 11233 .337/14.98 | 11233 .337/14.98 | 17790 .531/22.51 | 22467 .674/27.54 |
| 5 | 5.563 | 2218 .109/3.349 | 3613 .134/5.775 | 3613 .134/5.775 | | 6957 .258/14.62 | 6957 .258/14.62 | 10111 .375/20.78 | 10111 .375/20.78 | 16852 .625/32.95 | 20223 .750/38.55 |
| 6 | 6.625 | 2468 .109/4.289 | 3034 .134/6.389 | 3034 .134/6.389 | | 6340 .280/18.79 | 6340 .280/18.79 | 9781 .432/28.57 | 9781 .432/28.57 | 16257 .715/45.30 | 19562 .864/53.16 |
| 8 | 8.625 | 1896 .109/5.914 | 2574 .148/13.40 | 2574 .148/13.40 | 2500/22.36 | 5600 .322/28.55 | 5600 .322/28.55 | 8696 .500/43.39 | 8696 .500/43.39 | 15756 .906/74.69 | 15217 .875/72.42 |
| 10 | 10.75 | 1870 .134/15.19 | 2118 .180/24.16 | 2302 .165/18.70 | 3750 .250/28.04 | 5093 .365/40.48 | 5093 .365/40.48 | 8274 .593/64.33 | 8274 .593/64.33 | 6977 .500/54.74 | |
| 12 | 12.75 | 1835 .156/20.98 | 1763 .180/24.16 | 2118 .180/24.16 | 3125 .250/33.38 | 4776 .406/53.52 | 4412 .375/49.56 | 8082 .687/88.51 | 5882 .500/65.42 | | |
| 14 | 14.0 | 1671 .156/23.98 | 1762 .189/31.75 | 2679 .250/36.71 | 3342 .312/45.61 | 4693 .438/63.37 | 4018 .375/54.57 | 8036 .750/106.1 | 5357 .500/72.09 | | |
| 16 | 16.0 | 1546 | | 2344 .250/42.05 | 2925 .312/52.27 | 4688 .500/82.77 | 3516 .375/62.58 | 7903 .843/136.5 | 4688 .500/82.77 | | |
| 18 | 18.0 | 1375 .165/31.43 | 1566 .189/35.76 | 2083 .250/47.39 | 2600 .312/58.94 | 4683 .562/104.8 | 3125 .375/70.58 | 7808 .937/170.8 | 4167 .500/93.48 | | |
| 20 | 20.0 | 1410 .188/39.78 | 1635 .218/46.05 | 1875 .250/52.73 | 2812 .375/78.60 | 4448 .593/122.9 | 2812 .375/78.60 | 7733 1.031/208.9 | 3750 .500/104.1 | | |
| 24 | 24.0 | 1362 .218/53.32 | | 1563 .250/63.41 | 2343 .375/94.62 | 4234 .687/171.2 | 2344 .375/94.62 | 7813 1.218/296.4 | 3125 .500/125.5 | | |

Figures and tables are for reference only. No implication is made that these values can be used for design work. Applicable codes and practices in industry should be considered.

See Pg. 25

# Pipes & Tubes & Calc's – OH MY!!!

FLOW

SQUARE ONE

THE PIPELINER

## FLOW CAPACITY OF DISTRIBUTION PIPELINES

| INLET PRESSURE (psig) | PRESSURE DROP PER 100 FT OF TUBE (psig) | Flow of Air at 60°F in SCFH — TUBE SIZE 1/8" | 1/4" | 3/8" | 1/2" | 3/4" | 1" |
|---|---|---|---|---|---|---|---|
| 50 | 1 | 20 | 180 | 405 | 760 | 1,610 | 3,040 |
| | 5 | 49 | 400 | 910 | 1,700 | 3,600 | 6,800 |
| | 10 | 70 | 580 | 1,300 | 2,410 | 5,100 | 9,720 |
| 100 | 1 | 28 | 245 | 550 | 1,020 | 2,160 | 4,070 |
| | 5 | 65 | 545 | 1,230 | 2,280 | 4,820 | 9,100 |
| | 10 | 90 | 775 | 1,750 | 3,240 | 6,820 | 12,970 |
| 150 | 1 | 32 | 290 | 660 | 1,220 | 2,580 | 4,870 |
| | 5 | 75 | 650 | 1,470 | 2,730 | 5,775 | 10,900 |
| | 10 | 110 | 930 | 2,100 | 3,880 | 8,170 | 15,540 |
| 200 | 5 | 85 | 745 | 1,680 | 3,120 | 6,590 | 12,450 |
| | 10 | 125 | 1,060 | 2,390 | 4,430 | 9,330 | 17,750 |
| 300 | 5 | 105 | 900 | 2,040 | 3,780 | 7,980 | 15,070 |
| | 10 | 150 | 1,280 | 2,900 | 5,370 | 11,300 | 21,480 |
| 400 | 5 | 125 | 1,040 | 2,340 | 4,340 | 9,160 | 17,300 |
| | 10 | 175 | 1,470 | 3,330 | 6,160 | 12,970 | 24,660 |
| 500 | 5 | 130 | 1,180 | 2,660 | 4,940 | 10,440 | 19,700 |
| | 10 | 190 | 1,680 | 3,790 | 7,020 | 14,770 | 28,100 |
| 1,000 | 5 | 190 | 2,030 | 3,920 | 7,270 | 15,360 | 29,000 |
| | 10 | 270 | 2,470 | 5,580 | 10,330 | 21,740 | 41,300 |
| 1,500 | 5 | 230 | 2,030 | 4,570 | 8,470 | 17,900 | 33,800 |
| | 10 | 330 | 2,880 | 6,500 | 12,040 | 25,350 | 48,200 |
| 2,000 | 5 | 265 | 2,340 | 5,270 | 9,770 | 20,650 | 39,000 |
| | 10 | 380 | 3,320 | 7,500 | 13,890 | 29,200 | 55,600 |
| 2,500 | 5 | 300 | 2,610 (1,230) | 5,890 | 10,920 | 23,100 (10,890) | 43,550 (20,531) |
| | 10 | 427 | 3,710 (1,749) | 8,380 | 15,510 | 32,850 (15,382) | 62,100 (29,276) |

**See Pg. 27**

# Question Review

- Question #1:  What is the application?
- Question #2:  What are the gases required?
- Question #3:  What are my materials of construction?
- Question #4:  What are the pressure and flow requirements ?
- Question #5:  What is the source of supply?

# How do we control the system?

- **Question #6**: What type of manifold do I need?
  - How critical is the supply of gas to the application?
    - Not critical, low demand… → Protocol Station
    - Not critical, higher demand… → Simplex, Manual Changeover
    - Critical… → Automatic Changeover
    - Super-Critical… → Fully Automatic Switchover

# Manifold Selection Chart

SQUARE ONE

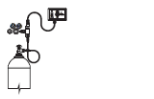
THE PIPELINER

## MANIFOLD SELECTION CHART

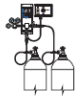
**SINGLE REGULATOR**
Single regulator equipment is used when interruption of gas supply is not a critical issue

**MANUAL SWITCHOVER**
The switchover process is done by opening/closing/ turning valves manually (gas flow interruption may occur)

### STATIONS
Stations are used in low flow applications. They are smaller than Cabinet-Style or Open-Style manifolds and less complex to make as they require only small parts. In general, Stations are the most economical manifold option available.



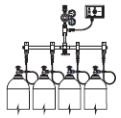
PSB3000 Series
Protocol Stations



MCS3000 Series
Manual Changeover Stations

### OPEN-STYLE MANIFOLDS
Open-Style manifolds allow the operator to freely adjust the pressure settings and to perform the proper sequence of valve closing and opening. This requires the operator to be available and knowledgeable enough to work with such equipment.

