IFC® Chapter 5306: Medical Gases

2018 Washington State Fire Prevention Institute

Chelan, Washington

YOUR INSTRUCTOR

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GOAL

Improve your understanding of the 2018 *International Fire Code*® permitting, design, installation and inspection requirements for medical gases and NFPA Category 1 gas systems required by IFC® §5306.

YOUR QUESTIONS

What specific questions do you have about medical gas systems?

Activity

MEDICAL GAS SYSTEMS

With the person sitting next to you, create a list of five (5) locations where you are likely to find medical gas systems.

PRESENTATION OBJECTIVES

Upon completion, you will be able to outline the *International Fire Code*® requirements for medical gas systems.

To accomplish this, you will be able to:

1. Explain the *International Fire Code*® construction and operating permit requirements for medical gases and systems, including acceptance testing and commissioning.

2. Identify medical gas cylinders and their capacities.

3. Identify medical gas system components.

PRESENTATION OBJECTIVES (CONTINUED)

Upon completion, you will be able to outline the *International Fire Code*® requirements for medical gas systems.

To accomplish this, you will be able to:

4. Interpret line drawings of simple medical gas systems to verify components are installed correctly.

5. Summarize construction requirements for interior and exterior one-hour rooms for medical gas storage.

6. Apply the requirements of IFC® Chapter 53 for medical gases to plan review and inspections.

MODULE # 1

MEDICAL GAS OVERVIEW

IFC® DEFINITIONS

- § 5302.1
- ***Compressed gas***
- Material or mixture that:
  - Is a gas at 68°F or less at 14.7 psia of pressure; and,
  - Has a boiling point of 68°F or less at 14.7 psia which is either liquefied, nonliquefied or in solution,
    - except those gases which have no other health- or physical-hazard properties *are not* considered to be compressed until the pressure in the packaging exceeds 41 psia at 68°F .

IFC® DEFINITIONS

- ***Compressed gas container***
  - A pressure vessel designed to hold compressed gases at pressures greater than one atmosphere at 68°F and includes cylinders, containers and tanks.
- ***Compressed gas system***
  - An assembly of equipment designed to contain, distribute or transport compressed gases. It can consist of a compressed gas container or containers, reactors and appurtenances, including pumps, compressors and connecting piping and tubing.

WASHINGTON REGULATIONS

- RCW 18.06
- Department of Labor and Industries
  - Journeyman plumbers with "medical gas piping installation endorsement"
  - WAC 296-400A-026
    - 32 training hours
    - Est. 600 in state (8/16/18)

Source: http://www.lni.wa.gov/LawRule/default.asp

LOX IN HOME HEALTH CARE

- IFC § 6306

MEDICAL GASES

- Oxygen
- Medical air
- Nitrous oxide
- Nitrogen
- Carbon dioxide
- Medical gas mixtures
- Instrument air/surgical air
- Medical vacuum
- Waste anesthesia gas disposal (WAGD)
- Anesthetic gas scavenging system (AGSS)

Gas	Common Usage
Oxygen	Supplemental oxygenation for hypoxemia and hypoxia
Nitrous Oxide	Analgesic and anesthetic for pre-operative procedures
Nitrogen	Power surgical equipment during various procedures
Carbon dioxide	Suspend or inflate various tissues. Used in laser surgeries
Carbon monoxide	Trace amounts as ingredient in lung diffusion testing
Medical air	Pulmonary nebulizers to reduce the risk of excess oxygen in the lungs or other body tissues
Helium	Fixed partial upper airway obstructions or increased air resistance
Medical vacuum	Suction equipment and evacuation procedures
Instrument air	Powers pneumatic surgical equipment

Medical Gas/Fluid Hazards

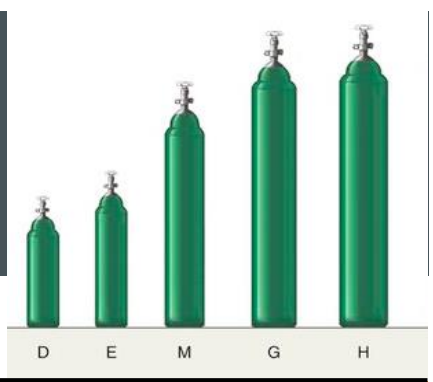
Gas/Fluid	Hazard
Oxygen, nitrous oxide	Oxidizer
Nitrogen, carbon dioxide, nitrous oxide	Asphyxiant
Carbon monoxide	Flammable
Medical air	Compressed gas (pressure)
Helium	Asphyxiant
Instrument air	Compressed gas (pressure)
Cryogenic fluids	Tissue and respiratory damage

GAS: OPERATING/CONSTRUCTION PERMITTING

Table 105.6.9 Limits

Gas	Amount (cu. ft.) at NTP
Corrosive	200
Flammable	200
Highly toxic	Any
Inert and simple asphyxiant	6,000
• Nitrogen, carbon dioxide, nitrous oxide	
Oxidizing (including oxygen)	504
Pyrophoric	Any
Toxic	Any

VESSEL CAPACITIES (CU. FT.)



Pure Gas	Cylinder Color	D	E	M	G	H
Oxygen USP		13	22	112	188	226
Medical Air USP		13	22	106	179	213
Nitrous Oxide USP		32	53	263	488	555
Nitrogen NF		12	21	104	174	209
Helium USP		12	20	99	186	199
Carbon Dioxide USP		31	54	263	430	555

MODULE # 2

SYSTEM EQUIPMENT AND COMPONENTS

RISK CATEGORIES (NFPA 99, §4.1)

- Activities, systems or equipment where failure:

Category 1	is likely to cause major patient, staff or visitor death/injury.
Category 2	is likely to cause *minor* patient, staff or visitor death/injury.
Category 3	*not likely* to cause injury, but will cause discomfort.
Category 4	has *no impact* on patient care.

RISK CATEGORIES (NFPA 99, §A- 4.1)

- Reliability:

Category 1	• Expected to work or be available at all times for patients
Category 2	• Expected to provide a high level or reliability • Short term downtime can be tolerated • Support patients but not critical for life support
Category 3	• Normal building system reliabilities are expected • Support patient needs but not patient care
Category 4	• No impact on patient care.

RISK CATEGORIES (NFPA 99, §A- 4.1)

- Examples:

Category 1	• Ambulatory surgical center • Two patients with full operating room services • Reconstructive surgeons' office
Category 2	• Outpatient service procedure sedation • Cooling towers: Houston
Category 3	• Cooling towers: Seattle • Dental office; no general anesthesia
Category 4	• Typical physician office/exam room • Lawn sprinkler systems

CENTRAL SUPPLY: KEY REQUIREMENTS

- Central supply sources must be identified and labeled
- Warning signs for oxygen and other medical gases
- Central supply conditions
  - Outdoor enclosures
  - Indoor enclosures
- Construction

Courtesy Bion Medical

August 24, 2018

MANIFOLD W/O RESERVE SUPPLY

- Source redundancy
- Automatic changeover
- Alarms
  - Local visual
  - Remote master indicating changeover

SIGNS

99-§5.1.3.1.8 Rooms for positive pressure gases *other than* oxygen and medical air:

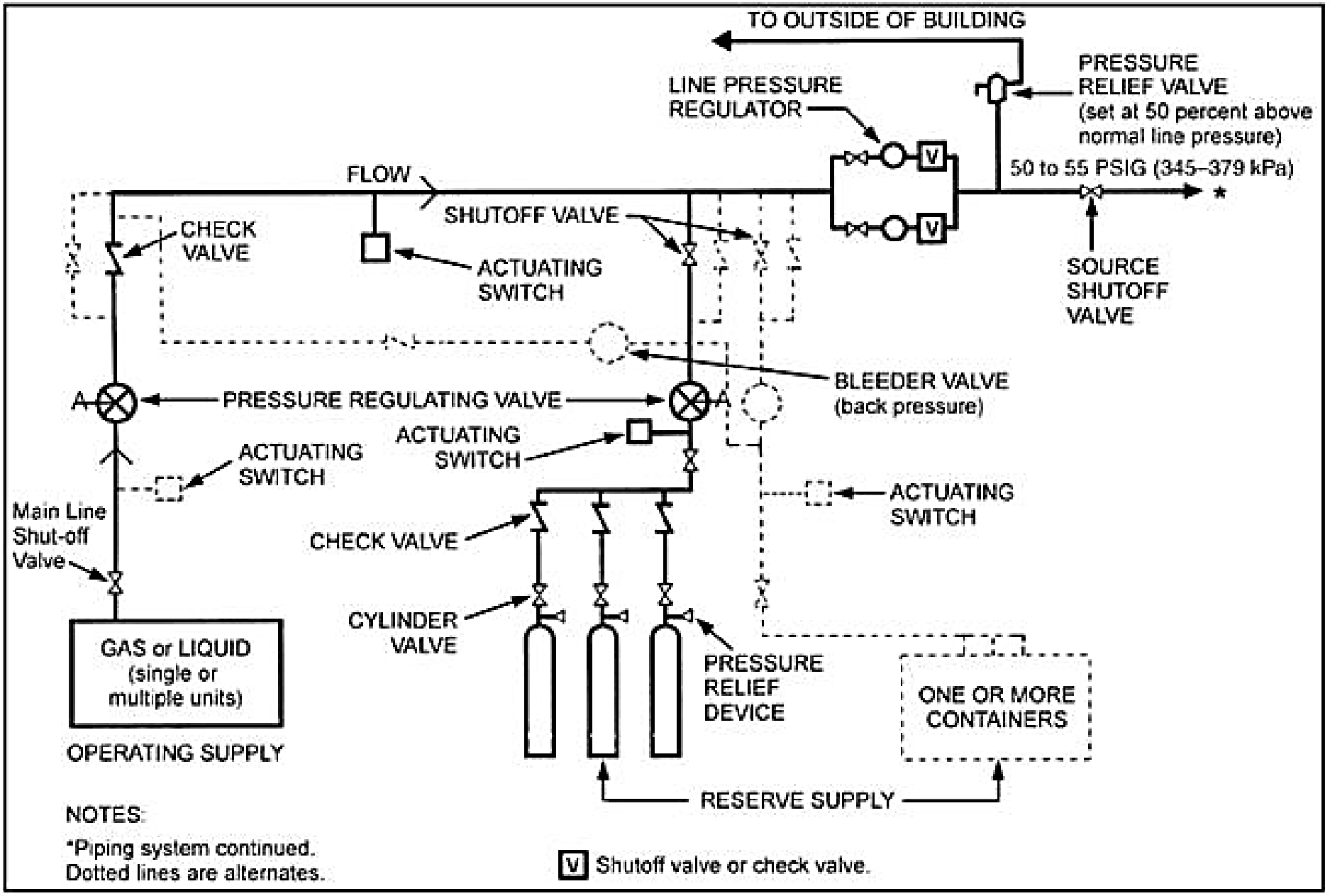
Positive Pressure Gases
NO Smoking or Open Flame
Room May Have Insufficient Oxygen
Open Door and Allow Room to
Ventilate Before Entering

