Thank You for Attending Today's Webinar

Your Host

Mike DeLacluyse
President
Lesman Instrument Company
miked@lesman.com

Today's Featured Speaker

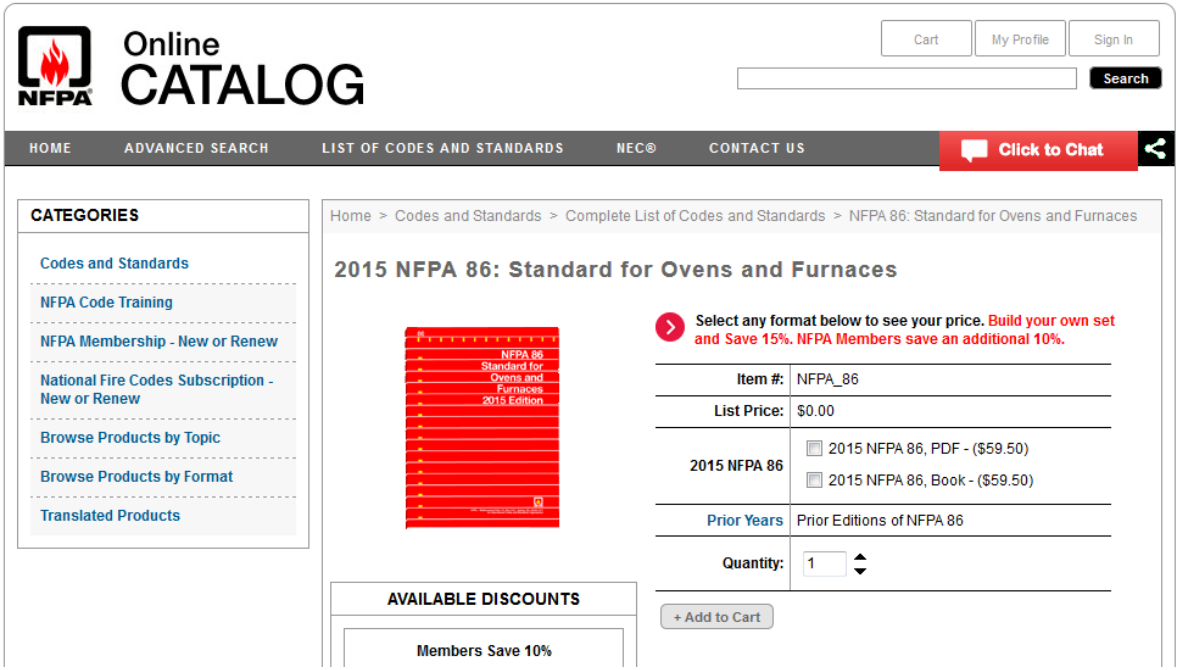
A.J. Piskor
Combustion & Controls Specialist
Lesman Instrument Company
ajp@lesman.com

Fuel Trains 101

- Topics we will cover today:
  - Components within the Fuel Train
  - Arrangement of Components
  - Best Practices for each component
  - Valve Proving vs. Vent Valve
  - Leak Testing for Shut-Off Valves
  - Your Questions

Fuel Trains 101

- NFPA 86 Standard for Ovens and Furnaces 2015 Edition



- Go to nfpa.org and search their online catalog
- $59.50 for PDF or Book, NFPA Members save 10%

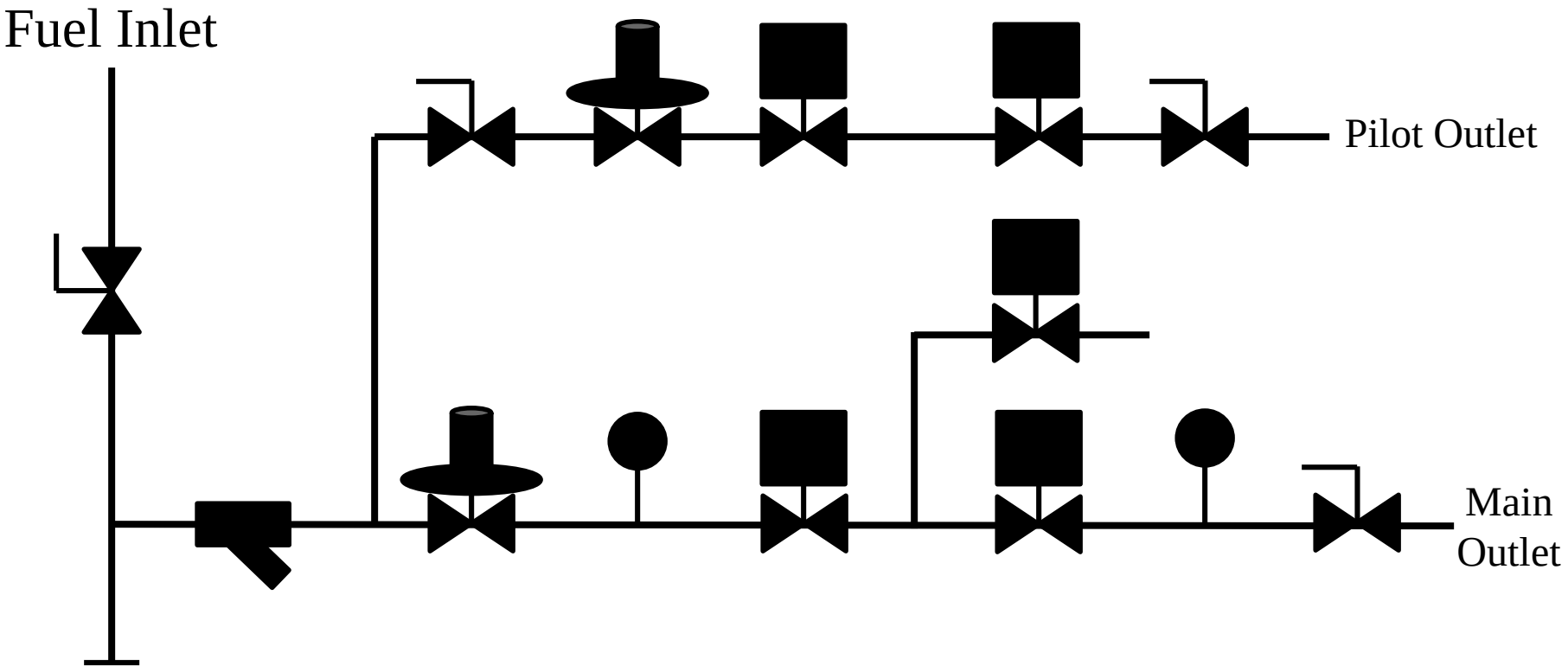
Common Themes within NFPA 86

- Devices shall be listed for the service intended.
  - Can't use an air switch on a gas line.
- Devices shall be applied and installed in accordance with the manufacturer's instructions.
  - Same applies for maintenance.

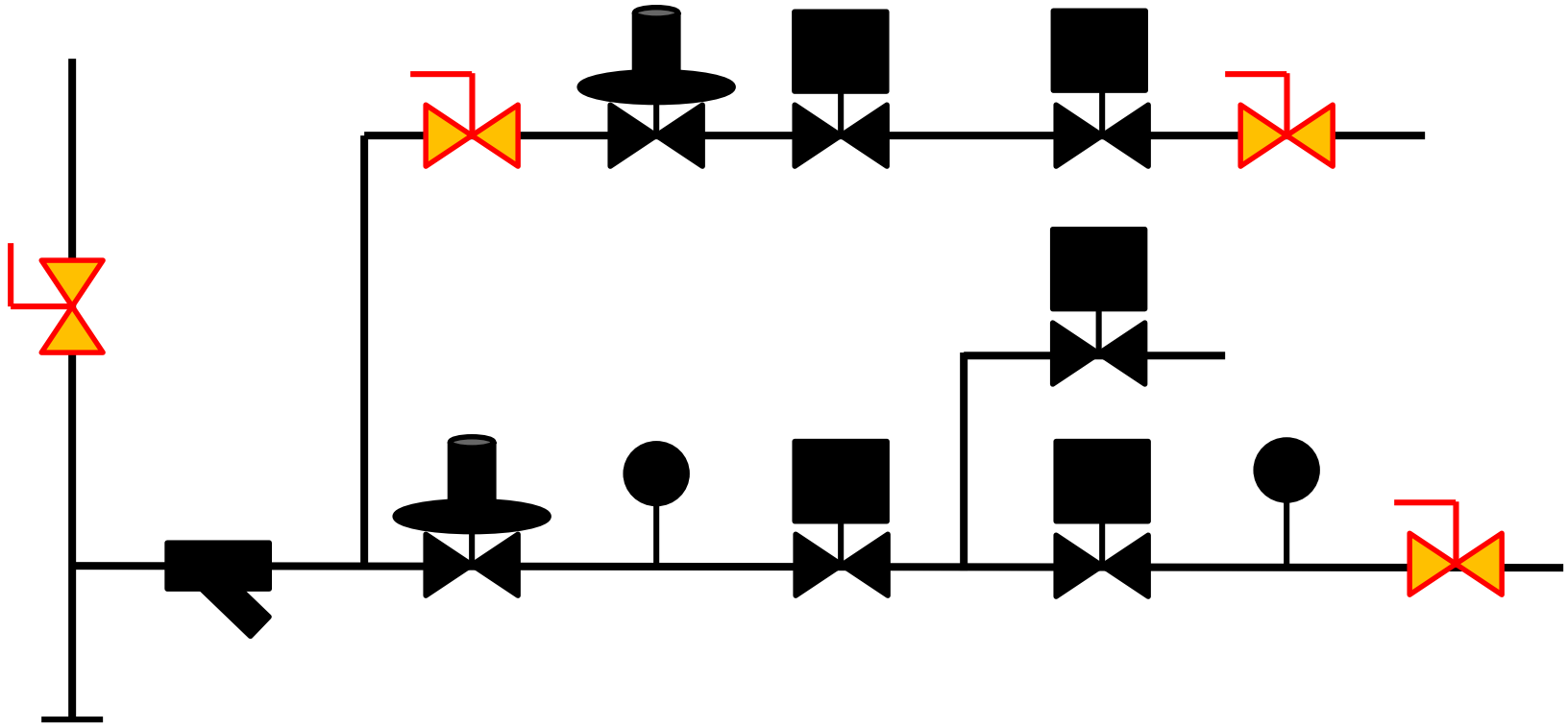
What is the purpose of a Fuel Train?