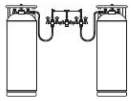
SIM3000
Simplex Manifolds



SCM3000 Series
Simplex Center, Manually Operated, Switchover Manifolds

### CABINET-STYLE MANIFOLDS
The cabinet greatly restricts the access to preset regulators and electronic/electric devices. But, the switchover process is controlled automatically, hence making the manifold easier to operate. Their level of complexity and the quantity of parts required to fabricate them, make the Cabinet-Style manifold the most expensive option among other comparably functioning Open-Style manifolds.

### CRYOGENIC MANIFOLDS
Cryogenic manifolds withdraw cryogenic fluid and deliver cryogenic fluid. Open-Style manifolds, Cabinet-Style manifolds and Stations are all withdrawing gas and delivering gas. With a properly sized vaporizer and regulator installed downstream of a cryogenic manifold, you can achieve flows (in gaseous state) that other types of manifolds cannot achieve. Also, liquid cylinders contain significantly more molecules than high pressure gas cylinders, thus requiring less floor space.



OLM500 Series
Open-Style, Manually Operated, Liquid Withdraw/Dispense Manifolds

See Pg. 16 & 17



SQUARE ONE

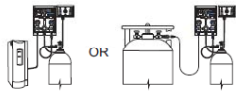
THE PIPELINER

**AUTOMATIC SWITCHOVER**
Switches over from an "In Use" side to the "Stand-By" side by regulator pressure differential

**BACK-UP SWITCHOVER**
Gas will always flow from the low pressure side as long as its pressure is higher than the "Back-Up" regulator set point

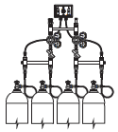
**FULLY AUTOMATIC SWITCHOVER**
The switchover process is controlled electronically. LEDs are indicating the status of the system in real time

PDC3000 Series & PDC350 Series
Pressure Differential Changeover Stations

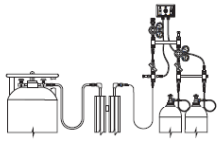



BUS3500 Series
Automatic Changeover Back-Up Stations

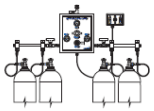
FCS3000 Series
Fully Automatic Changeover Stations



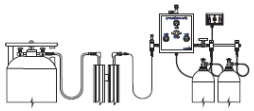
OSA3000 Series
Open-Style, Operator-Adjusted, Switchover Manifolds



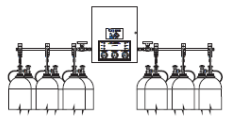
OBM3500 Series
Open-Style, Operator-Adjusted, Back-Up Manifolds



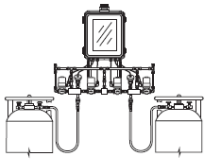
PDSM3000 & PDSM500 Series
Cabinet-Style, Pressure Differential Switchover Manifolds



PDSM3500 Series
Cabinet-Style, Automatic Switchover Back-Up Manifolds

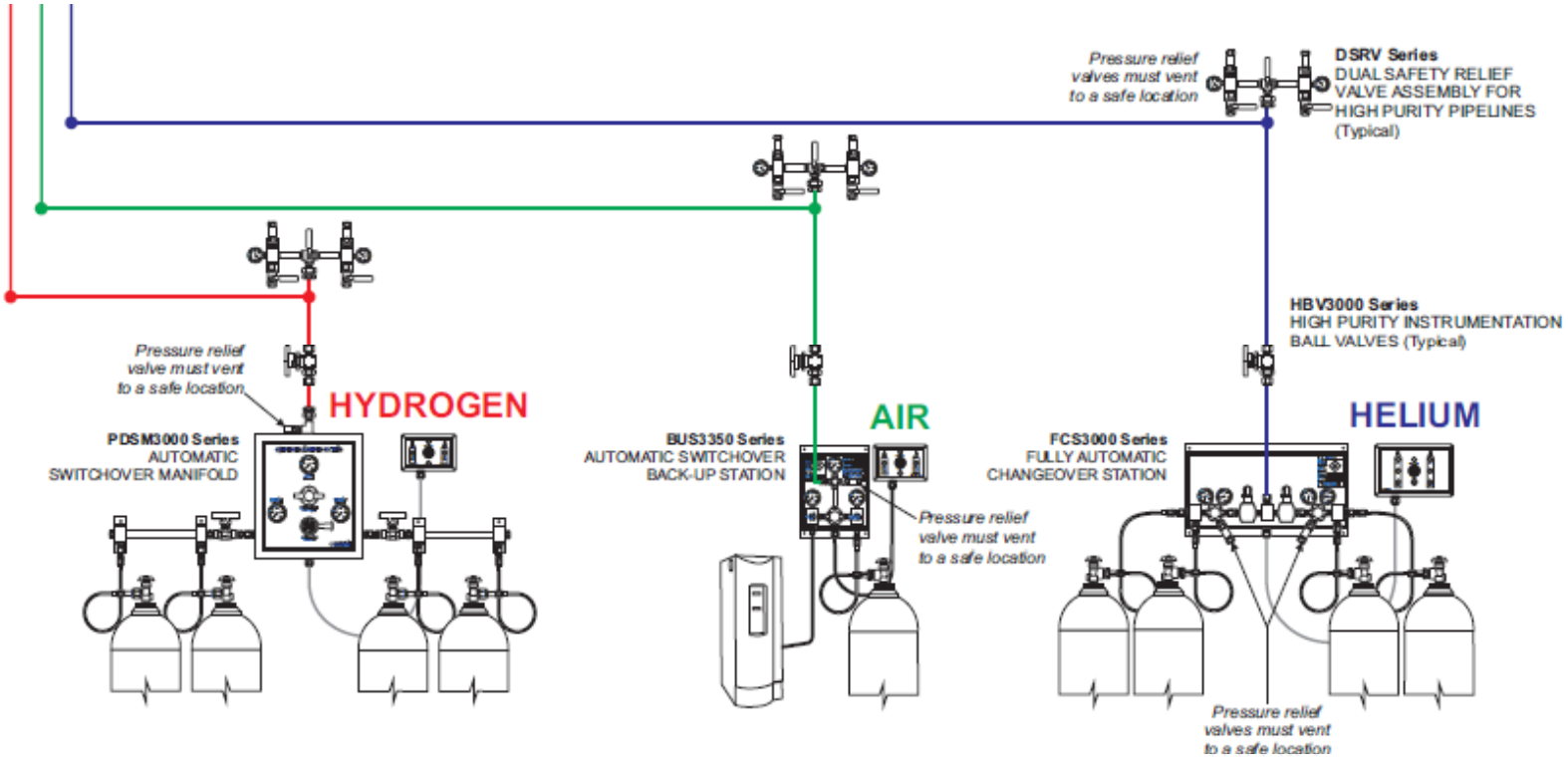


AFAM3000 Series
Fully Automatic Switchover Manifolds



CFAM500 Series
Cryogenic Fully Automatic Switchover Manifolds

# GC Ex. Controlling the Gases



# How do we SIZE the system?

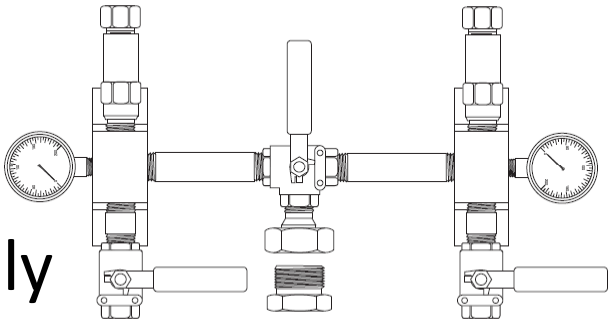
- **Question #7**: How many cylinders do I need?
- Recall Question #4C… Flow Requirements
  - On average, cylinder change-outs/delivery should be no more than once/week.
  - Example: Shimadzu GC2010
    - Max flow of 1200mL/min
    - 1200mL/min = 72L/hour = 2.54 cubic feet per hour (CFH)
    - Recall, a standard helium cylinder contains ~ 300 cubic feet, so…
    - 1 cylinder will last ~ 118 hours or 5 days