SIGNS

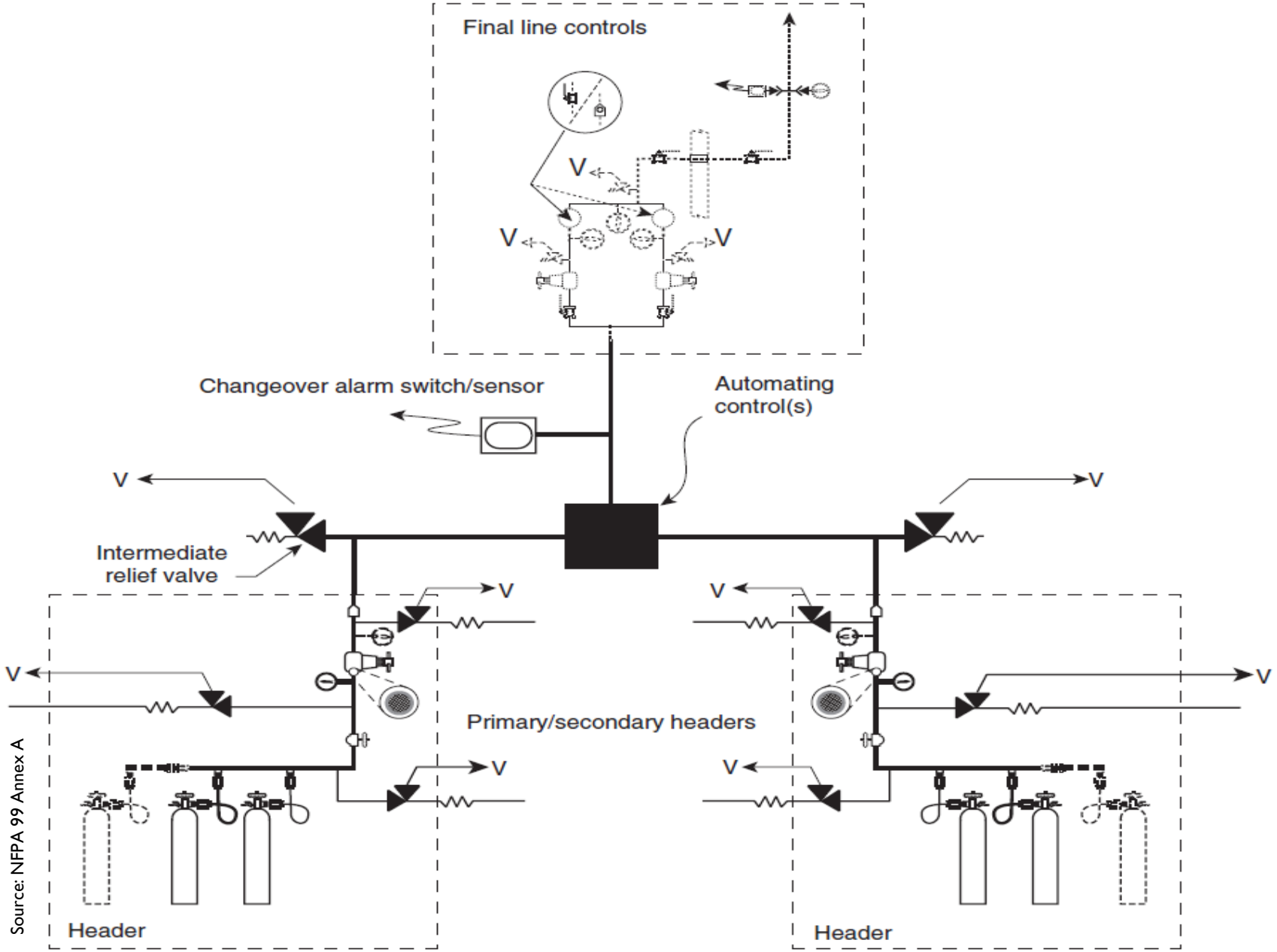
99-§5.1.3.1.9 Rooms for central supply for *only* oxygen or medical air:

Medical Gases
NO Smoking or Open Flame

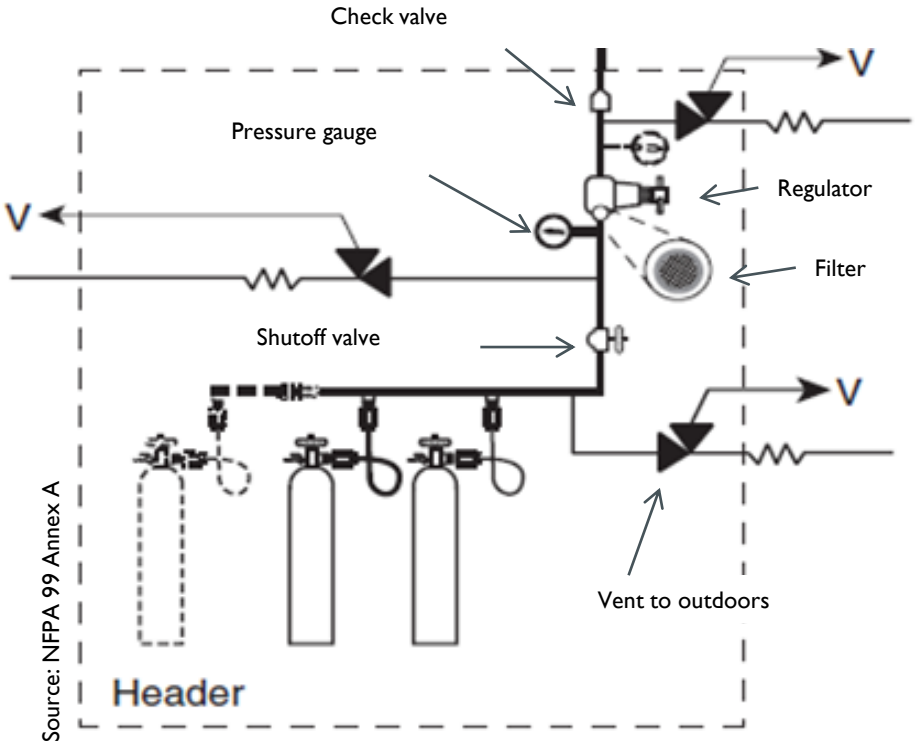
CAUTION:
OXIDIZING GAS(ES) STORED WITHIN
NO SMOKING



Courtesy Gentec Systems Corporation


Final line controls
V
V
V
Changeover alarm switch/sensor
Automating control(s)
V
V
Intermediate relief valve
V
V
V
V
Primary/secondary headers
V
V
Source: NFPA 99 Annex A
Header
Header

HEADERS (NFPA 99-§ 5.1.3.5.9)



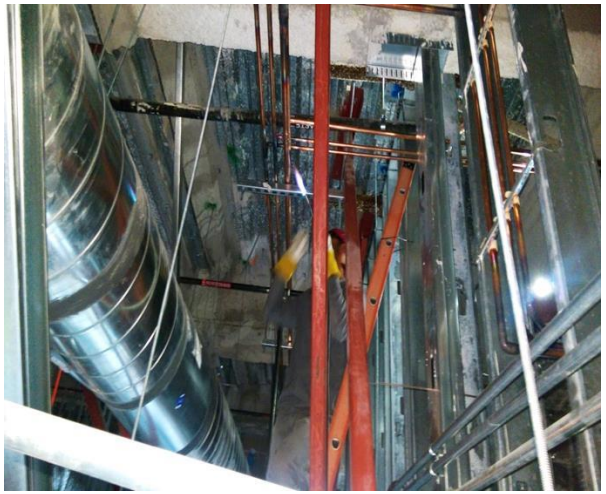
Source: NFPA 99 Annex A

MATERIALS

Courtesy Advanced Technology Group

DISTRIBUTION/VACUUM

- Distribution (pressure)
  - Copper, Type L
  - ASTM B 819 *Standard Specification for Seamless Copper Tube for Medical Gas Systems*
  - Type K
    - Pressures exceed 185 psi and tube is larger than $3^{1/8}$-inch OD.
- Vacuum (suction)
  - Copper
  - Stainless steel



Courtesy Premier Plumbing and Heating

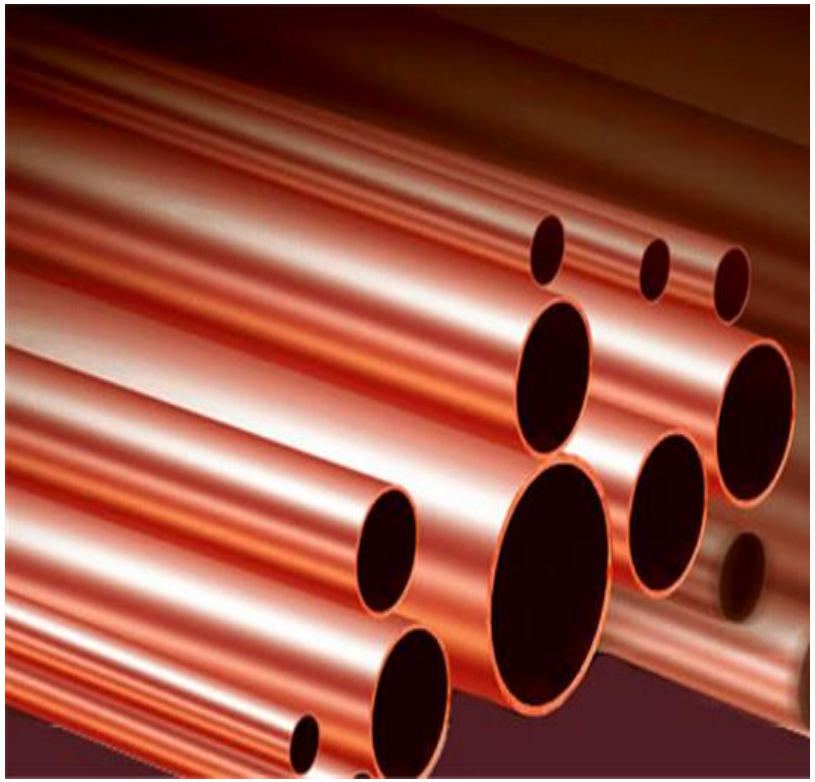
K OR L: WHAT'S THE DIFFERENCE?