- The main purpose of a Fuel Train is to safely introduce and interrupt the fuel supply to the burner by:
  - Regulating the Fuel Pressure
  - Monitoring the Fuel Pressure
  - Turning the Fuel ON and OFF

Standard Fuel Train Arrangement



Equipment Isolation / Manual Shutoff Valves



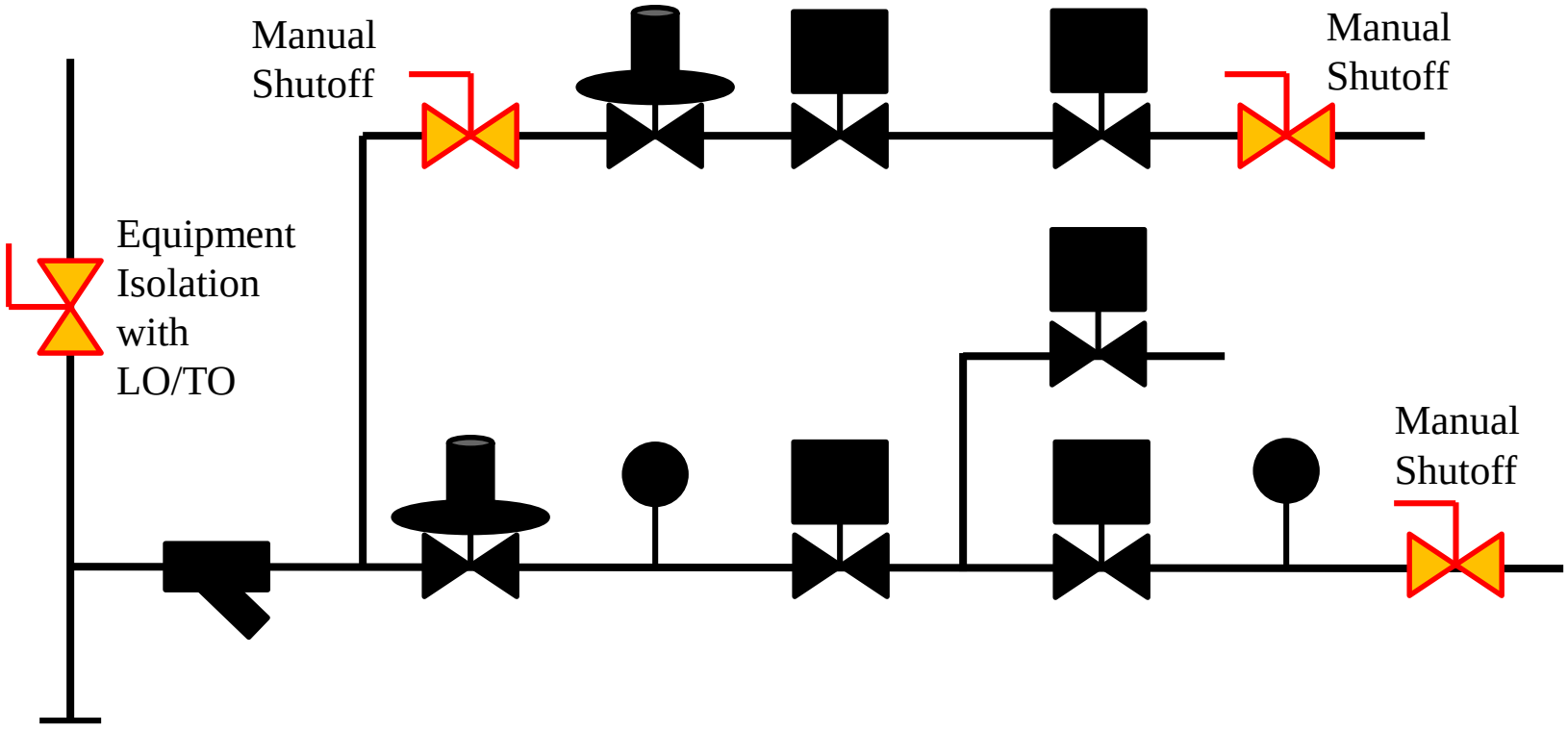
Equipment Isolation / Manual Shutoff Valves

- **NFPA 86 3.3.78.3 Equipment Isolation Valve.** A manual shutoff valve for the shutoff of the fuel to each piece of equipment.
- **NFPA 86 3.3.78.4 Emergency Shutoff Valve.** A manual shutoff valve to allow the fuel to be turned off in an emergency.

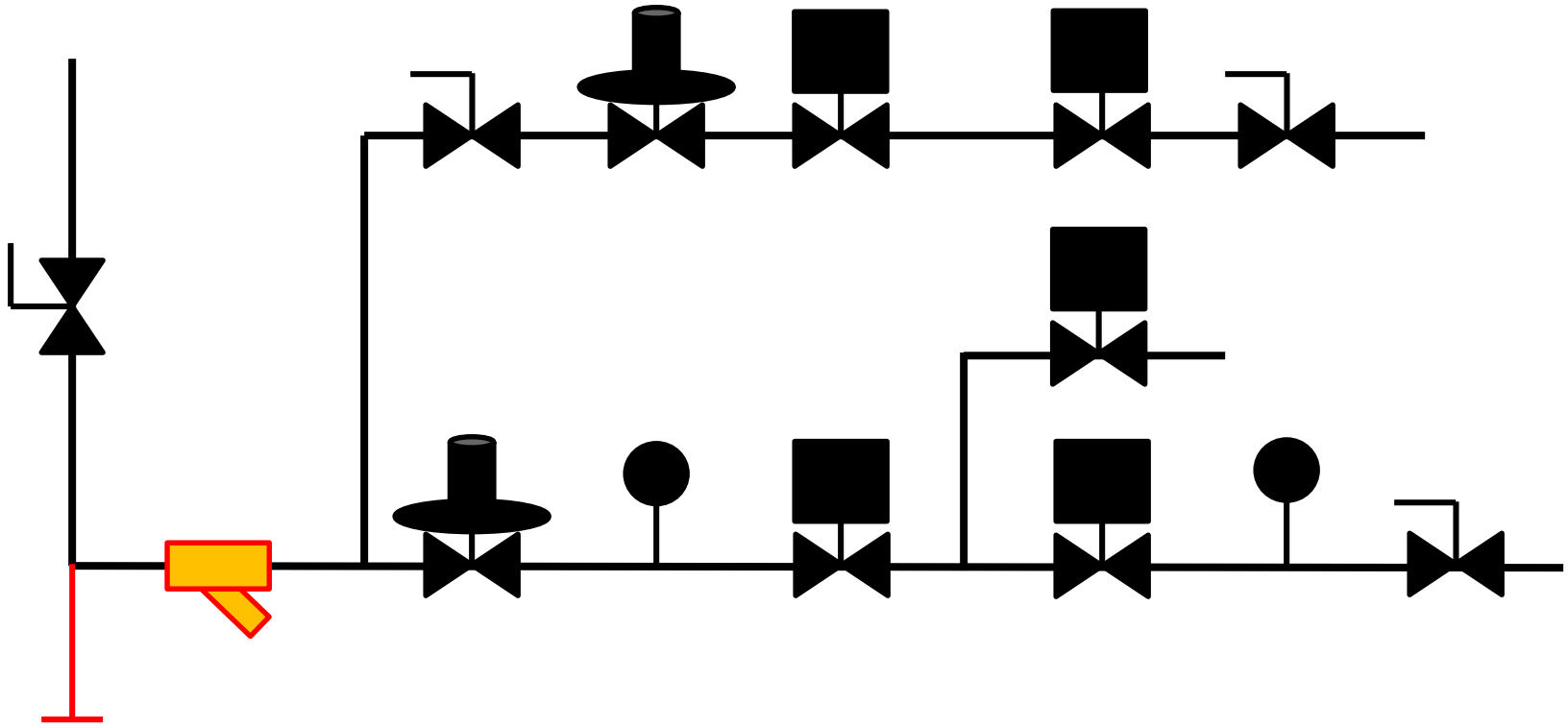
Equipment Isolation / Manual Shutoff Valves

- For both Equipment Isolation and Emergency Shutoff, the following shall apply (**NFPA 86 6.2.3**):
  - They shall be readily accessible.
  - They shall have permanently affixed visual indication of the valve position.
  - They shall be able to be operated from full open to full close and return without the use of tools.
- These are typically quarter-turn valves with stops.