**2 CYLINDERS TOTAL**

# How do we protect the system?

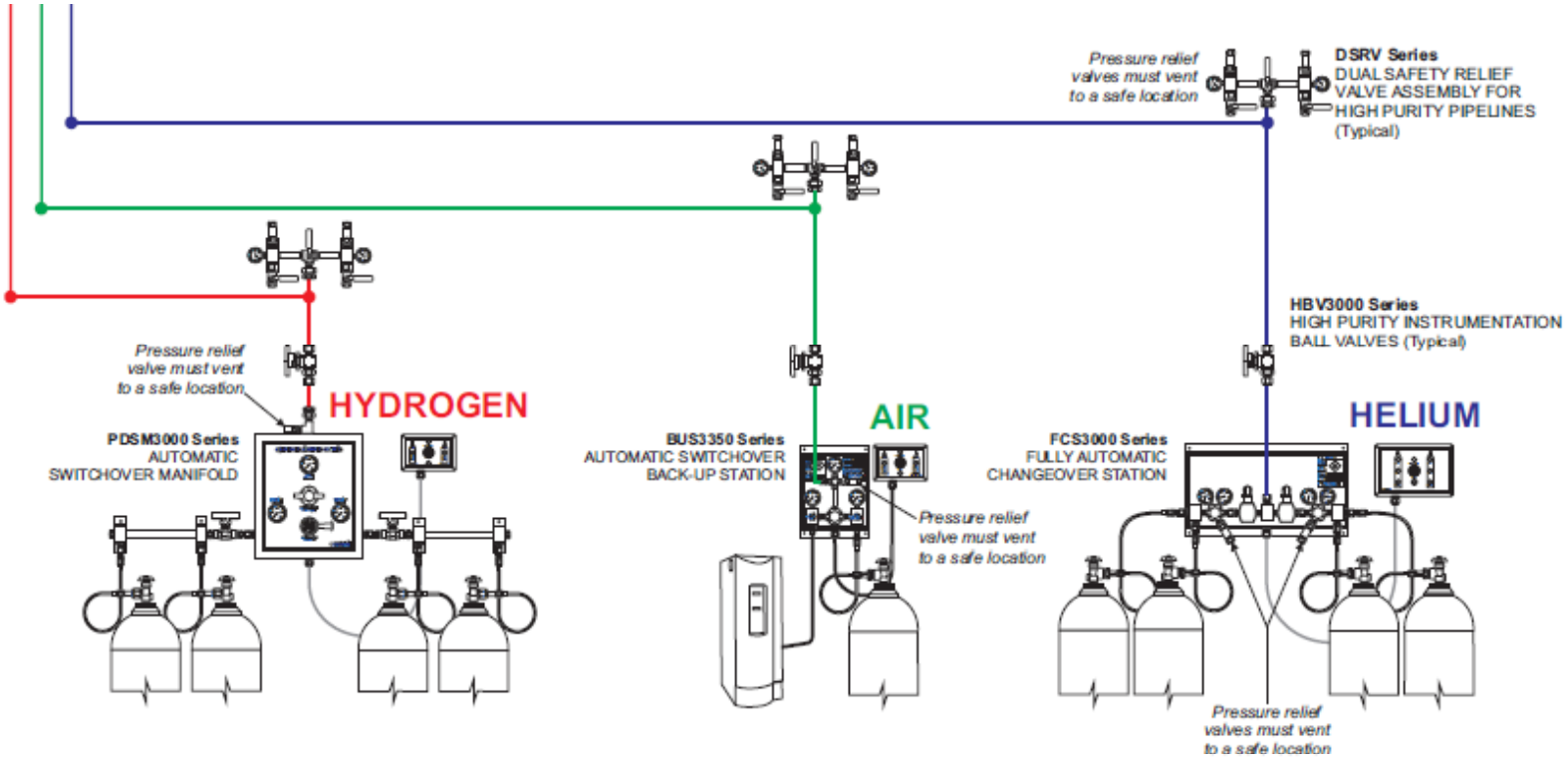
- **Question #8:** What type of safety equipment do I need?
  - Protect the gas control equipment
  - Protect the analytical equipment
  - Protect the people using the equipment

# Protecting the System



- Pipeline Protection
  - Dual Safety Relief Valve Assembly
    - PROTECT = PRESSURE RELIEF VALVES
    - ISOLATE = “SHUT-OFF” BALL VALVE
    - BY-PASS = DIVERTER VALVE/ISOLATION VALVE COMBO
    - VENT/PURGE = “BLEED” Ball Valve
    - Sample/Test Port
    - Tie-In Port

# Protecting the System

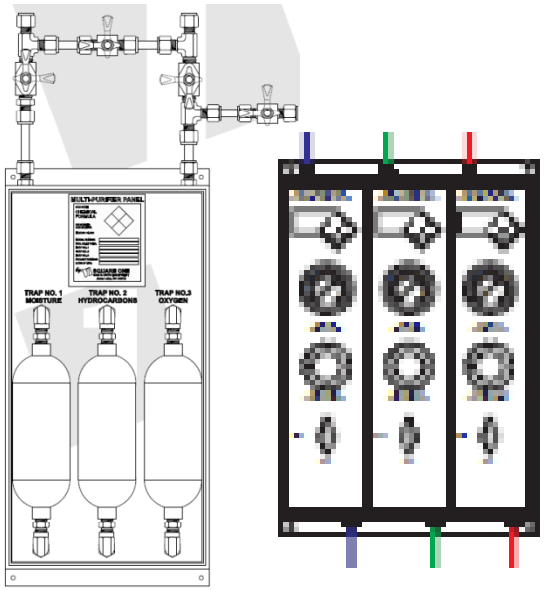




←See Pg. 18

# Protecting the Analytical Equipment

- Point-of-Use Equipment
  - Precise Pressure Control
  - Precise Flow Control
  - Filtration/Purification
  - Multiple Equipment Controls