- Wall thickness

Outside Diameter (in.)	Type K	Type L
3/8	.049	.035
5/8	.049	.042
¾	.065	.045
1	1.125	.050

Courtesy Alibaba

MARKING



Courtesy Alibaba

- ASTM B819
  - Pressure side

Type L	Type K
OXY	OXY
OXY/MED	OXY/MED
OXY/ACR	OXY/ACR
ACR/MED	ACR/MED
MED	MED

  - Vacuum side
    - "Prominently labeled"
    - Exception for B819-compliant tube

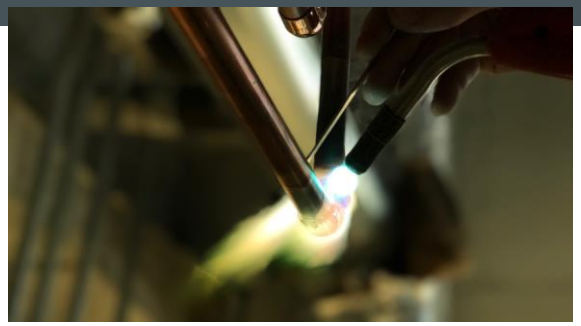
DISTRIBUTION PIPE

- Equipped with isolation valves
- Piped in parallel *optional*

- Pressure relief valves
  - Vented outdoors
  - Away from hazards

BRAZING CONTROLS

- When brazing joints, must be continuously purged with oil-free dry nitrogen NF (national formulary)
  - Prevents copper oxide inside joint surfaces

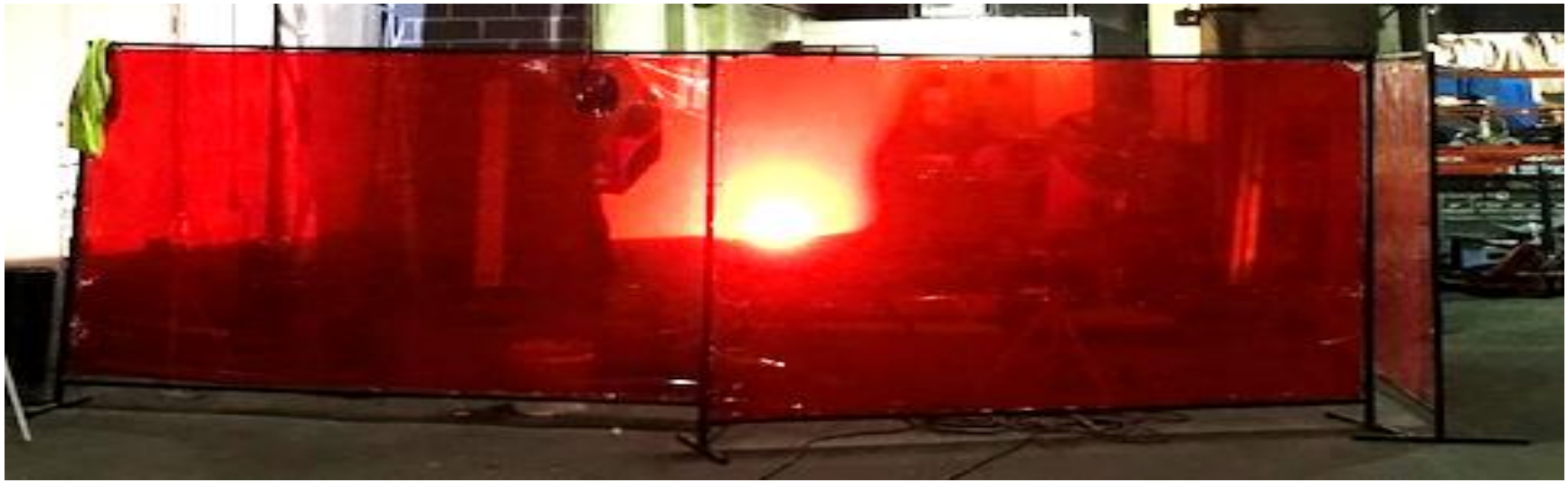


POST-BRAZING CHECK (NFPA 99- § 5.1.10.4.7)

- Washed with water and wire brush
- Visually inspected
  - Reject if:
    - Flux or flux residue
    - Base metal melted or eroded
    - Unmelted filler material
    - Filler metal not visible around entire joint
    - Cracks in tube or joint
    - Cracks in braze filler metal
    - Joint fails pressure test

Image courtesy Evergreen Medical

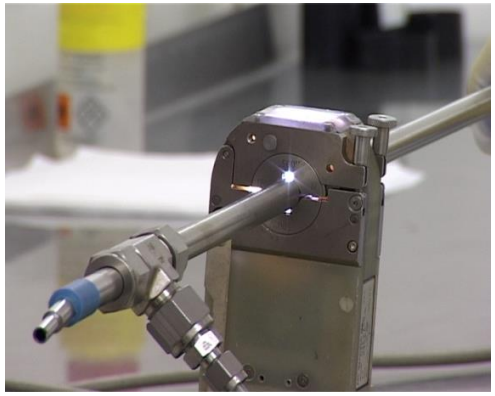
WELDING: SUCTION PIPE



- Welding joins metals by melting and fusing them together, usually with the addition of a welding filler metal.
- Joints produced are strong, usually as strong as the metals joined or even stronger.

WELDING RESTRICTIONS

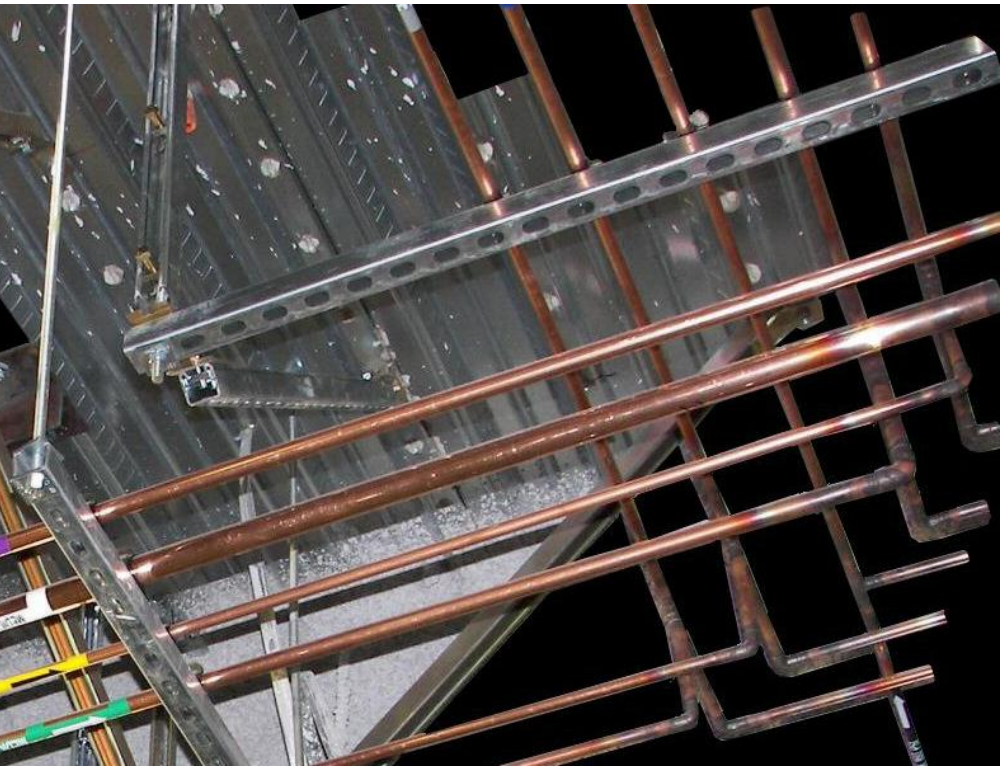
- Vacuum systems
- Gas-tungsten arc welding with orbital device
- Welder qualifications
  - ASME *Boiler and Pressure Vessel Code*



Courtesy GMCK Gallagher

Courtesy Westermans International

PIPE SUPPORT (NFPA 99- § 5.1.10.11.4)