Equipment Isolation / Manual Shutoff Valves

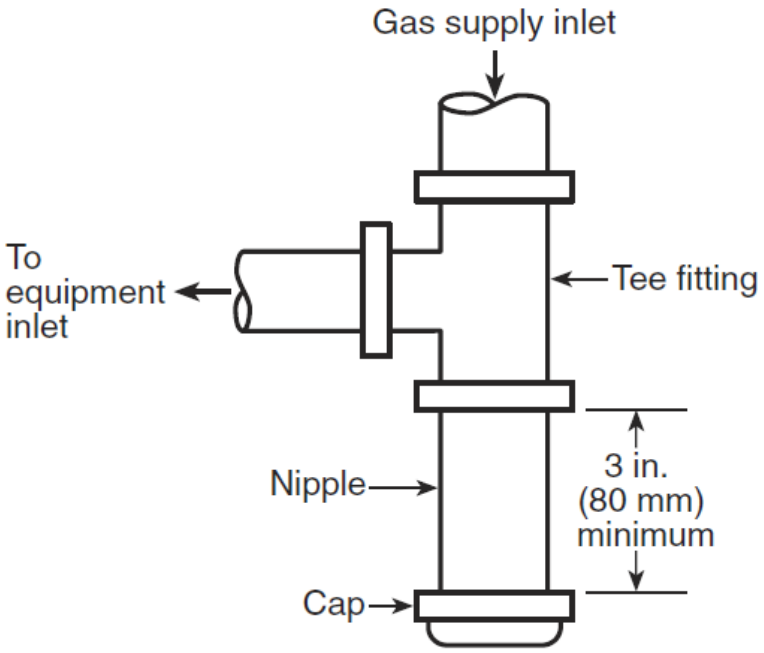


Sediment Trap (Drip Leg) and Y-Strainer



Sediment Trap (Drip Leg)

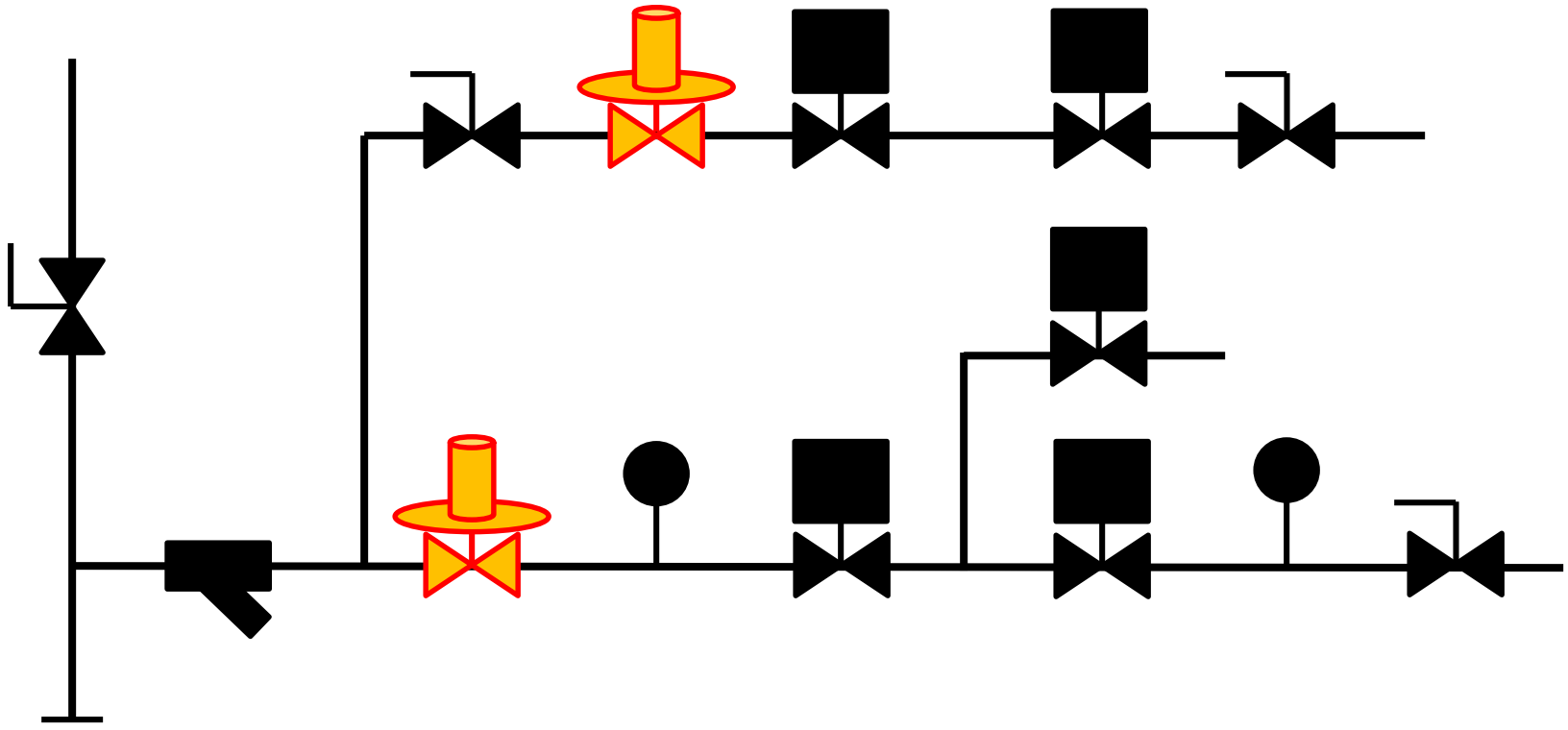
- **NFPA 86 6.2.5.2** Sediment traps shall have a vertical leg with a minimum length of three pipe diameters (minimum of 3 in.) of the same size as the supply pipe.
- Main purpose is to catch any larger particulate matter and/or condensation in fuel supply.
- Can install “blow-down” valve at the bottom of the trap for easy cleaning.



Y-Strainer / Gas Filter

- **NFPA 86 6.2.5.3** A gas filter or strainer shall be installed in the fuel gas piping and shall be located downstream of the equipment isolation valve and sediment trap and upstream of all other fuel gas system components.
- Captures smaller particulate matter that got past the sediment trap.
- Can also have a “blow-down” valve for easy cleaning.