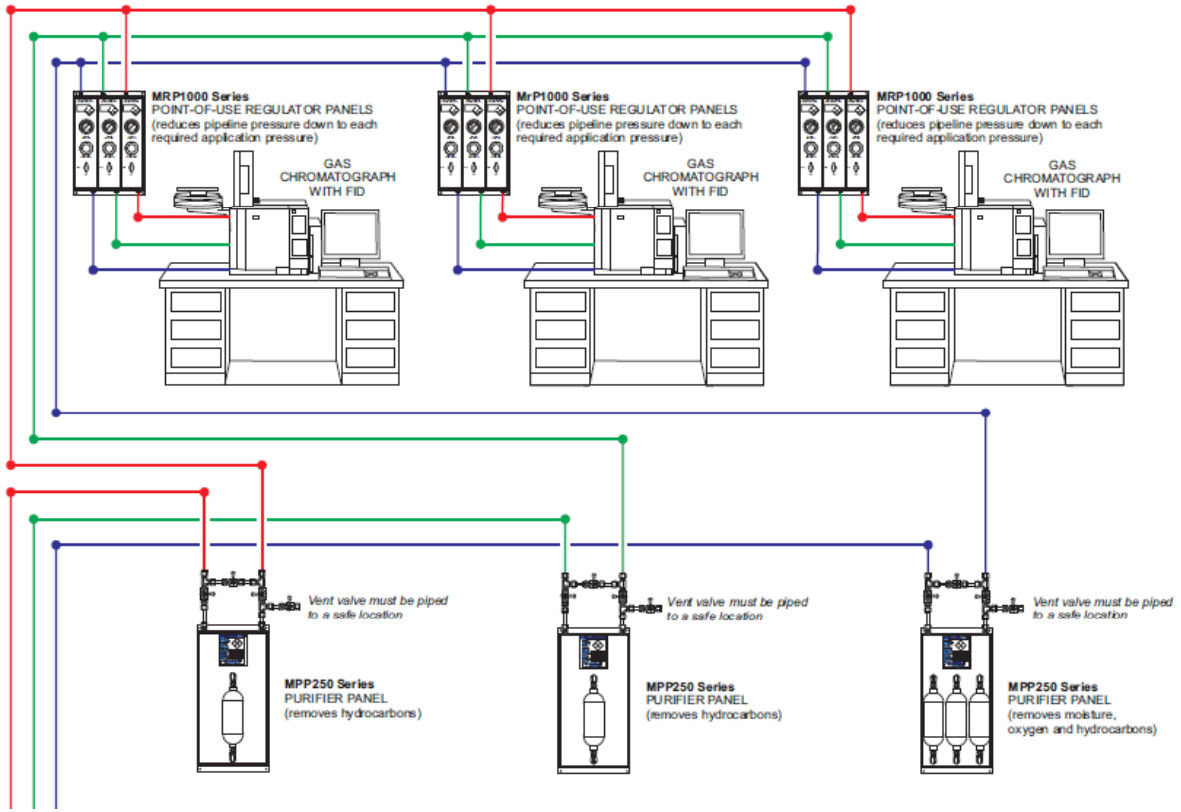



# Protecting the Instruments

SQUARE ONE

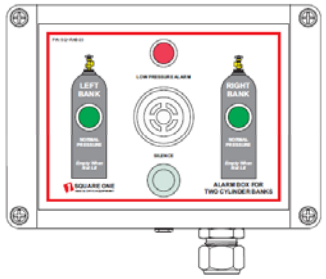
THE PIPELINER

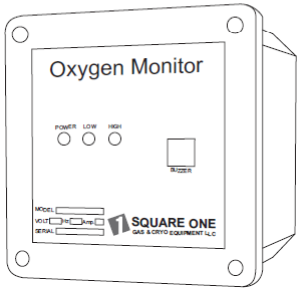
## SUGGESTED INSTALLATION: GAS CHROMATOGRAPHY



# Protecting Personnel

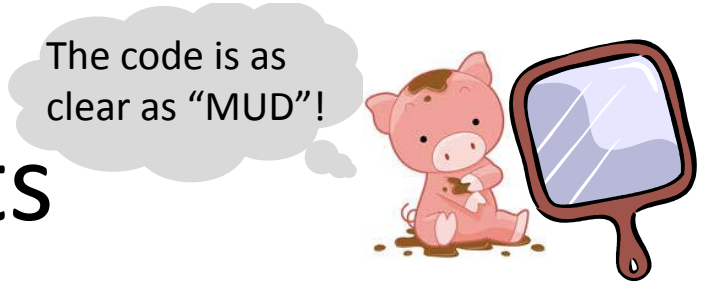
- Audio/Visual Alarms
- Proper Signage
- Gas Detection Equipment
- Voice Dialers
- Flashing Beacons
- Fail-Safe Automatic Shut-offs
- Excessive Flow Shut-offs
- Gas Cabinets



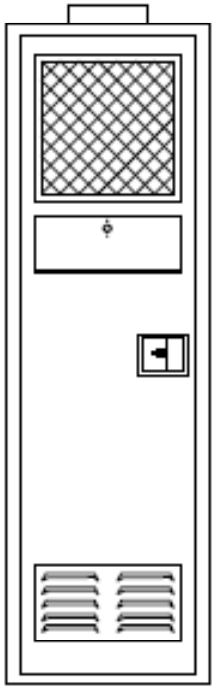





# Gas Cabinets




- **Question #9**: Do I need a gas cabinet?



- NFPA 55 is the standard for storage, use and handling of compressed gases.
- NFPA 55 divides gases into 5 classes
  - Corrosives {Section 7.5}
  - Flammables {Section 7.6}
    - HYDROGEN {Chapter 10}
  - Oxidizers {Section 7.7}
  - Pyrophorics {Section 7.8}
  - Toxic & Highly Toxics {Section 7.9}