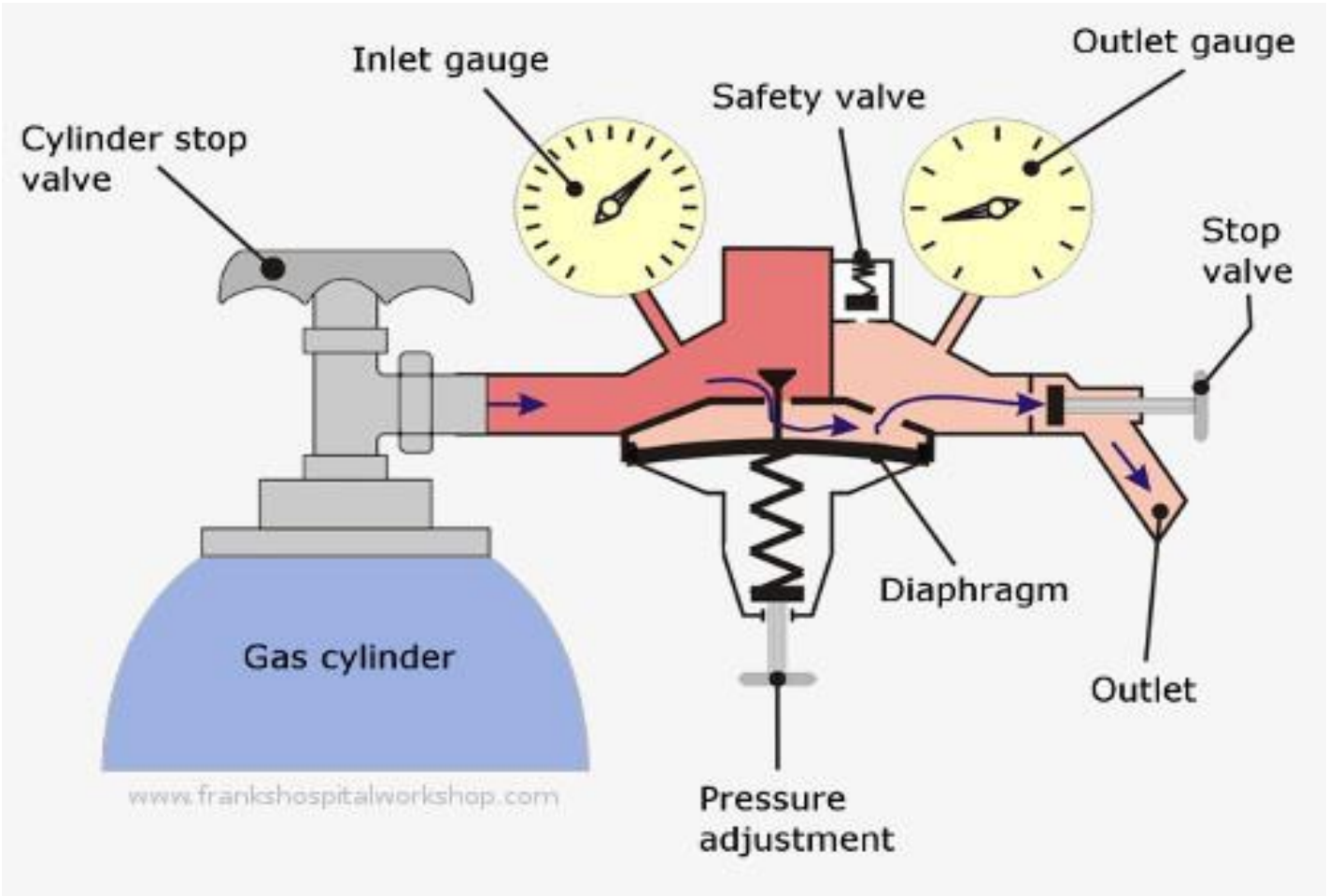
- Supported from building structure

Pipe Support Spacing Limits

Pipe Size			
Diameter Nominal (DN)	Nominal Pipe Size (in.)	Outside Diameter (in.)	Hanger Spacing (ft.)
DN 8	¼	3/8	5
DN 10	3/8	½	6
DN 15	½	5/8	6
DN 20	¾	7/8	7
DN 25	1	1 1/8	8
DN 32	1 ¼	1 3/8	9
DN 40 +	1 ½	1 5/8	10
Risers (all sizes)	Every floor, but not to exceed 15 feet		

VALVES

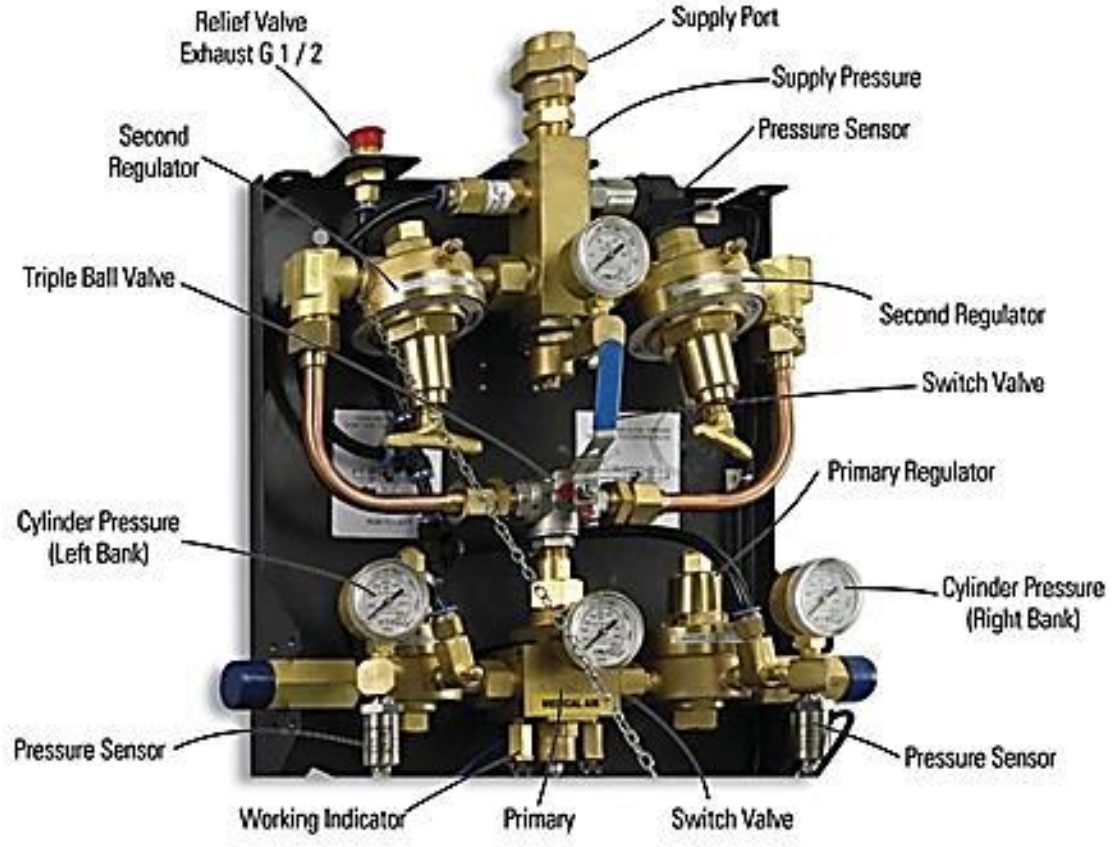
- Final line pressure regulators



RELIEF VALVES

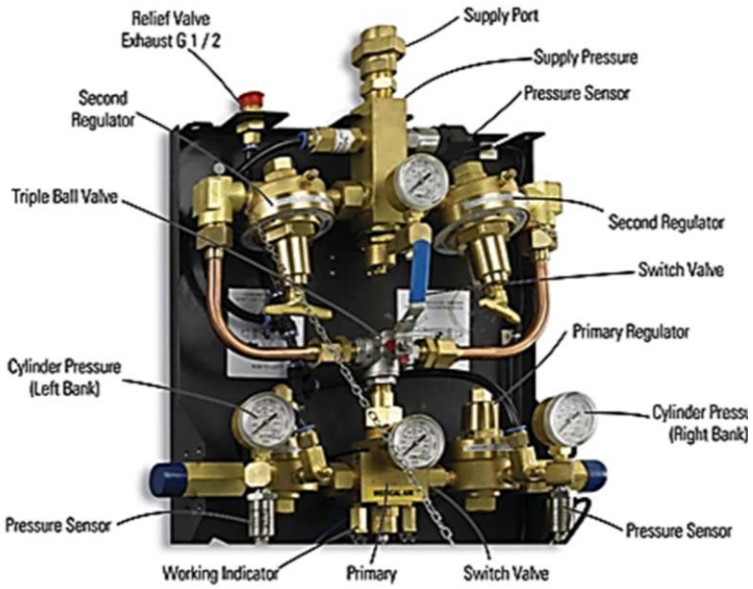
- Vented to exterior
  - Exception: compressed air at <3,000 ft^3 at STP
- Discharge capacity at least equal to relief outlet
  - If two or more, not less than aggregate cross section of all vents
- Vent to non-hazardous locations
- Vent outlet turned downward
- Meet *ASME B31.2 Pressure Process Piping*

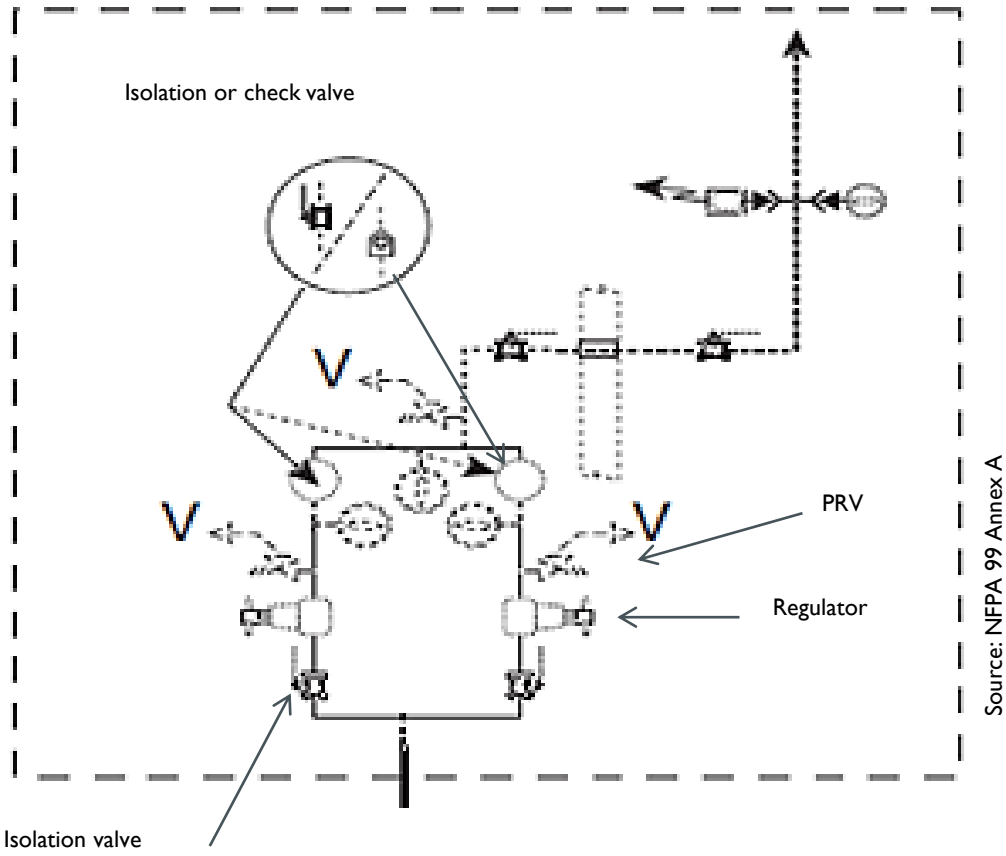
MANIFOLDS



Courtesy MMA Korea

"FINAL LINE CONTROLS"





Source: NFPA 99 Annex A

MEDICAL AIR

- Human respiration and device calibration only
- Equipment
  - Compressors
  - Air drying equipment
  - Medical gas receiver