Pressure Regulators



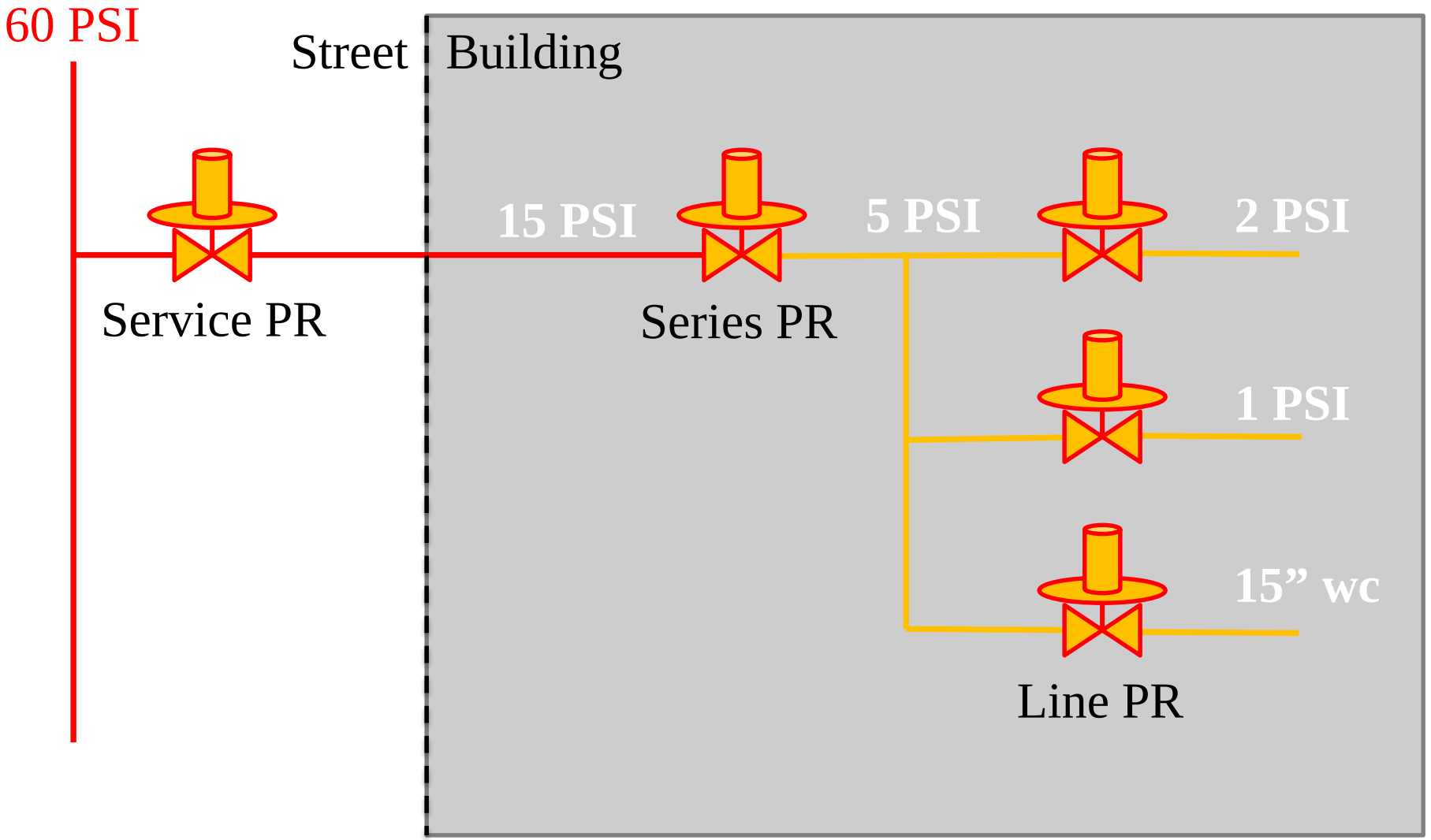
Pressure Regulators

- **NFPA 86 3.3.54 Pressure Regulator.** A device placed in a gas line for reducing, controlling, and maintaining the pressure in that portion of the piping system downstream of the device.
  - **3.3.54.1 Line Pressure Regulator.** A pressure regulator placed in a gas line between the service regulator and the appliance (equipment) regulator.
  - **3.3.54.2 Monitoring Pressure Regulator.** A pressure regulator in a nonregulated state and set in series with another pressure regulator for the purpose of automatically taking over, in an emergency, control of the pressure downstream of the regulator in cases where pressure exceeds a set maximum.

Pressure Regulators (cont.)

- **3.3.54.3 Series Pressure Regulator.** A pressure regulator in series with one service or line pressure regulator.
- **3.3.54.4 Service Pressure Regulator.** A pressure regulator installed by the servicing gas supplier to reduce and limit the service line gas pressure to delivery pressure.

Regulator Arrangement Example



Overpressure Protection

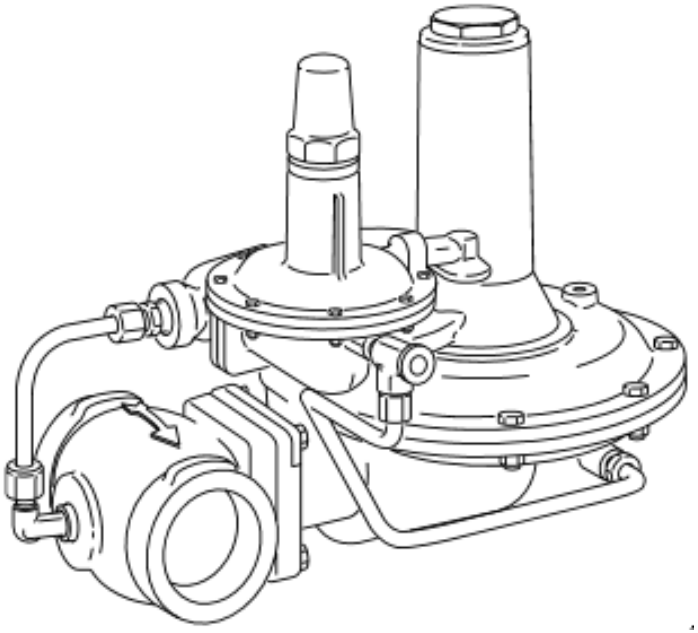
- **NFPA 86 6.2.7.1** Overpressure protection shall be provided in either of the following cases:
  - (1) When the supply pressure exceeds the pressure rating of any downstream component
  - (2) When the failure of a single upstream line regulator or service pressure regulator results in a supply pressure exceeding the pressure rating of any downstream component.

Overpressure Protection

- **NFPA 86 6.2.7.2** Overpressure protection shall be provided by any one of the following:
  - (1) A series regulator in combination with a line regulator or service pressure regulator
  - (2) A monitoring regulator installed in combination with a line regulator or service pressure regulator
  - (3) A full-capacity pressure relief valve
  - (4) An overpressure cutoff device, such as a slam-shut valve or a high-pressure switch in combination with an adequately rated shutoff valve

Pressure Regulators – Best Practices

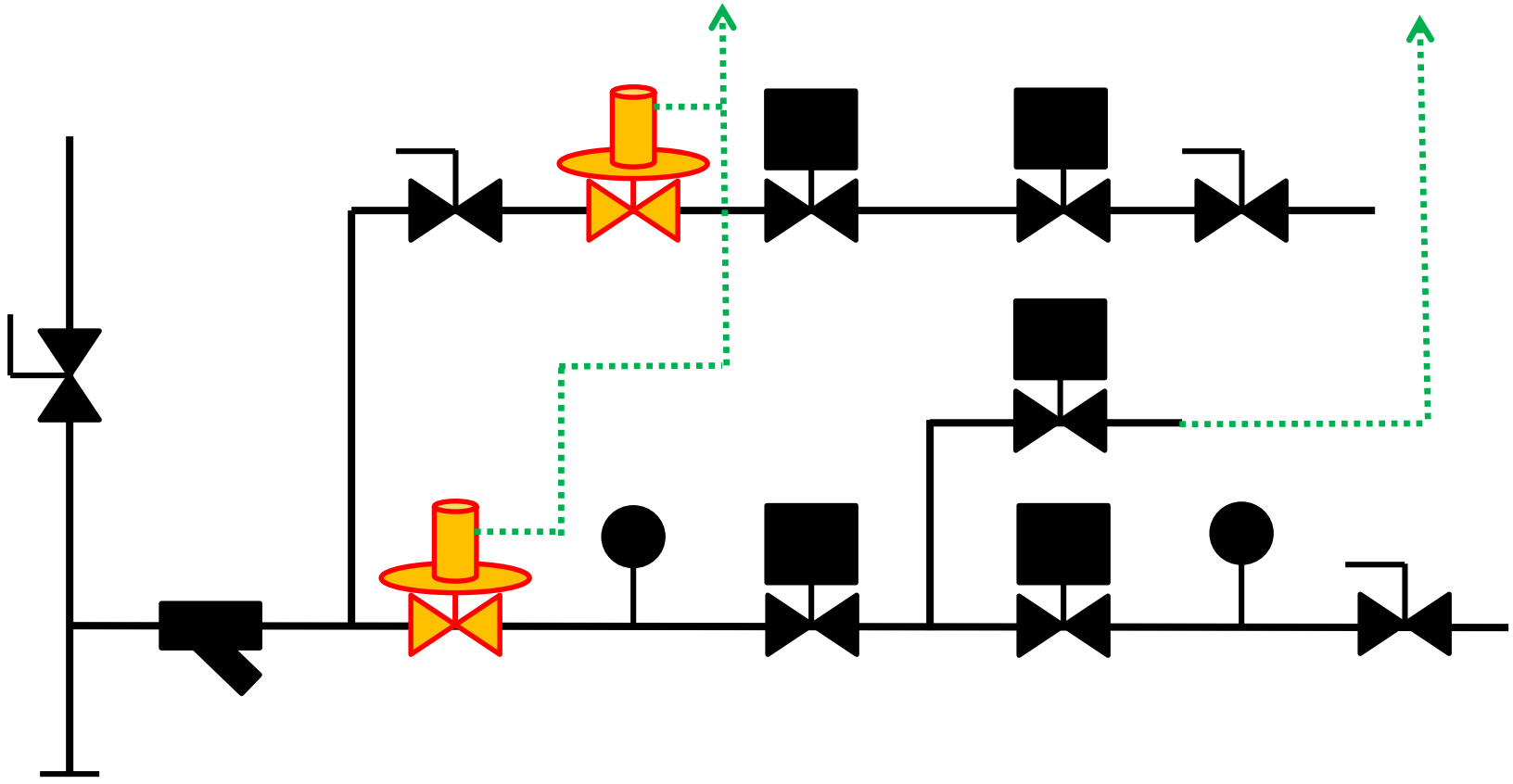
- For high inlet pressures (over 15 PSIG) and low outlet pressures (under 1 PSIG), consider using a piloted regulator.
- Piloted regulators have internal sensing, eliminating the need for long downstream sensing lines.
- Typically react faster to flow changes versus downstream sensing regulators.