# How do I know what type of gas I am dealing with?

SQUARE ONE

THE PIPELINER

## MATERIAL COMPATIBILITY CHART AND USEFUL GAS PROPERTIES

| Gas | Primary Hazards | | | | | Metals | | | | | Plastics | | | | Elastomers | | | Explosive Limits | | Toxicity Levels | | Physical Properties | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Asphyxiant | Toxic | Flammable | Corrosive | Oxidizer | Aluminum | Brass | Copper | Monel | Stainless Steel | Kel-F | Teflon | Tefzel | Kynar | Viton | Buna-N | Neoprene | LEL (% in Air) | UEL (% in Air) | TLV-TWA (ppm in Air) | TLV-STEL (ppm in Air) | SPECIFIC VOLUME (ft³/lb) | BOILING POINT @ 1 atm (°F) | SPECIFIC GRAVITY (Air=1) |
| ACETYLENE | | | | | | | | U | S | S | S | S | S | S | S | S | S | 2.5 | 100 | - | - | 14.77 | -119.6 | 0.899 |
| AIR | | | | | | | | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 12.55 | -317.8 | 1.000 |
| AMMONIA | | | | | | | | U | S | S | S | S | S | U | U | S | S | 15.0 | 28.0 | 25 | 35 | 22.49 | -28.3 | 0.588 |
| ARGON | | | | | | | | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 9.68 | -302.5 | 1.379 |
| ARSINE | | | | | | | | S | S | S | S | S | S | S | S | S | S | - | - | 0.05 | - | 4.91 | -79.9 | 2.691 |
| BORON TRICHLORIDE | | | | | | | | D | S | S | S | S | S | - | - | - | - | - | - | - | - | 3.10 | 55.1 | 4.045 |
| BORON TRIFLUORIDE | | | | | | | | D | S | S | S | S | S | - | - | - | - | - | - | 1C | - | 5.68 | -147.5 | 2.341 |
| BROMINE TRIFLUORIDE | | | | | | | | D | S | S | D | D | S | U | U | U | U | - | - | - | - | 415.1 | 258.2 | 4.727 |
| 1,3-BUTADIENE | | | | | | | | S | S | S | S | S | S | S | S | S | S | 2.0 | 12.0 | 2 | - | 6.98 | 23.7 | 1.868 |
| n-BUTANE | | | | | | | | S | S | S | S | S | S | S | S | S | S | 1.8 | 8.4 | 800 | - | 6.45 | 31.0 | 2.007 |
| 1-BUTENE | | | | | | | | S | S | S | S | S | S | S | S | S | S | 1.6 | 10.0 | - | - | 6.70 | 21.1 | 1.937 |
| cis-2-BUTENE | | | | | | | | S | S | S | S | S | S | S | S | S | S | 1.7 | 9.7 | - | - | 6.61 | 53.1 | 1.937 |
| trans-2-BUTENE | | | | | | | | S | S | S | S | S | S | S | S | S | S | 1.7 | 9.7 | - | - | 6.62 | 47.3 | 1.937 |
| CARBON DIOXIDE | X | | | | | S | S | S | S | S | S | S | S | S | S | D | D | - | - | 5000 | 30000 | 8.74 | -126.5 | 1.519 |
| CARBON MONOXIDE | | X | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 12.5 | 74.0 | 25 | - | 13.80 | -312.7 | 0.967 |
| CHLORINE | | X | | X | X | U | U | U | S | S | S | S | S | S | S | U | U | - | - | 0.5 | 1 | 5.39 | -28.8 | 2.448 |
| CHLORINE TRIFLUORIDE | | X | | X | | U | - | - | S | S | D | D | S | U | U | U | U | - | - | - | - | 4.09 | 53.1 | 3.192 |
| DEUTERIUM | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 4.9 | 75.0 | - | - | 96.00 | -417.0 | 0.139 |
| DICHLOROSILANE | | X | X | X | | U | - | - | S | S | S | S | S | S | - | - | - | 4.1 | 98.8 | - | - | 3.72 | 46.7 | 3.487 |
| DI-, MONO-, AND TRIMETHYLAMINES | | X | X | X | | U | U | U | S | S | S | S | S | S | U | U | - | - | - | - | - | - | - | - |
| DISILANE | | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 6.01 | 6.7 | 2.148 |
| ETHANE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 3.0 | 12.4 | - | - | 12.76 | -127.5 | 1.038 |
| ETHYL CHLORIDE | | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 3.8 | 15.4 | 100 | - | 5.82 | 54.0 | 2.227 |
| ETHYLENE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 2.7 | 36.0 | - | - | 13.71 | -154.8 | 0.969 |
| FLUORINE | | X | | X | X | D | D | D | S | S | D | D | D | D | U | U | U | - | - | 1 | 2 | 10.18 | -306.8 | 1.312 |
| HALOCARBON- 14 | | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | - | - | - |
| HALOCARBON- 23 | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 5.48 | -115.9 | 2.917 |
| HALOCARBON-116 | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 2.77 | -108.7 | 4.765 |
| HELIUM | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 96.67 | -452.0 | 0.138 |
| HYDROGEN | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 4.0 | 75.0 | - | - | 191.95 | -423.2 | 0.070 |
| HYDROGEN BROMIDE | | X | | X | | U | U | U | S | S | S | S | S | S | S | U | U | - | - | 3C | - | 4.74 | -88.0 | 2.794 |
| HYDROGEN CHLORIDE | | X | | X | | U | U | U | S | S | S | S | S | S | S | U | U | - | - | 5C | - | 10.55 | -120.8 | 1.259 |
| HYDROGEN FLUORIDE | | X | | X | | U | U | U | S | S | S | S | S | S | U | U | U | - | - | 3C | - | 5.65 | -108.7 | 4.765 |
| HYDROGEN SULFIDE | | X | X | X | | S | S | - | S | S | S | S | S | S | U | S | S | 4.0 | 44.0 | 10 | 15 | 11.26 | -74.9 | 1.176 |
| ISOBUTANE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 1.8 | 8.4 | - | - | - | - | - |
| ISOBUTYLENE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 1.8 | 9.8 | - | - | - | - | - |
| KRYPTON | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 4.61 | -244.1 | 2.893 |
| METHANE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 5.0 | 15.0 | - | - | 24.06 | -258.7 | 0.554 |
| METHYL CHLORIDE | | X | X | | | U | S | S | S | S | S | S | S | S | S | U | U | 7.0 | 17.4 | 50 | 100 | 4.83 | -11.2 | 1.740 |
| METHYL FLUORIDE | | X | X | | | S | S | S | S | S | S | S | S | S | - | - | - | - | - | - | - | 11.23 | -109.0 | 0.170 |
| NEON | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 19.18 | -410.9 | 0.697 |
| NITROGEN | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 13.80 | -320.4 | 0.967 |
| NITROGEN DIOXIDE | | X | | X | X | S | U | U | U | S | S | S | - | - | U | U | U | - | - | 3 | 5 | - | - | - |
| NITROGEN TRIFLUORIDE | | X | | | X | - | S | S | S | S | S | S | S | S | S | - | - | - | - | 10 | - | 5.43 | -200.2 | 2.451 |
| NITROUS OXIDE | | | | | X | S | S | S | S | S | S | S | S | S | S | S | S | - | - | 50 | - | 8.74 | -128.3 | 1.520 |
| OCTAFLUOROCYCLOBUTANE | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 1.87 | 21.2 | 6.906 |
| OCTAFLUOROPROPANE | X | | | | | S | S | S | S | S | S | S | S | - | - | S | S | - | - | - | - | 2.01 | -34.3 | 6.491 |
| OXYGEN | | | | | X | D | S | S | D | S | S | S | S | S | D | U | D | - | - | - | - | 12.08 | -297.4 | 1.105 |
| PHOSPHINE | | X | X | | | S | - | - | S | S | S | S | S | - | - | - | - | - | - | 0.3 | 1 | 11.30 | -126.0 | 1.174 |
| PROPANE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | 2.1 | 9.5 | - | - | 8.62 | -43.7 | 1.522 |
| PROPYLENE | X | | X | | | S | S | S | S | S | S | S | S | S | S | S | U | 2.4 | 11.0 | - | - | 9.06 | -53.8 | 1.453 |
| SILANE | | | X | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | 5 | - | 11.98 | -170.4 | 1.109 |
| SILICON TETRACHLORIDE | | X | | X | | U | U | U | S | S | S | S | S | S | U | U | U | - | - | - | - | 8.25 | 136.6 | 5.866 |
| SILICON TETRAFLUORIDE | | X | | X | | U | U | U | S | S | S | S | S | S | U | U | U | - | - | - | - | 3.69 | -148.3 | 3.593 |
| SULFUR DIOXIDE | | X | | X | | S | U | S | S | S | S | S | S | S | S | U | U | - | - | 2 | 5 | 5.95 | 13.8 | 2.212 |
| SULFUR HEXAFLUORIDE | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | 1000 | - | 2.62 | -90.8 | 5.042 |
| SULFUR TETRAFLUORIDE | | X | | X | | U | U | U | S | S | S | S | S | S | U | U | U | - | - | - | - | 3.53 | -53.5 | 3.731 |
| TUNGSTEN HEXAFLUORIDE | | X | | X | | U | U | U | S | S | S | S | S | S | U | U | U | - | - | - | - | 1.26 | 63.0 | 10.283 |
| XENON | X | | | | | S | S | S | S | S | S | S | S | S | S | S | S | - | - | - | - | 2.93 | -162.6 | 4.533 |

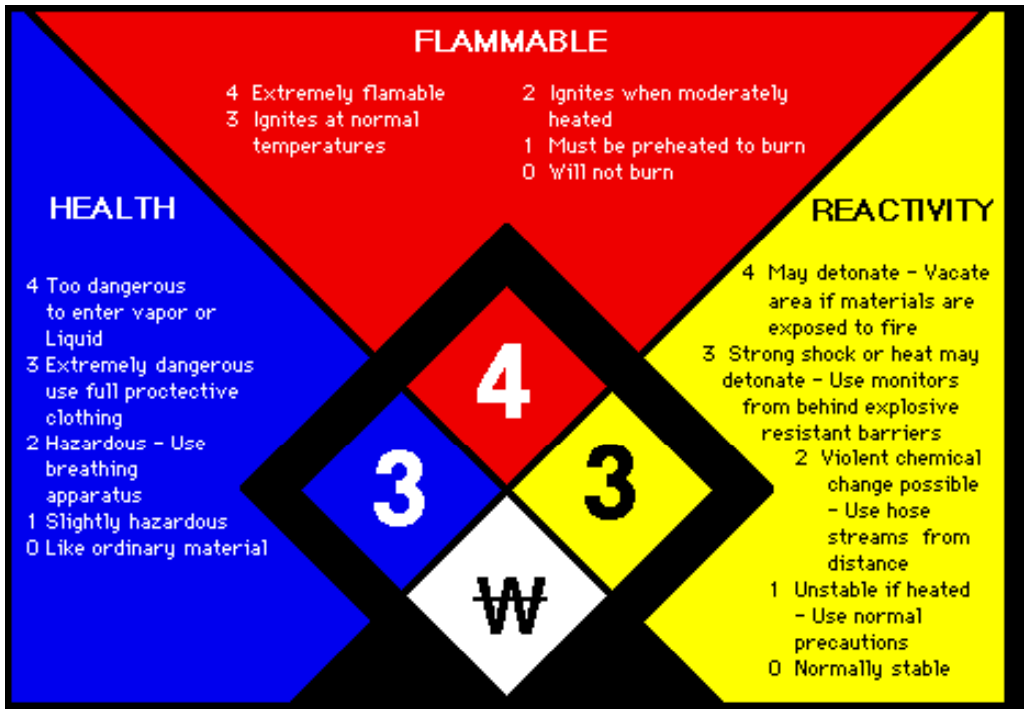
S = Satisfactory
- = Insufficient Data or Not Applicable
U = Unsatisfactory
D = Suitability depends on condition of use
C = Ceiling value
X = Indicates primary hazard