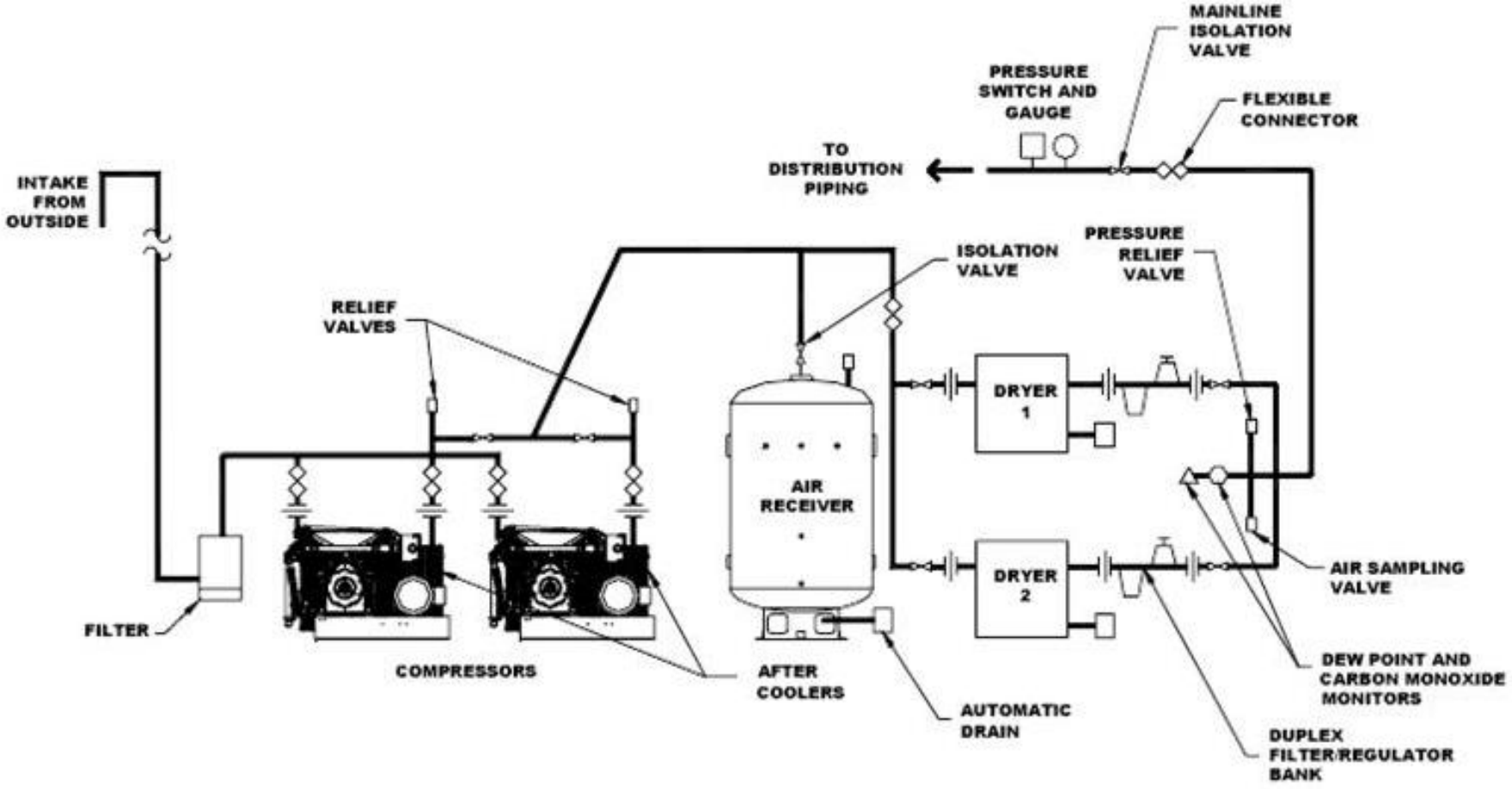
DEHUMIDIFIER

INSTRUMENT AIR

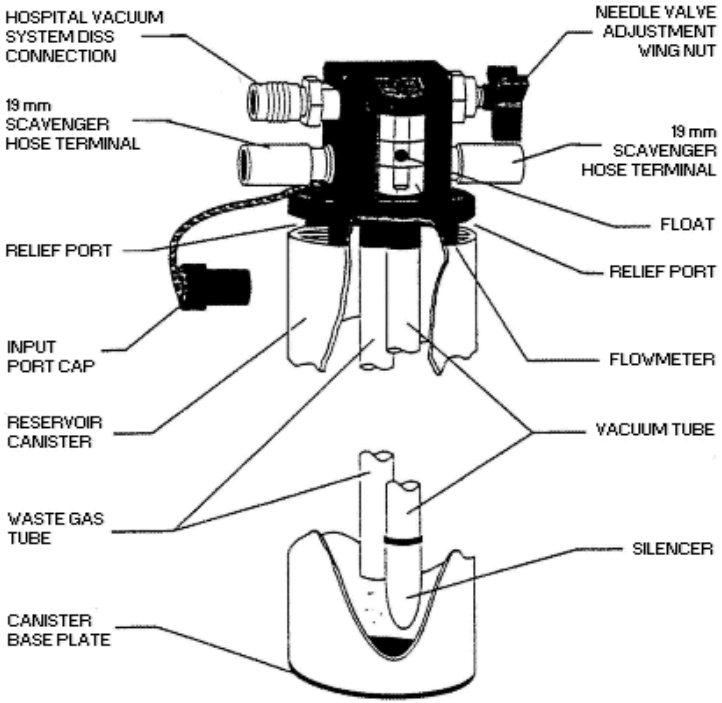
Image courtesy News Medical Life Sciences

- Medical devices unrelated to respiration:
  - Surgical saws
  - Drills
  - Reamers

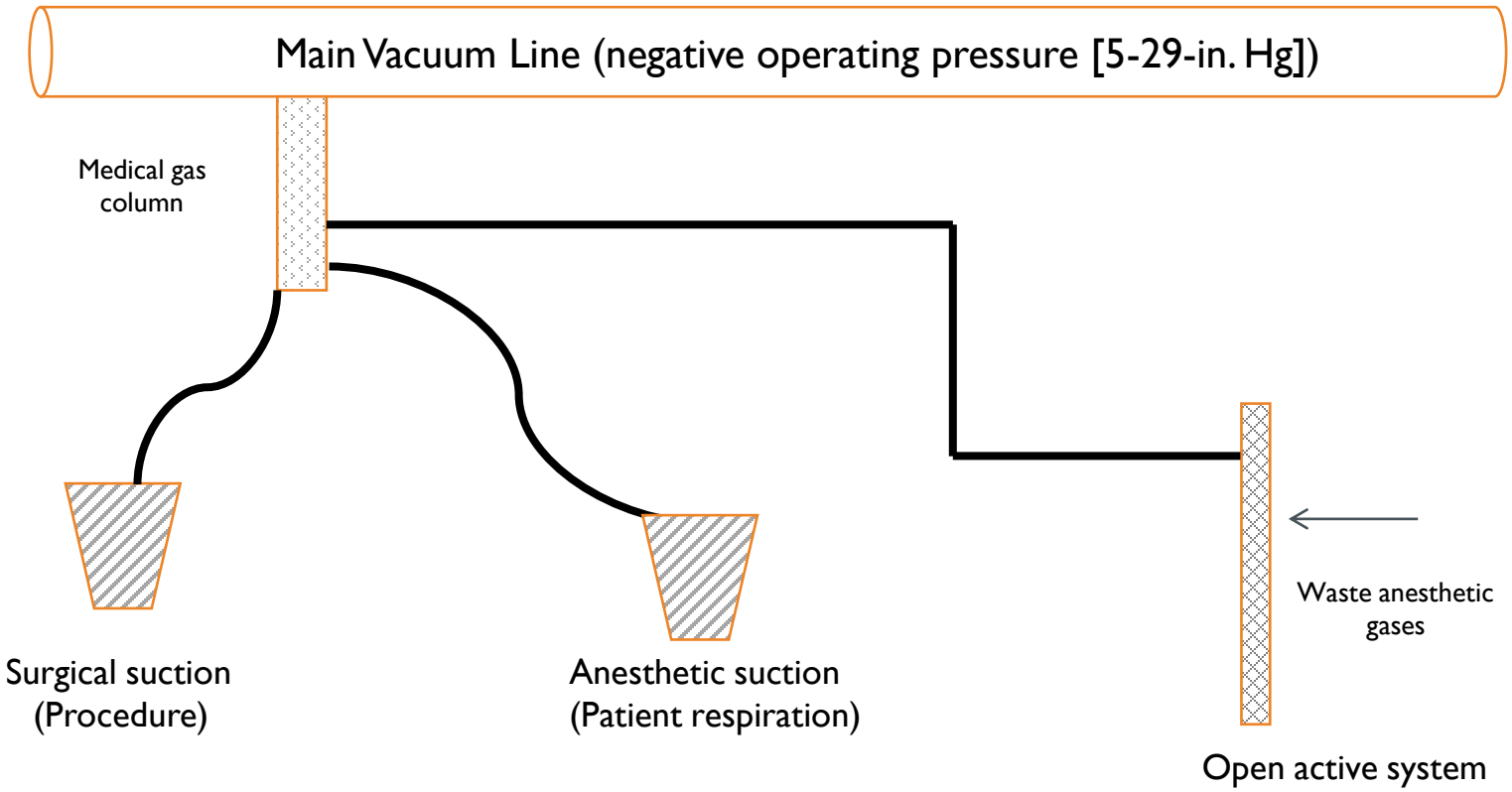
INSTRUMENT AIR



VACUUM/SUCTION



ANESTHETIC GAS SCAVENGING



WASTE ANESTHETIC GAS DISPOSAL

- Collects waste gases and exhaust to outdoors
  - Operational redundancy required
  - Equipment installed to avoid pressure drops