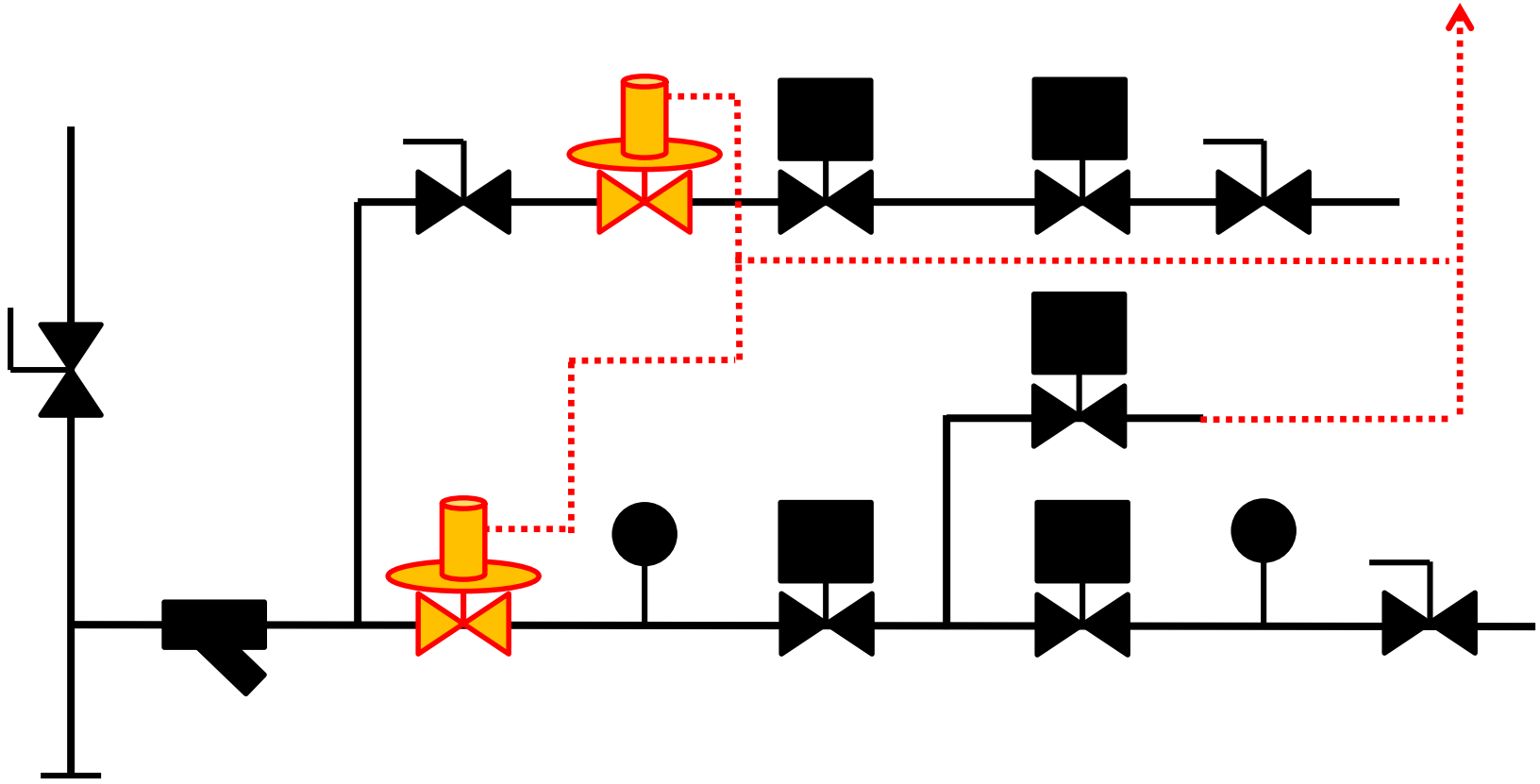
Pressure Regulators – Best Practices

- Adjustment springs come in a wide range of operation and are usually low cost, I recommend getting extra springs for potential adjustments in the future.
- For regulators that have a vent connection, you can couple multiple regulator vents (main and pilot for example) into a common vent line, but you CANNOT tie a regulator vent into the discharge of a vent valve.
- See NFPA 86 6.2.6 for additional info.