See Pg. 20 →

# Compressed Gas Classifications

- Corrosives {Section 7.5}
  - Ammonia, Chlorine, Hydrogen Sulfide, Sulfur Dioxide
- Flammables {Section 7.6}
  - Hydrogen,  Acetylene, Methane
- Oxidizers {Section 7.7}
  - Oxygen, Nitrous Oxide
- Pyrophorics {Section 7.8}
  - Silane
- Toxic & Highly Toxics {Section 7.9}
  - Ammonia, Carbon Monoxide, Chlorine

# NFPA 704 Hazard Diamond




The system is characterized by the "diamond shape" that is actually a "square-on-point" shape. It identifies the hazards of a material and the degree of severity of the health, flammability, and instability hazards. **Hazard severity is indicated by a numerical rating that ranges from zero (0) indicating a minimal hazard, to four (4) indicating a severe hazard.** The hazards are arranged spatially as follows: health at nine o'clock position, flammability at twelve o'clock position, and instability at three o'clock position. In addition to the spatial orientation that can be used to distinguish the hazards, they are also color-coded as follows: blue for health, red for flammability, and yellow for instability.

# NFPA 55

# Table 6.3.1

**This table applies to <u>ALL</u> gases.**

| MAXIMUM ALLOWABLE QUANTITY OF GASES PER CONTROL AREA | | | | |
|---|---|---|---|---|
| Sprinklered Areas | No | | Yes | |
| Gas Cabinet, Gas Room, or Exhausted Enclosure | No | Yes | No | Yes |
| Corrosive<br>Cryogenic<br>Flammable<br>Highly Toxic<br>Nonflammable<br>Oxidizing<br>Pyrophoric<br>Toxic<br>Unstable | Maximum allowable quantities vary greatly upon the hazardous material classification.<br><br>Please consult NFPA 55, particularly Table 6.3.1 and the entire Section 6 in general. | | | |



**Table 6.3.1 Maximum Allowable Quantity of Gases per Control Area (Quantity Thresholds for Gases Requiring Special Provisions)**

| Material | Unsprinklered Areas | | Sprinklered Areas | |
|---|---|---|---|---|
| | No Gas Cabinet, Gas Room, or Exhausted Enclosure | Gas Cabinet, Gas Room, or Exhausted Enclosure | No Gas Cabinet, Gas Room, or Exhausted Enclosure | Gas Cabinet, Gas Room, or Exhausted Enclosure |
| *Corrosive Gas* | | | | |
| Liquefied | 68 kg (150 lb) | 136 kg (300 lb) | 136 kg (300 lb) | 272 kg (600 lb) |
| Nonliquefied | 23 $m^3$ (810 $ft^3$) | 46 $m^3$ (1620 $ft^3$) | 46 $m^3$ (1620 $ft^3$) | 92 $m^3$ (3240 $ft^3$) |
| *Cryogenic Fluid* | | | | |
| Flammable | 0 L (0 gal) | 170 L (45 gal) | 170 L (45 gal) | 170 L (45 gal)* |
| Oxidizing | 170 L (45 gal) | 340 L (90 gal) | 340 L (90 gal) | 681 L (180 gal) |
| *Flammable Gas* | | | | |
| Liquefied | 114 L (30 gal) | 227 L (60 gal) | 227 L (60 gal) | 454 L (120 gal) |
| Nonliquefied | 28 $m^3$ (1000 $ft^3$) | 56 $m^3$ (2000 $ft^3$) | 56 $m^3$ (2000 $ft^3$) | 112 $m^3$ (4000 $ft^3$) |
| *Highly Toxic Gas* | | | | |
| Liquefied | 0 kg (0 lb) | 2.3 kg (5 lb) | 0 kg (0 lb) | 4.5 kg (10 lb) |
| Nonliquefied | 0 $m^3$ (0 $ft^3$) | 0.6 $m^3$ (20 $ft^3$) | 0 $m^3$ (0 $ft^3$) | 1.1 $m^3$ (40 $ft^3$) |
| *Nonflammable Gas* | | | | |
| Liquefied | No limit | No limit | No limit | No limit |
| Nonliquefied | No limit | No limit | No limit | No limit |
| *Oxidizing Gas* | | | | |
| Liquefied | 57 L (15 gal) | 114 L (30 gal) | 114 L (30 gal) | 227 L (60 gal) |
| Nonliquefied | 43 $m^3$ (1500 $ft^3$) | 85 $m^3$ (3000 $ft^3$) | 85 $m^3$ (3000 $ft^3$) | 170 $m^3$ (6000 $ft^3$) |
| *Pyrophoric Gas* | | | | |
| Liquefied | 0 kg (0 lb) | 0 kg (0 lb) | 1.8 kg (4 lb) | 3.6 kg (8 lb) |
| Nonliquefied | 0 $m^3$ (0 $ft^3$) | 0 $m^3$ (0 $ft^3$) | 1.4 $m^3$ (50 $ft^3$) | 2.8 $m^3$ (100 $ft^3$) |
| *Toxic Gas* | | | | |
| Liquefied | 68 kg (150 lb) | 136 kg (300 lb) | 136 kg (300 lb) | 272 kg (600 lb) |
| Nonliquefied | 23 $m^3$ (810 $ft^3$) | 46 $m^3$ (1620 $ft^3$) | 46 $m^3$ (1620 $ft^3$) | 92 $m^3$ (3240 $ft^3$) |
| *Unstable Reactive (Detonable) Gas, Class 3 or Class 4* | | | | |
| Liquefied | 0 kg (0 lb) | 0 kg (0 lb) | 0.5 kg (1 lb) | 1 kg (2 lb) |
| Nonliquefied | 0 $m^3$ (0 $ft^3$) | 0 $m^3$ (0 $ft^3$) | 0.3 $m^3$ (10 $ft^3$) | 0.6 $m^3$ (20 $ft^3$) |
| *Unstable Reactive (Nondetonable) Gas, Class 3* | | | | |
| Liquefied | 1 kg (2 lb) | 2 kg (4 lb) | 2 kg (4 lb) | 4 kg (8 lb) |
| Nonliquefied | 1.4 $m^3$ (50 $ft^3$) | 3 $m^3$ (100 $ft^3$) | 3 $m^3$ (100 $ft^3$) | 6 $m^3$ (200 $ft^3$) |
| *Unstable Reactive Gas, Class 2* | | | | |
| Liquefied | 114 L (30 gal) | 227 L (60 gal) | 227 L (60 gal) | 454 L (120 gal) |
| Nonliquefied | 21 $m^3$ (750 $ft^3$) | 43 $m^3$ (1500 $ft^3$) | 43 $m^3$ (1500 $ft^3$) | 85 $m^3$ (3000 $ft^3$) |
| *Unstable Reactive Gas, Class 1* | | | | |
| Liquefied | No limit | No limit | No limit | No limit |
| Nonliquefied | No limit | No limit | No limit | No limit |

Note: The maximum quantity indicated is the aggregate quantity of materials in storage and use combined.