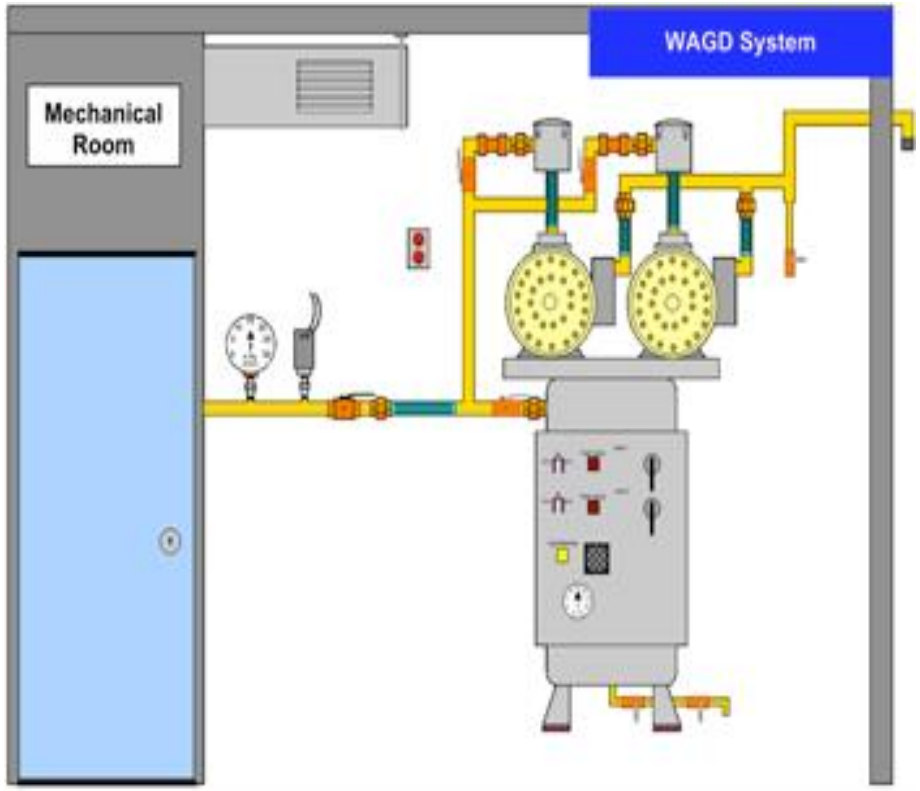
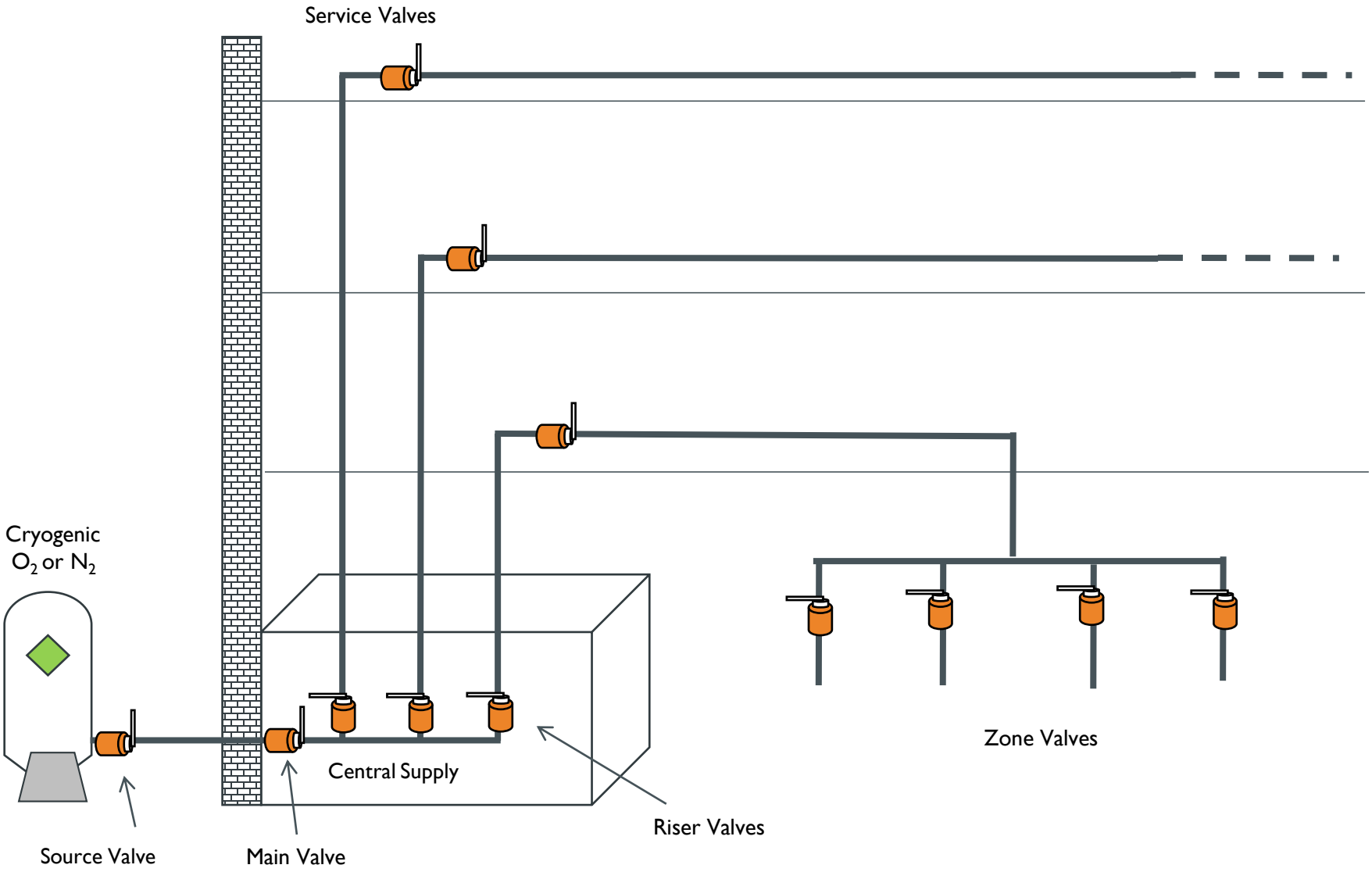


Image courtesy MGC (Medical Gas Certifications)

EMERGENCY CONTROL VALVES

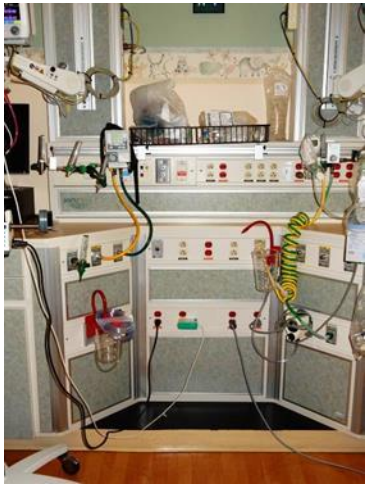
- Source
- Main line
  - Where enters building
- Riser
  - Each riser from mainline
- Service
  - Allow service or modification of lateral branch lines
    - Behind locked door
    - Above ceiling
    - Locked open in secure area


Service Valves
Cryogenic
O_2 or N_2
Central Supply
Zone Valves
Riser Valves
Source Valve
Main Valve

ZONE VALVES

- Immediately outside:
  - Vital life-support area
  - Critical care area
  - Moderate, deep sedation area
  - General anesthesia area
- Placed in wall
  - Serve only outlets/inlets on same story
  - Not located in room with outlets/inlets it controls

PATIENT DISTRIBUTION OUTLETS



MODULE # 3

BUILDING CONSTRUCTION

MEDICAL GAS SYSTEM LIMITS

- NFPA 99-§ 5.1.3.5.2
- Central supply permitted to be piped only for gases used under direct medical supervision for:
  - Direct patient care
  - Medical devices for respiration
  - Power for patient medical devices
  - Calibration for these items

Image courtesy GE Healthcare

LOCATIONS (NFPA 99- §5.1.3.3.6)

Indoor central supply locations for oxygen and nitrous must not communicate with:

- Critical patient care areas (ICU/CCU/ER)
- Anesthetizing areas
  - Deep, moderate or general sedation
- Locations storing flammables
- Flam/com liquid storage tanks
- Rooms with open electrical contacts or transformers
- Engines
- Kitchens
- Areas with open flames

GENERAL ENVIRONMENT

- Access by delivery vehicles and for cylinder management
- Temperature control < 130°F
  - Indirectly heated (steam/ hot water)
  - Nitrous and carbon dioxide not lower than -20°F
- Lockable doors or gates
- Electrical Code compliance
- Warning signs

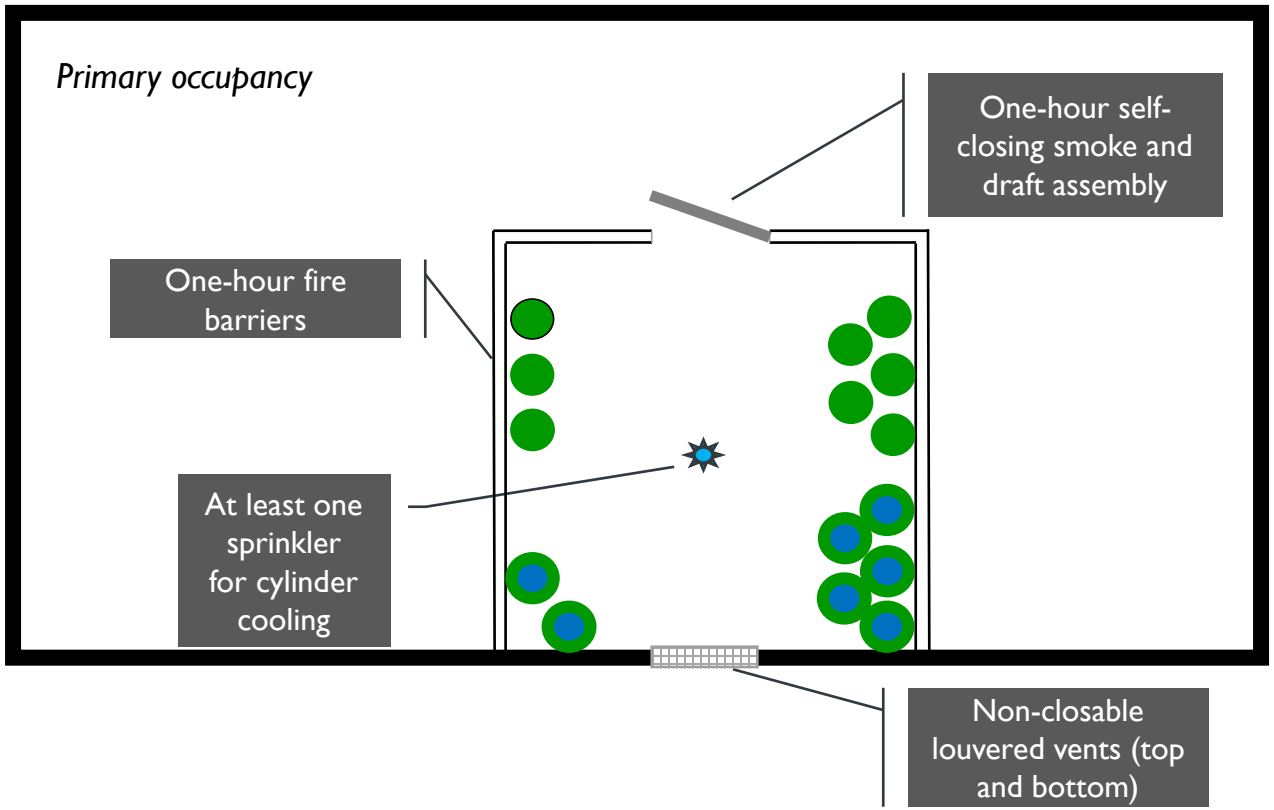
GAS CABINETS IFC®§ 5306.2.3

- See § 5003.8.6
- Not less than 0.097-inch (12-gage) steel
  - Self-closing limited access ports or non-combustible windows
  - Self-closing doors
  - Interior compatible with stored products
  - Negative pressure ventilation
- Average velocity across access ports or windows not less than 200 fpm with not less that 150 fpm at any point
- Connected to exhaust system
- Internally sprinklered

Image courtesy of O.E. Mayer Co.