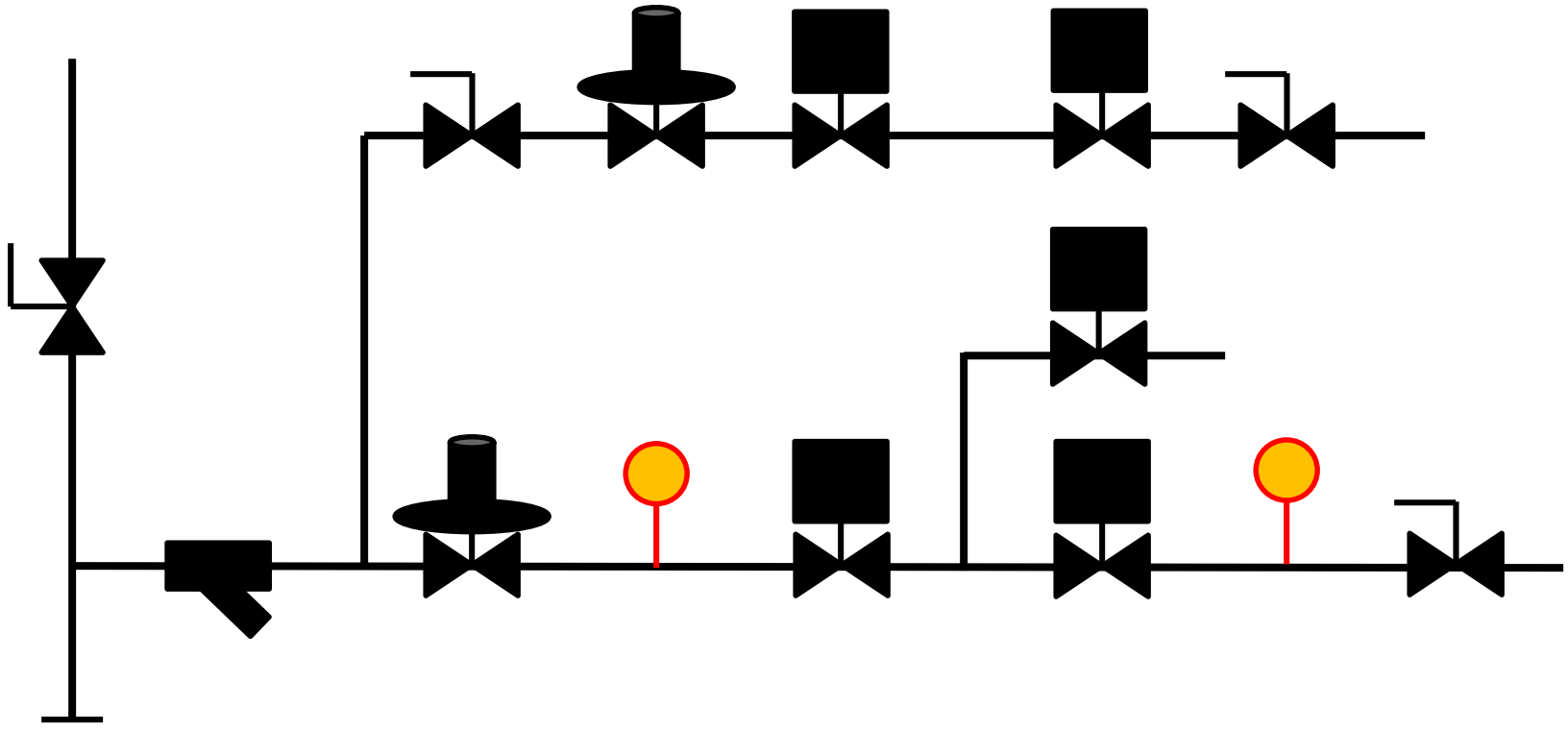
Proper Venting of Regulators



Incorrect Venting of Regulators



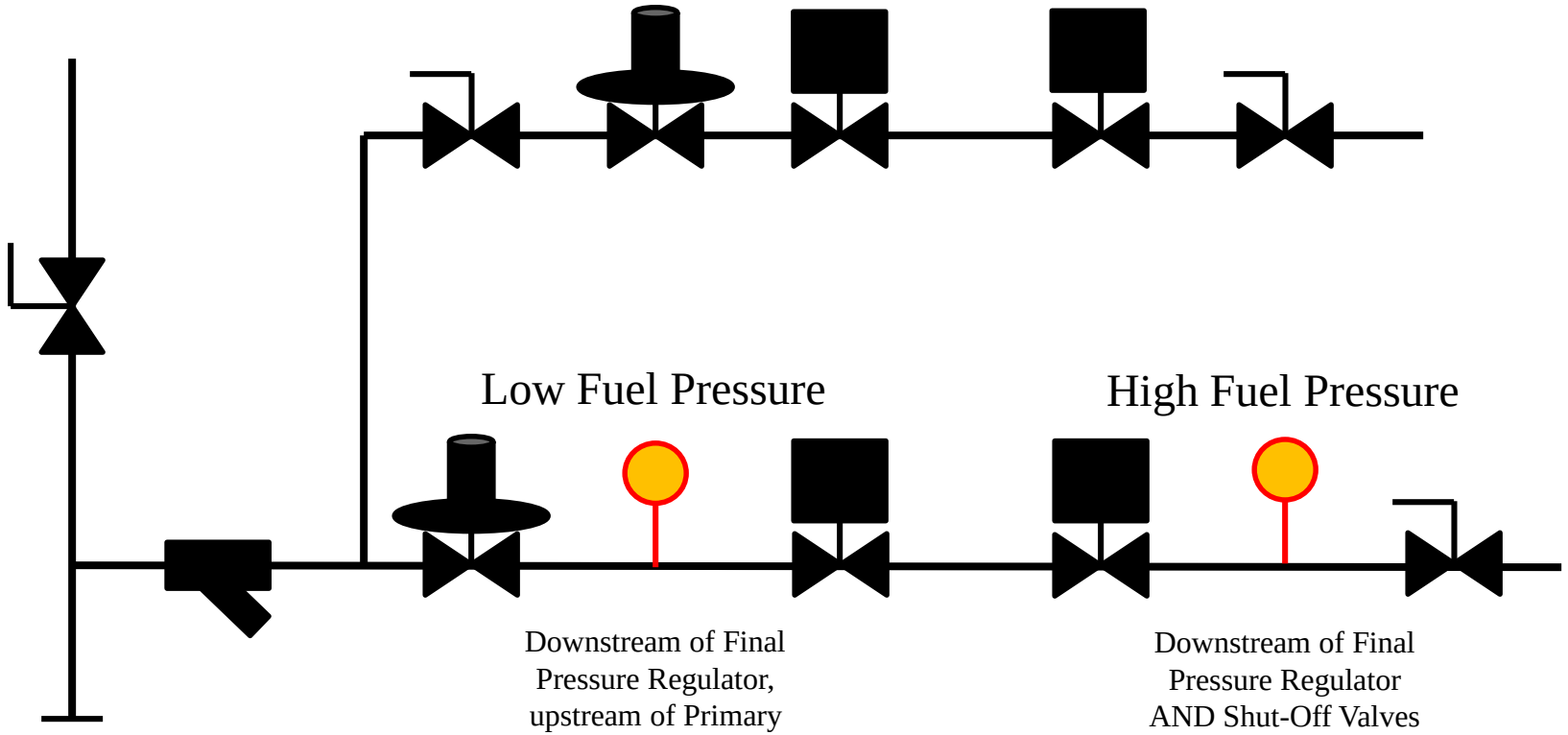
Fuel Pressure Switches



Fuel Pressure Switches

- **NFPA 86 8.9 Fuel Pressure Switches**
  - **8.9.1** A low fuel pressure switch or sensor shall be provided and shall be interlocked into the burner management system.
  - **8.9.2** A high fuel pressure switch or sensor shall be provided and shall meet the following criteria:
    - (1) It shall be interlocked into the burner management system.
    - (2) It shall be located downstream of the final pressure-reducing regulator.
  - **8.9.3** Pressure switch or sensor settings shall be made in accordance with the operating limits of the burner system.

Fuel Pressure Switches – Best Practices



Fuel Pressure Switches – Best Practices

- From experience, it is my personal preference to use a **manual** reset fuel pressure switch unless:
  - Fuel Train is difficult to access
  - Burner Management System has first out annunciation

Fuel Pressure Switches – Best Practices

- For setting the fuel pressure switches, I recommend the following:
  - With the burner at LOW fire, decrease the setting on the HIGH fuel pressure switch until it trips. Note the setting, and adjust the switch to 20% above that setting.
    - EX: If the switch tripped at 10”wc, set the switch for 12”wc
  - With the burner at HIGH fire, increase the setting on the LOW Fuel pressure switch unti lit trips. Note the setting, and adjust the switch to 20% below that setting.
    - EX: If the switch tripped at 10”wc, set the switch for 8”wc

Time Delays on Pressure Switches

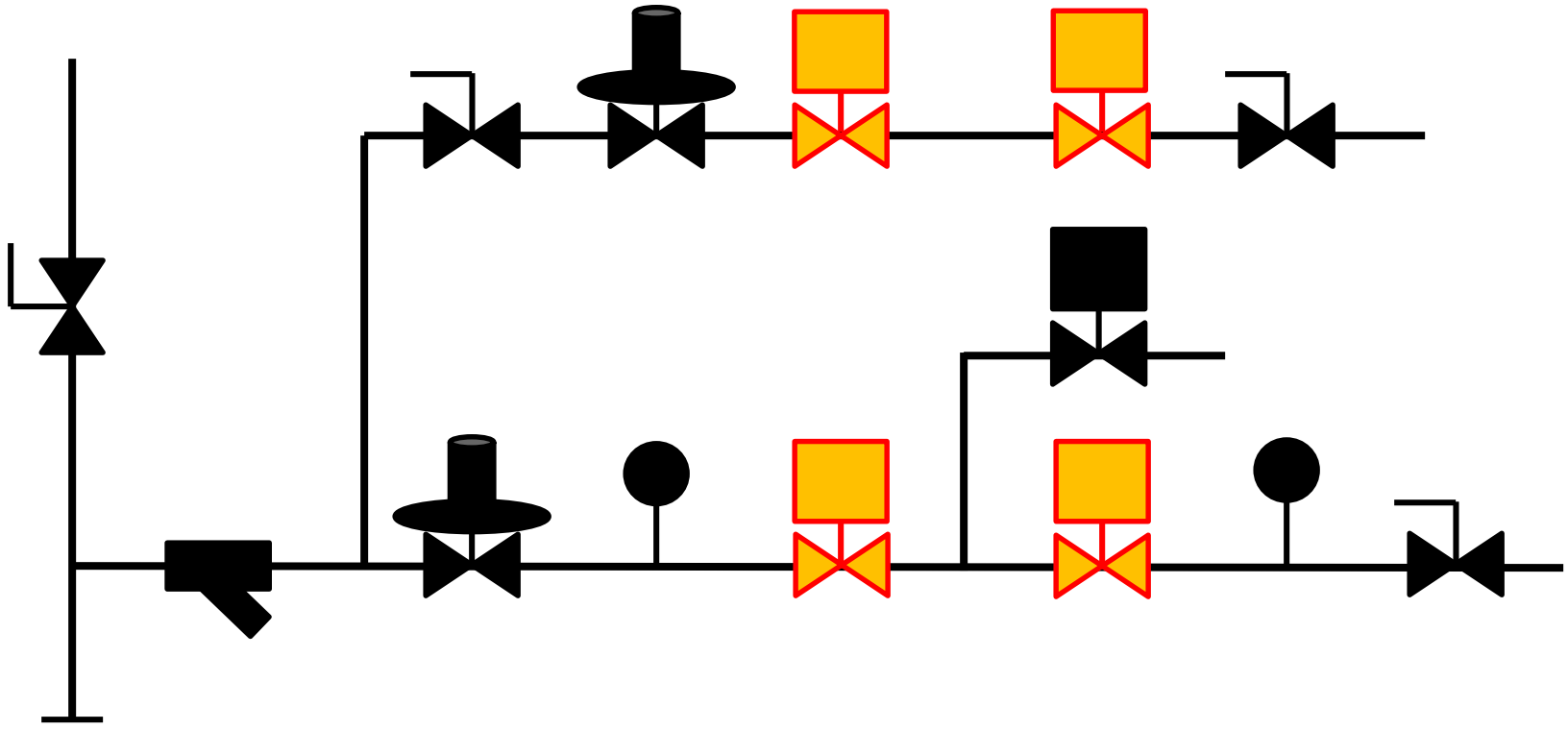
- **NFPA 86 8.2.8.2** The requirement in 8.2.8 shall not prohibit a time delay applied to the action of pressure-proving, flow-proving, or proof-of-closure safety switch as used in accordance with 8.8.1.3(3), where the following conditions exist:

Time Delays on Pressure Switches (cont.)

- (1) There is an operational need demonstrated for the time delay.
- (2) The use of a time delay is approved.
- (3) The time delay feature is not adjustable beyond 5 seconds.
- (4) A single time delay does not serve more than one pressure-proving or flow-proving safety device.
- (5) The time from an abnormal pressure or flow condition until the holding medium is removed from the safety shutoff valves does not exceed 5 seconds.