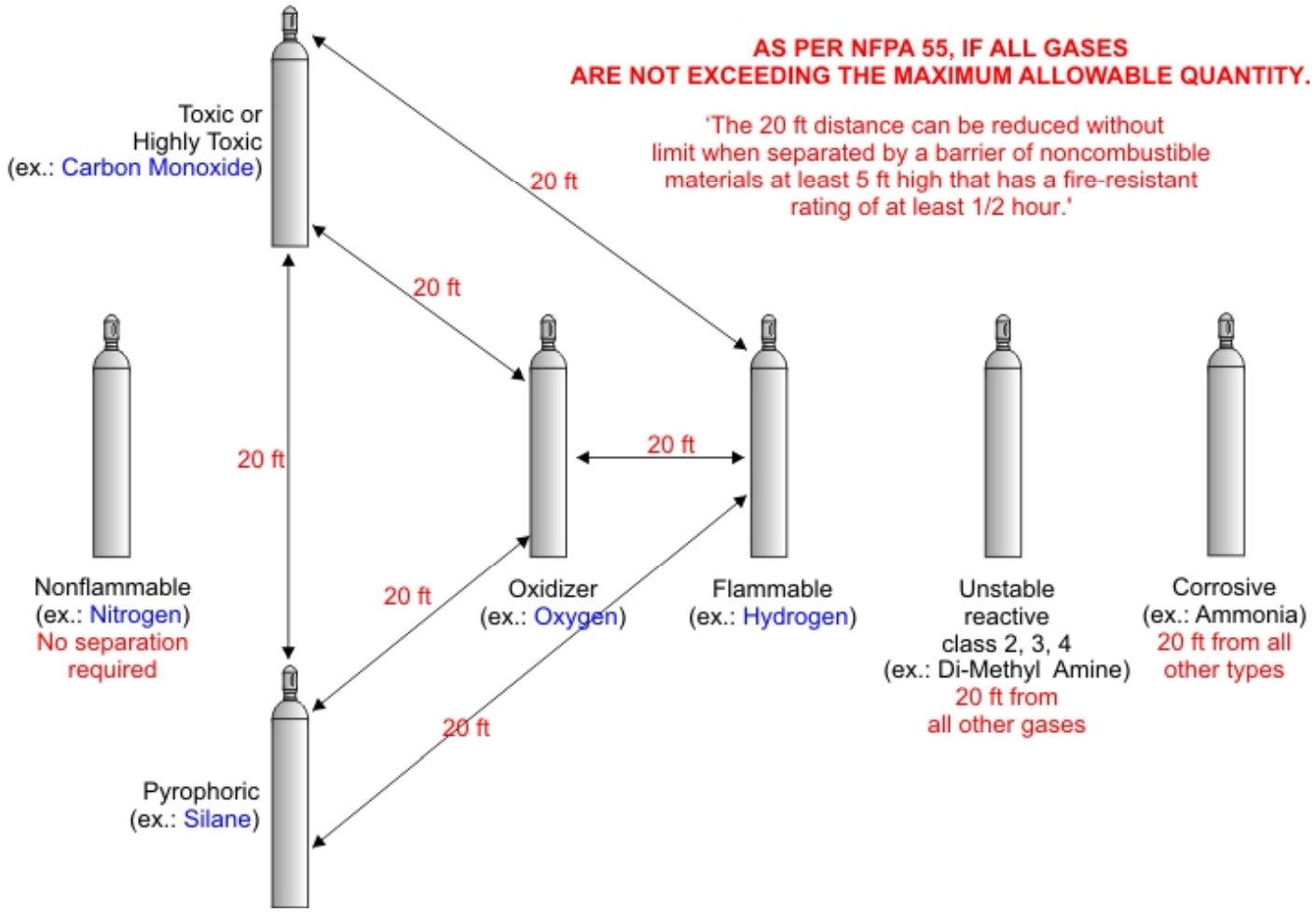
*A gas cabinet or exhausted enclosure is required. Pressure-relief devices or stationary or portable containers shall be vented directly outdoors or to an exhaust hood. *(See 8.2.6.)*

# GC Application – Hydrogen Use

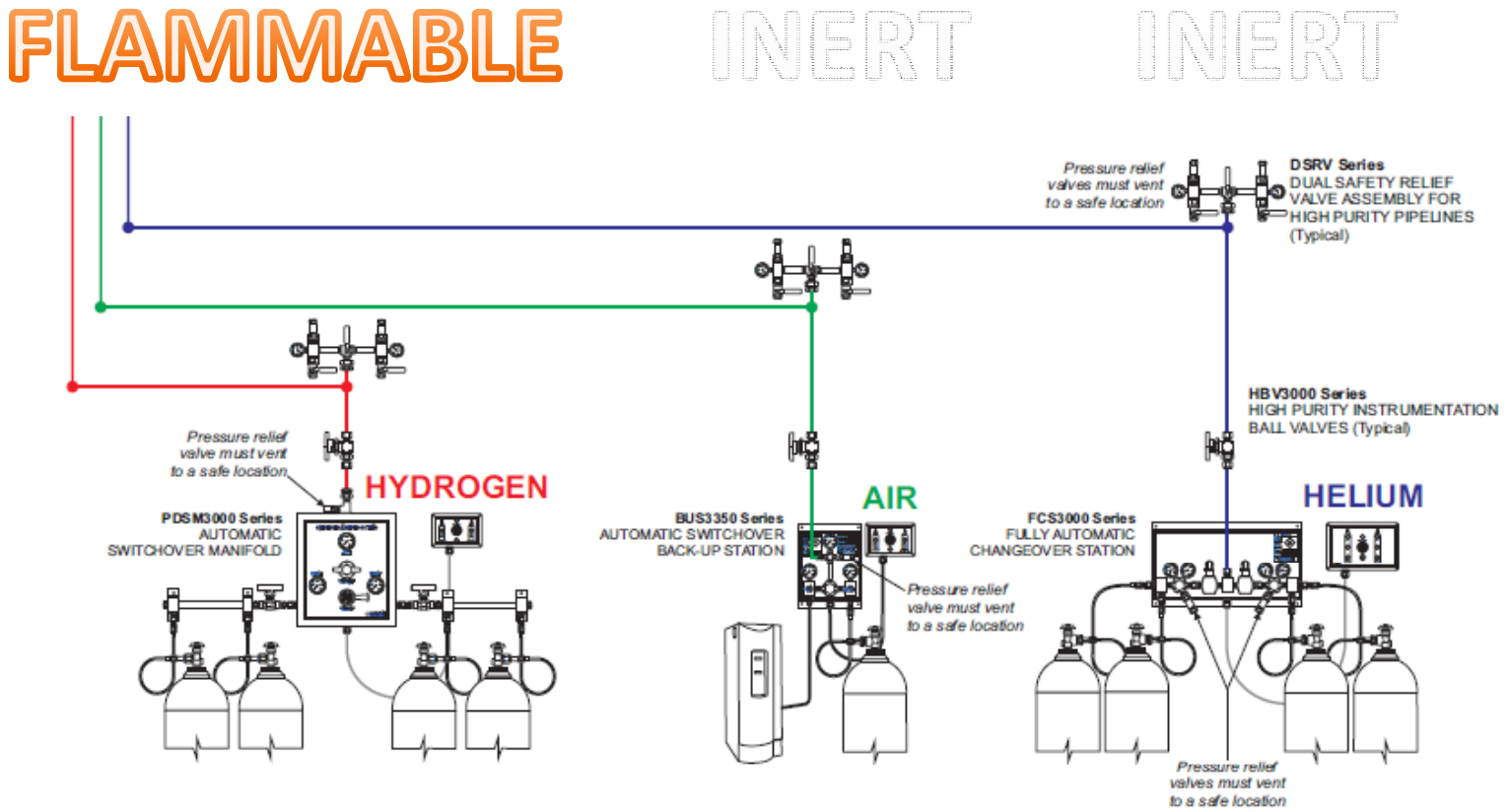

- How much Hydrogen is required?
  - Recall from our chart… Hydrogen is Flammable!!!
  - For the GC w/ FID we need ~50mL/min… < 1 cfh
  - Recall a standard cylinder of H has ~ 300 cf
    - 1 cylinder or 2 cylinders at most will be acceptable
  - Per NFPA 10.1.1, *"This chapter shall not apply to individual systems using containers having a total hydrogen content of less than 11 $m^3$ (400 scf) if each system is separated by a distance not less than 1.5m (5 ft)."*
  - Per Table 6.3.1, the maximum allowable quantity of a flammable gas in an unsprinklered area without a gas cabinet is 1000 cubic feet.
  - CONCLUSION: for 1 or 2 cylinders, a gas cabinet is NOT required.