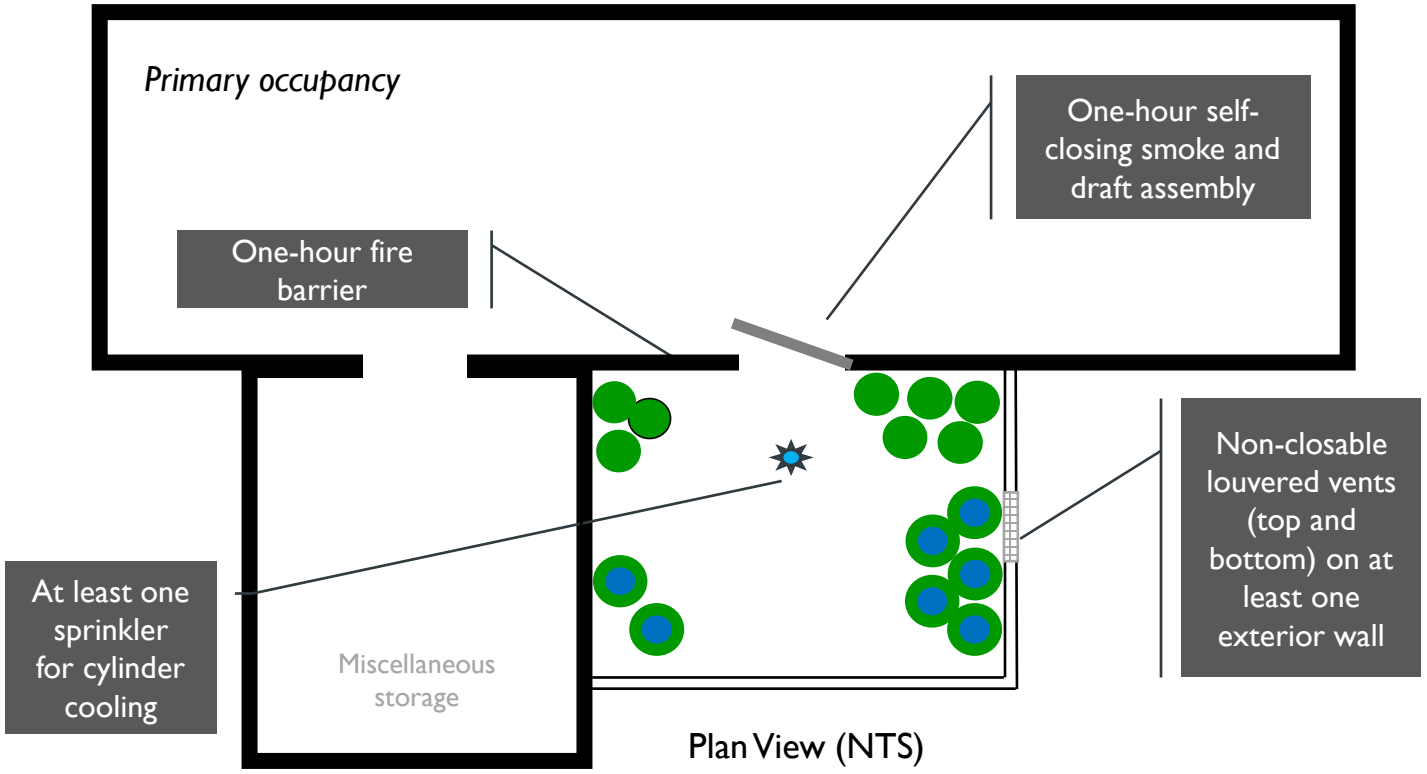
Image courtesy of Safety Cabinets

ONE-HOUR EXTERIOR ROOM § 5306.2.1

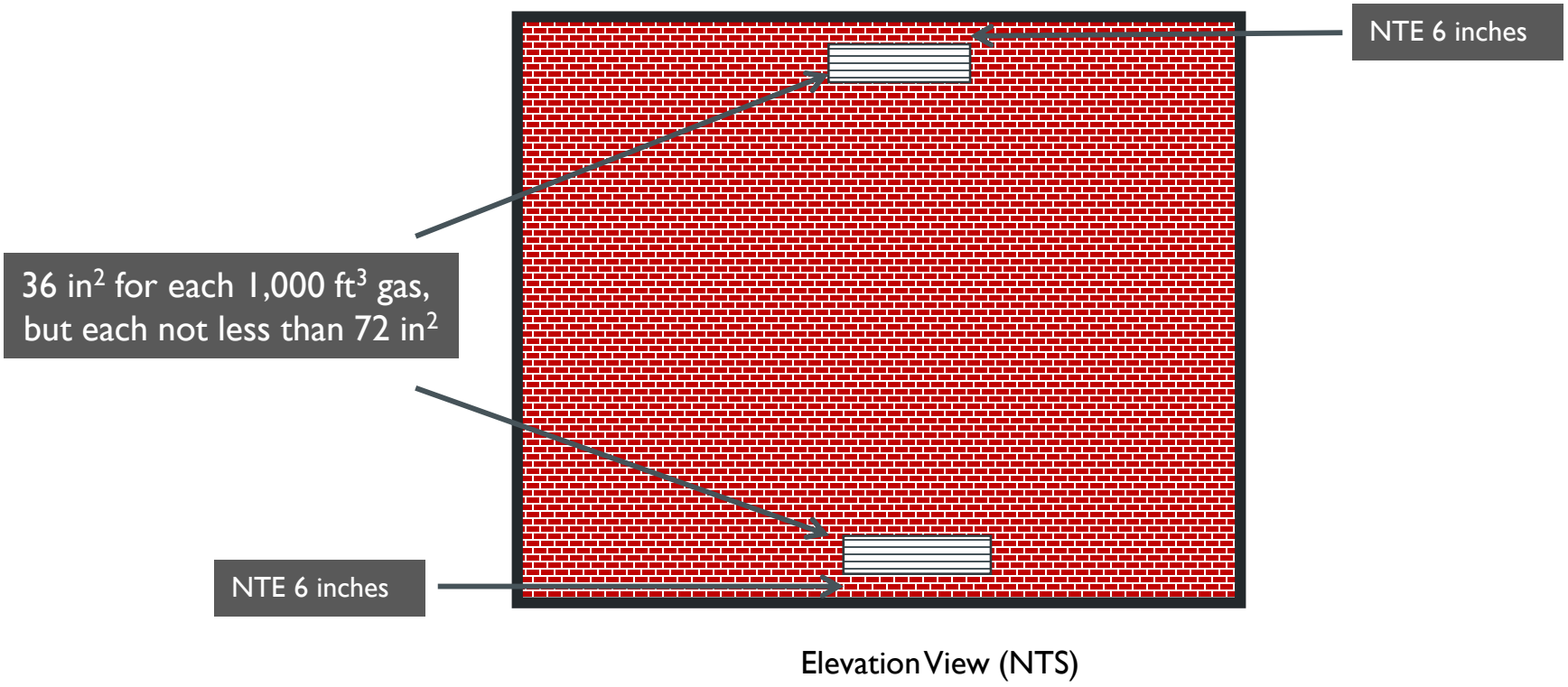


Plan View (NTS)

ONE-HOUR EXTERIOR ROOM § 5306.2.1



OPEN LOUVERED VENTS § 5306.2.1



Elevation View (NTS)