- Snubbers are allowed, as long as it meets the above criteria (cannot delay for more than 5 seconds).

Safety Shutoff Valves



Safety Shutoff Valves

- Most critical component in any fuel train.
- **NFPA 86 3.3.78.2 Safety Shutoff Valve** A normally closed valve installed in the piping that closes automatically to shut off the fuel, atmosphere gas, or oxygen in the event of abnormal conditions during shutdown.

NFPA 86 Requirements for Safety Shutoff Valves

- **8.8.1.11** Local visual position indication shall be provided at each safety shutoff valve to burners or pilots in excess of 150,000 Btu/hr.

NFPA 86 Requirements for Safety Shutoff Valves

- **8.8.2.2** Where a safety shutoff valve is required to be proved closed, the following shall apply:
- (A) A proved closed condition shall be accomplished by either of the following means
  - (1) A proof-of-closure switch incorporated in a listed safety shutoff valve assembly in accordance with the terms of the listing
  - (2) A valve proving system
- (B) Auxiliary and closed position indicator switches shall not satisfy the proved closed requirement of 8.8.2.2 (A)

NFPA 86 Requirements for Safety Shutoff Valves

- When is a safety valve required to be proven closed?

- When the capacity of the main or pilot exceeds 400,000 Btu/hr, at least one of the safety shutoff valves between each burner and the fuel supply shall be proved closed and interlocked with the pre-ignition purge interval.

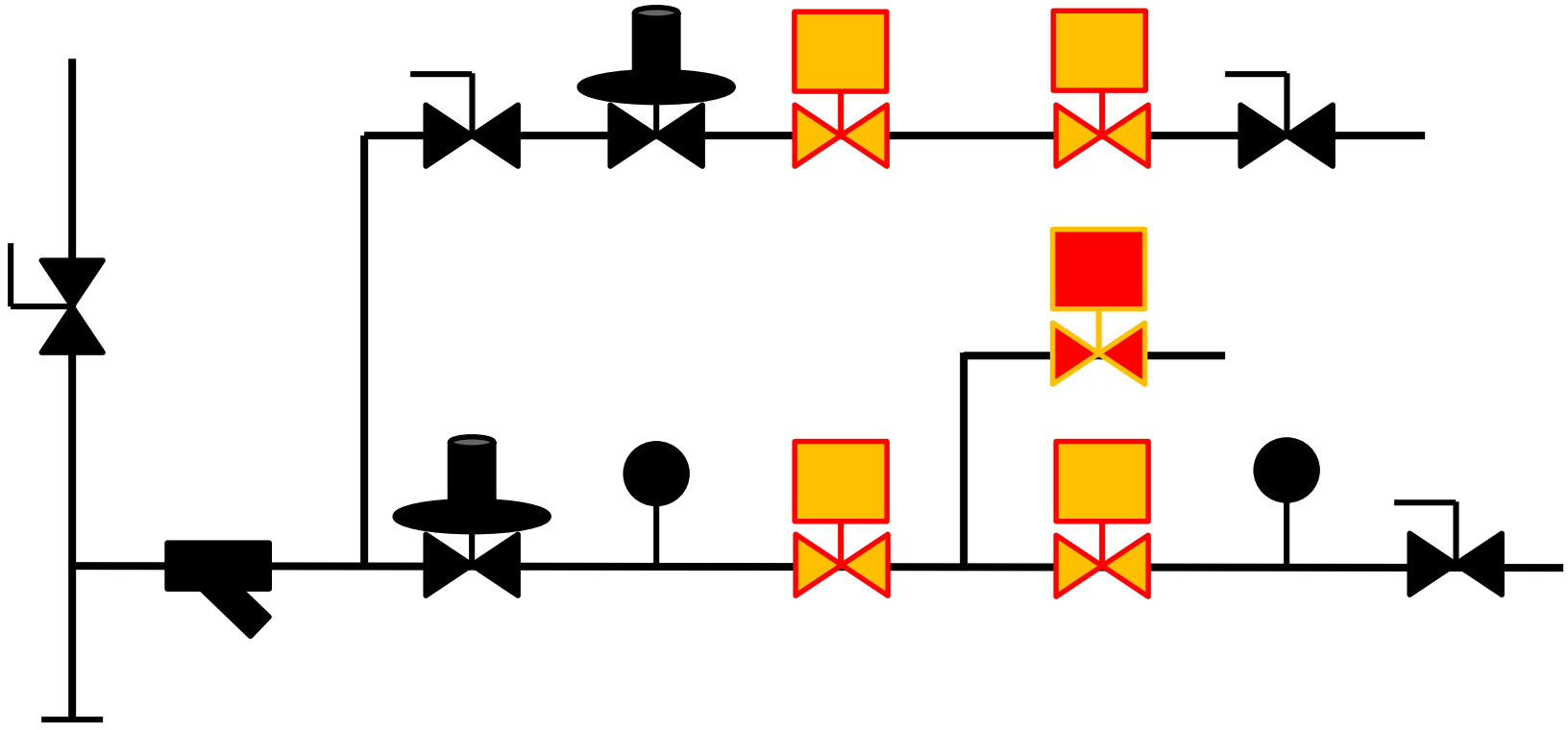
NFPA 86 Requirements for Safety Shutoff Valves

- **NFPA 86 8.8.1.12** Safety shutoff valves shall meet one of the following requirements:
  - (1) The safety shutoff valve shall close in 1 second or less upon being de-energized.
  - (2) Where safety shutoff valve closure time exceeds 1 second, the combined time for safety shutoff valve closure and flame failure response shall not exceed 5 seconds.

Best Practices for Safety Shutoff Valves

- To cascade or not to cascade?
  - Cascading shutoff valves energizes valves individually in sequence instead of energizing them all at the same time.
  - This can help in applications where introducing the fuel to quickly into the system causes issues with the regulators, pressure switches, or achieving a reliable light-off.
  - Also reduces the current draw through the burner management system.
- Cascading shutoff valves increases the time it takes the fuel to reach the burner, cutting into your pilot or main flame establishment period.