# Safe Storage of Gas Cylinders

## STORAGE OF GAS CONTAINERS



# GC Application – Cylinder Location



# Question Review

- Question #1:  What is the application?
- Question #2:  What are the gases required?
- Question #3:  What are my allowable materials of construction?
- Question #4:  What are the pressure and flow requirements ?
- Question #5:  What is the source of supply?
- Question #6:  What type of manifold/equipment do I require?
- Question #7:  How many cylinders do I need?
- Question #8:  What type of safety equipment do I need, in order to protect the both gas control and analytical equipment and the personnel using them?
- Question #9:  Do I need a gas cabinet?

# Useful Documents

SQUARE ONE — THE PIPELINER

## POINT-OF-USE QUESTIONNAIRE

### Purpose of this questionnaire

We are currently in the design stage of a high purity gas delivery system. The purpose of this questionnaire is to gather information on the gas requirements of the analytical equipment, process or experiment. The goal is to make sure to supply each application with gas at the appropriate quality, flow and pressure. Would you please fill out this questionnaire to the best of your knowledge and return it to:

*Please use one questionnaire per analytical equipment, process or experiment.*

### Identification

Questionnaire filled by _____ Date _____

Telephone number _____

e-mail address _____

Laboratory name, department, section _____

Building name or number _____ Room number _____

### Description of your application

Analytical equipment, description of experiment or process (please provide: Tag no., name, type of detector, brand of equipment, model number) _____

Is it an existing or a new requirement? _____ Is it a temporary or a permanent requirement? _____ If temporary, for how long? _____

### Gas requirements

| Gas 1 | Gas 2 | Gas 3 | Gas 4 |
|---|---|---|---|
| Gas name | Gas name | Gas name | Gas name |
| Minimum purity (gas grade or 9s) | Minimum purity (gas grade or 9s) | Minimum purity (gas grade or 9s) | Minimum purity (gas grade or 9s) |
| Impurities to avoid | Impurities to avoid | Impurities to avoid | Impurities to avoid |
| Temperature | Temperature | Temperature | Temperature |
| Purpose | Purpose | Purpose | Purpose |
| Supply pressure | Supply pressure | Supply pressure | Supply pressure |
| Flow (peak ***and*** per week) | Flow (peak ***and*** per week) | Flow (peak ***and*** per week) | Flow (peak ***and*** per week) |

### Special requirements or additional information

Please note any additional information or special requirements. If required, please attach another sheet to this document

**See Pg. 8 & 9**



SQUARE ONE — THE PIPELINER

## GAS REQUIREMENT WORKSHEET

### Identification

Worksheet filled by _____ Date _____

Telephone number _____

e-mail address _____

Laboratory name, department, section _____

Building name or number _____

*This worksheet is provided as a guideline only. The data should be compiled on an electronic spreadsheet such as Excel.*

*In order to better determine the pipeline diameter, the maximum peak flow for all applications must be considered.*

### Gas requirements

| Laboratory / room / department | Tag / equipment / process | Gas 1 | Gas 2 |
|---|---|---|---|
| | | Gas name | Gas name |
| | | Minimum purity (gas grade or 9s) | Minimum purity (gas grade or 9s) |
| | | Impurities to avoid | Impurities to avoid |
| | | Temperature | Temperature |
| | | Purpose | Purpose |
| | | Pipeline pressure | Pipeline pressure |
| Laboratory / room / department | Tag / equipment / process | Weekly flow | Weekly flow |
| Laboratory / room / department | Tag / equipment / process | Weekly flow | Weekly flow |
| Laboratory / room / department | Tag / equipment / process | Weekly flow | Weekly flow |
| Laboratory / room / department | Tag / equipment / process | Weekly flow | Weekly flow |
| | | Total - Weekly flow (cyl. per week) | Total - Weekly flow (cyl. per week) |
| | | Pipeline size | Pipeline size |
| | | Manifold type | Manifold type |

# SUMMARY

SQUARE ONE — THE PIPELINER

## PIPELINE DESIGN - KEY POINTS

| GAS SUPPLY MODE | CYLINDER STORAGE | GAS DELIVERY EQUIPMENT | PIPELINE TYPE |
|---|---|---|---|
| Quantity of different gases (Flow rates)<br><br>Grade (aka Purity) for each gas<br><br>Cylinder size for each gas | Sprinkler available<br><br>Gas cabinet, gas room, or exhausted area<br><br>Quantity for each gas<br><br>Exceed or within Maximum Allowable Quantity<br><br>Segregation by gas type<br><br>Explosion control requirements<br><br>Don't forget space for full and empty cylinders | Is gas supply interruption allowed?<br><br>Desired pipeline pressure per gas<br><br>Flow requirement per gas (equipment Cv)<br><br>Purity level required per gas<br><br>Cylinder supply status | Material compatibility (hard & soft)<br><br>Purity level requirements (installer)<br><br>Flow requirement per gas (diameter)<br><br>Pipeline pressure (wall thickness)<br><br>Pipe or tube?<br><br>Joints<br>brazed<br>soldered<br>compression<br>flared<br>threaded<br>welded |
| Optimized gas supply mode will require one delivery of cylinders per week | Design meets NFPA 55 Standard | Select the proper Square One manifold for each gas to meet application needs | Select the proper pipeline type for each gas to meet application needs |



SQUARE ONE — THE PIPELINER

## PIPELINE DESIGN - KEY POINTS (CONT.)

| PIPELINE TIE-IN KIT | FILTRATION | POINT-OF-USE CONTROL | WARNING & SAFETY |
|---|---|---|---|
| Supply isolation valve<br><br>Emergency tie-in valve<br><br>Pipeline pressure relief valve<br><br>Pipeline pressure gauge<br><br>Vent valve<br><br>Gas service outlet | Removal of:<br><br>Particles<br><br>Oxygen<br><br>Moisture<br><br>Hydrocarbons<br><br>Carbon dioxide<br><br>Trap and filter change out valves:<br><br>Inlet isolation<br><br>Service isolation<br><br>Vent<br><br>By-pass | Pressure reducing and control<br><br>Flow measurement and control<br><br>Final filtration<br><br>Multiple delivery point valves | Gas detection<br><br>Voice dialer<br><br>Excess flow shut-off<br><br>Fail safe automatic shut-off<br><br>System initializer<br><br>Signage |
| Provide pipeline protection and serviceability | Maintain integrity of the pipeline<br><br>Allow easy and contamination-free filter change-outs | Provide ease of gas control at each point-of-use | Provide notification to key personel of system malfunction<br><br>Meet NFPA 55 |

# Questions or Comments



**We appreciate your time.**
**Thanks for attending!**