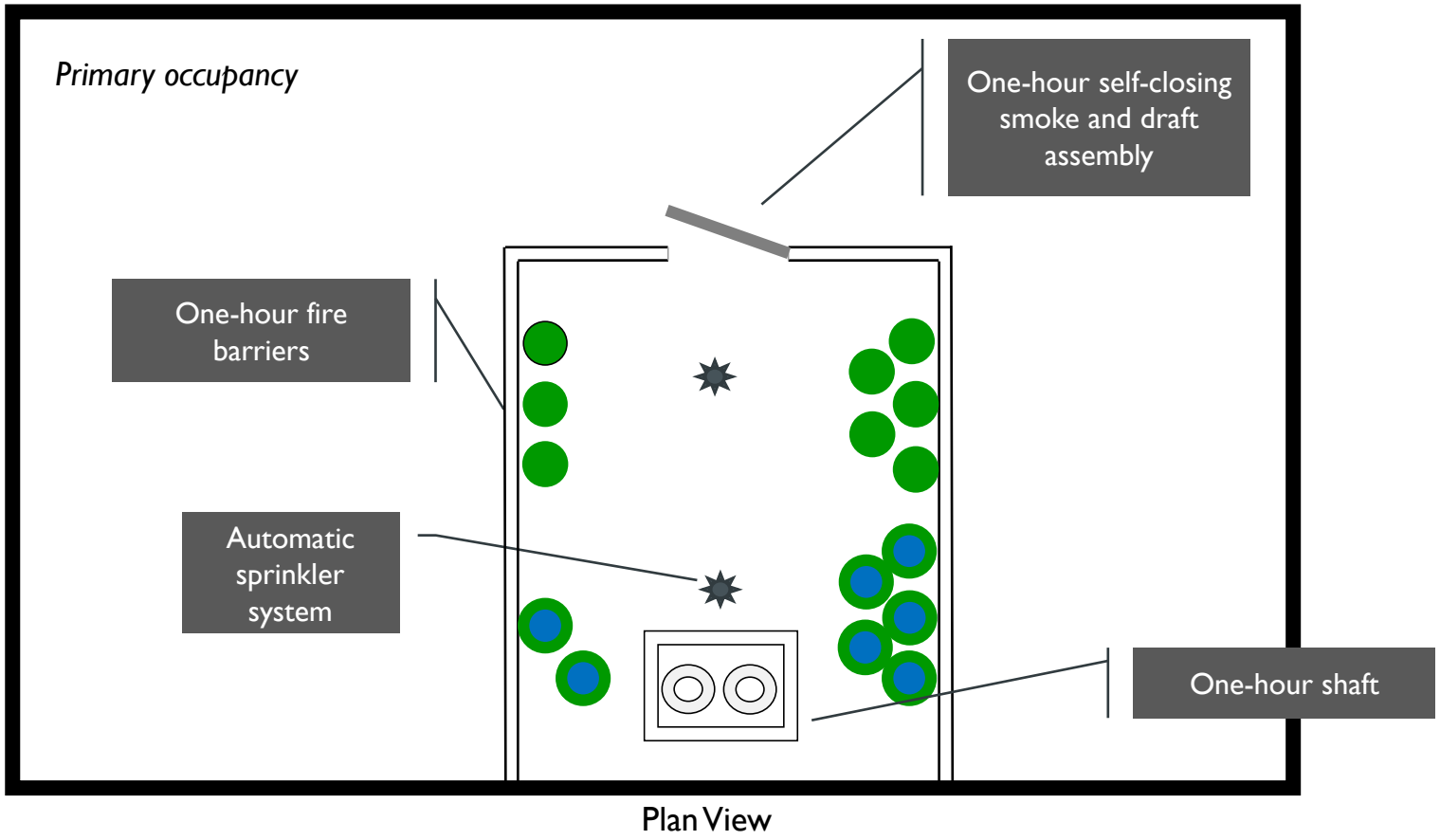
Activity

EXTERIOR ROOM VENTILATION

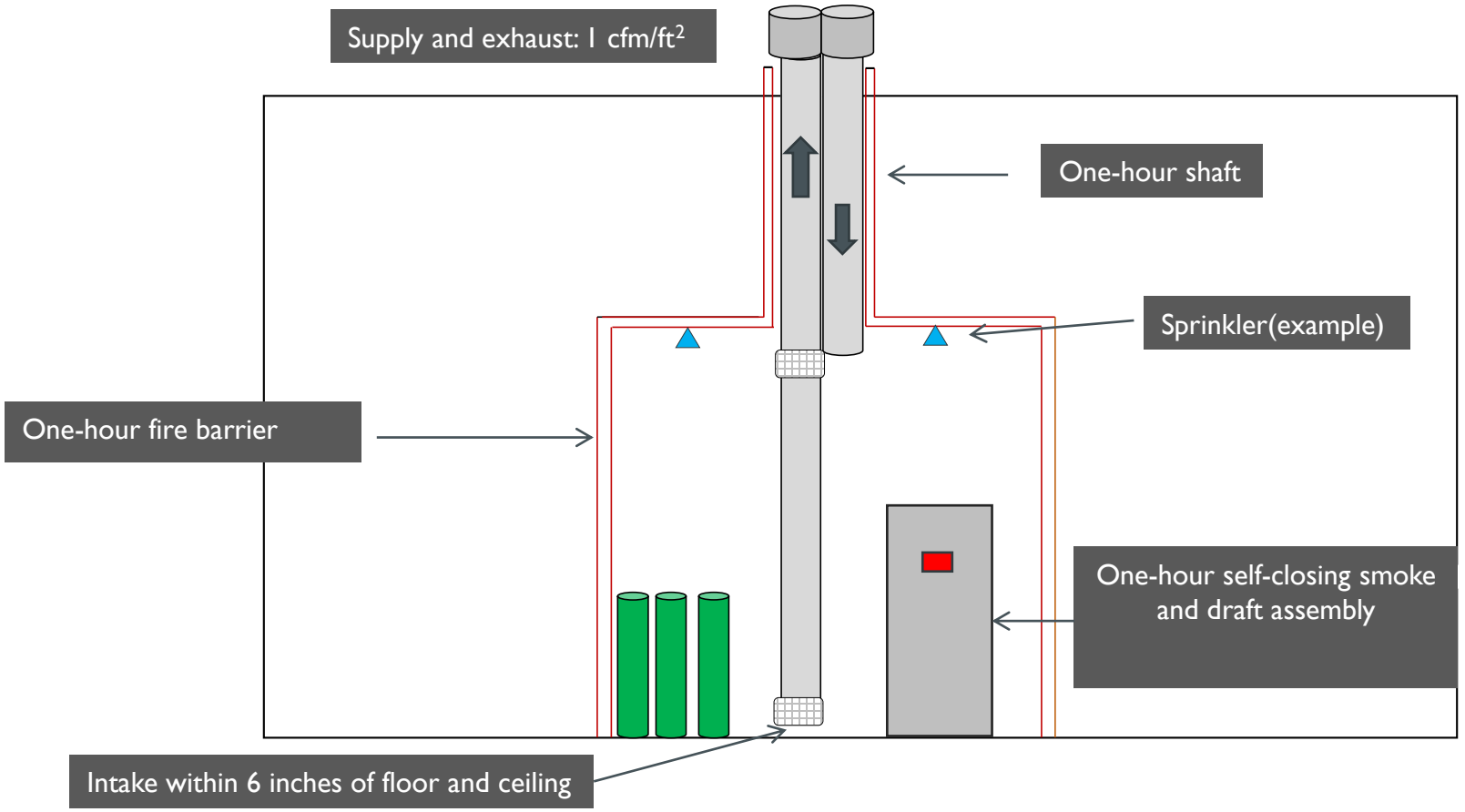
Q: Client wants to store 12,000 ft^3 of oxygen in exterior storage room. What is minimum area of each vent, in square inches?

A:

ONE-HOUR INTERIOR ROOM § 5306.2.2



ONE-HOUR INTERIOR ROOM § 5306.2.2



Section View

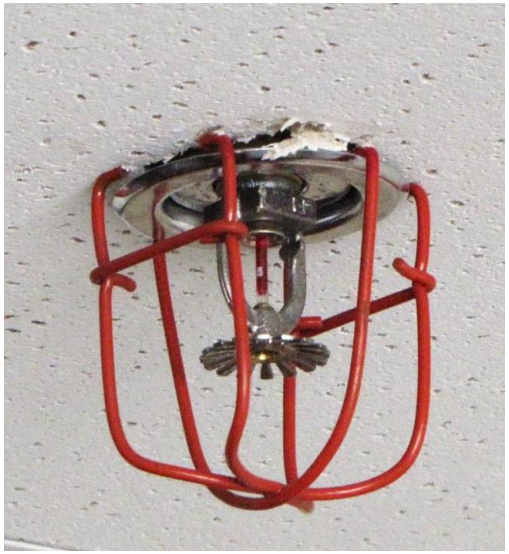
Activity

INTERIOR ROOM VENTILATION

Q: Client wants to build a 12 x 12-foot one-hour interior room for 3,000 ft^3 of oxygen, nitrogen and nitrous oxide. What is the minimum total exhaust rate required for the room?

A:

SPRINKLER PROTECTION



- Exterior rooms §5306.2.1
  - "Rooms shall be provided with not less than one automatic sprinkler to provide container cooling in case of a fire."
- Interior rooms §5306.2.2
  - "An automatic sprinkler system shall be provided for the room."

Discussion

SPRINKLER PROTECTION

In an otherwise unsprinklered building with a 100 sq. ft. interior medical gas storage room

- What minimum sprinkler design criteria would you allow
- Why?

OUTDOOR LOCATIONS

- IFC § 6304.2.1

Gas Quantity (ft^3/NTP)	Distance to Building *Not* Associated with Distribution; Public Way or Buildable Lot Line (feet)	Distance Between Storage Areas (feet)
0-50,000	5	5
50,001-100,000	10	10
100,001 or more	10	10

Note: Distances do not apply where two-hour fire barriers without openings or penetrations interrupt line of sight between storage and exposure.

MODULE # 4

INSPECTION, COMMISSIONING AND MAINTENANCE

ACCEPTANCE/COMMISSIONING (CONTRACTOR)

- Pipe blowdown
  - Oil-free dry nitrogen NF (non-flammable)
- Initial pressure test
  - 1.5 times system operating, but not less than 150 psi
  - All joints leak tested (safe for use with O_2 does not contain NH_3)

Image courtesy Evergreen Medical

COMMISSIONING (CONTRACTOR)

- Initial cross-connection test
  - Each line tested individually
- Initial pipe purge
  - No discoloration of clean white cloth

COMMISSIONING (CONTRACTOR)

- Standing vacuum test
  - 24-hour standing vacuum test between 12 inches and full vacuum

VERIFICATION (THIRD PARTY)

Image courtesy SC Medical

Image courtesy Evergreen Medical

- Standing pressure
- Cross-connection
- Alarms
- Pipe purge
- Pipe particulates

INSPECTION/MAINTENANCE (IFC® § 5306.5)

- NFPA 99-5.1.14.2
- Risk-assessment based inspection and maintenance schedule and procedures
  - Manufacturer's recommendations
  - Code official's requirements
- Minimum one-year frequency recommended

INSPECTION – TESTING - MAINTENANCE

- Medical air source
  - Room temperature
  - Filter condition
  - Presence of contaminants
  - Room ventilation and air intake
  - Air purity
  - Exhaust locations
- Manifolds
  - Ventilation
  - Labeling
  - Valve labeling
  - Alarms and warning systems
  - Each station outlet/inlet
    - Flow
    - Labeling
    - Leaks

Discussion

PERMITTING

Should a maintenance plan be a condition of the IFC®- required operational permit?

SUMMARY

1. Explain the *International Fire Code*® construction and operating permit requirements for medical gases and systems.
2. Interpret line drawings of simple medical gas systems to verify components are installed correctly.
3. Summarize construction requirements for interior and exterior one-hour rooms for medical gas storage.
4. Interpret line drawings of simple medical gas systems to verify components are installed correctly.
5. Summarize construction requirements for interior and exterior one-hour rooms for medical gas storage.
6. Apply the requirements of IFC® Chapter 53 for medical gases to plan review and inspections.

QUESTIONS/COMMENTS?

THANK YOU FOR YOUR PARTICIPATION

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