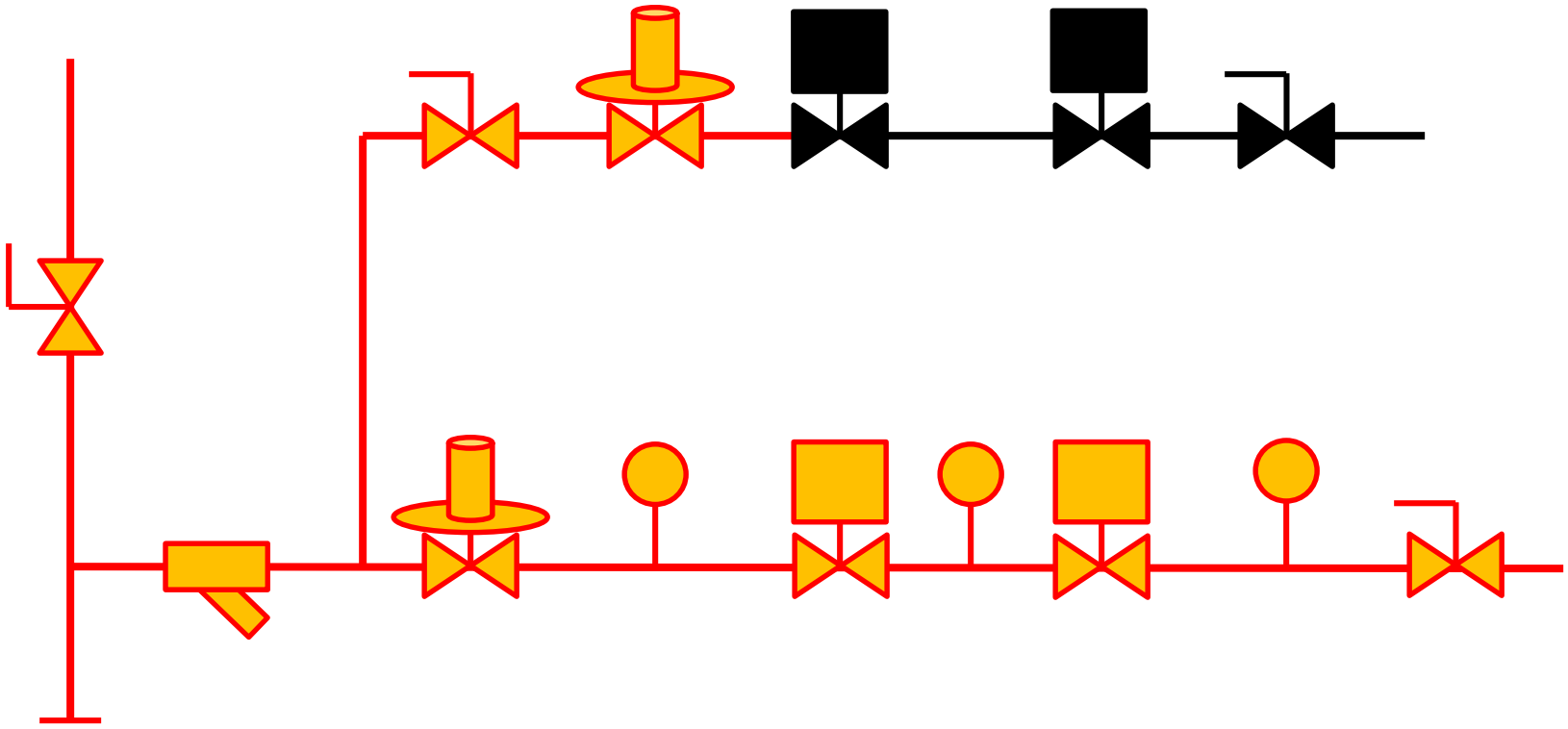
Double Block / Block and Bleed



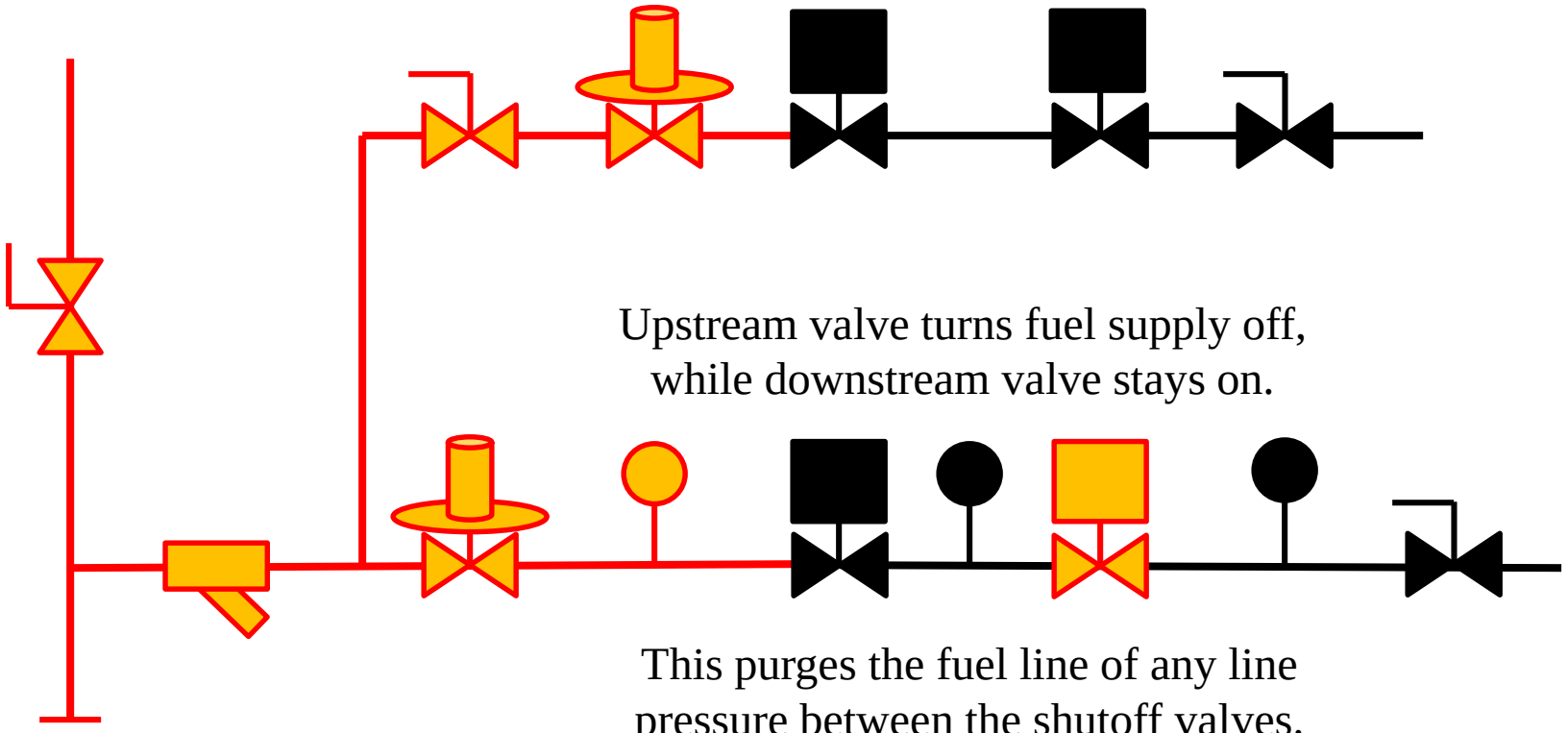
Valve Proving System

- **NFPA 86 3.3.79 Valve Proving System** A system used to check the closure of safety shutoff valves by detecting leakage.
- Replaces vent valve in block and bleed arrangement with a valve proving pressure switch
- Valves are cycled individually either prior to or after a run cycle to test the valves for leakage (by means of pressure).
- Does not replace annual valve seat leakage testing, this still needs to be done.

Run Mode – Pilot Off, Main On



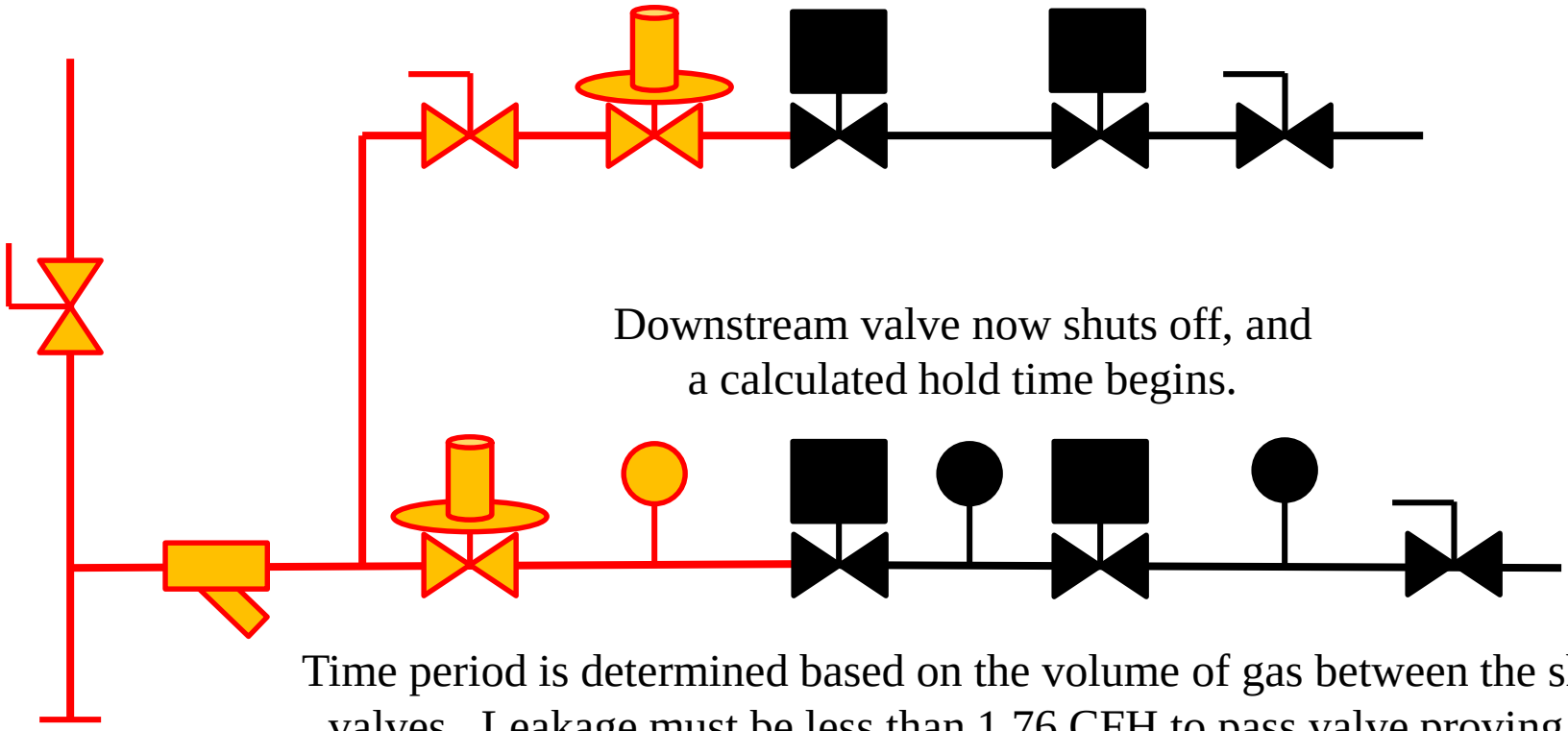
Initiate Valve Proving Sequence



Upstream valve turns fuel supply off, while downstream valve stays on.

This purges the fuel line of any line pressure between the shutoff valves.

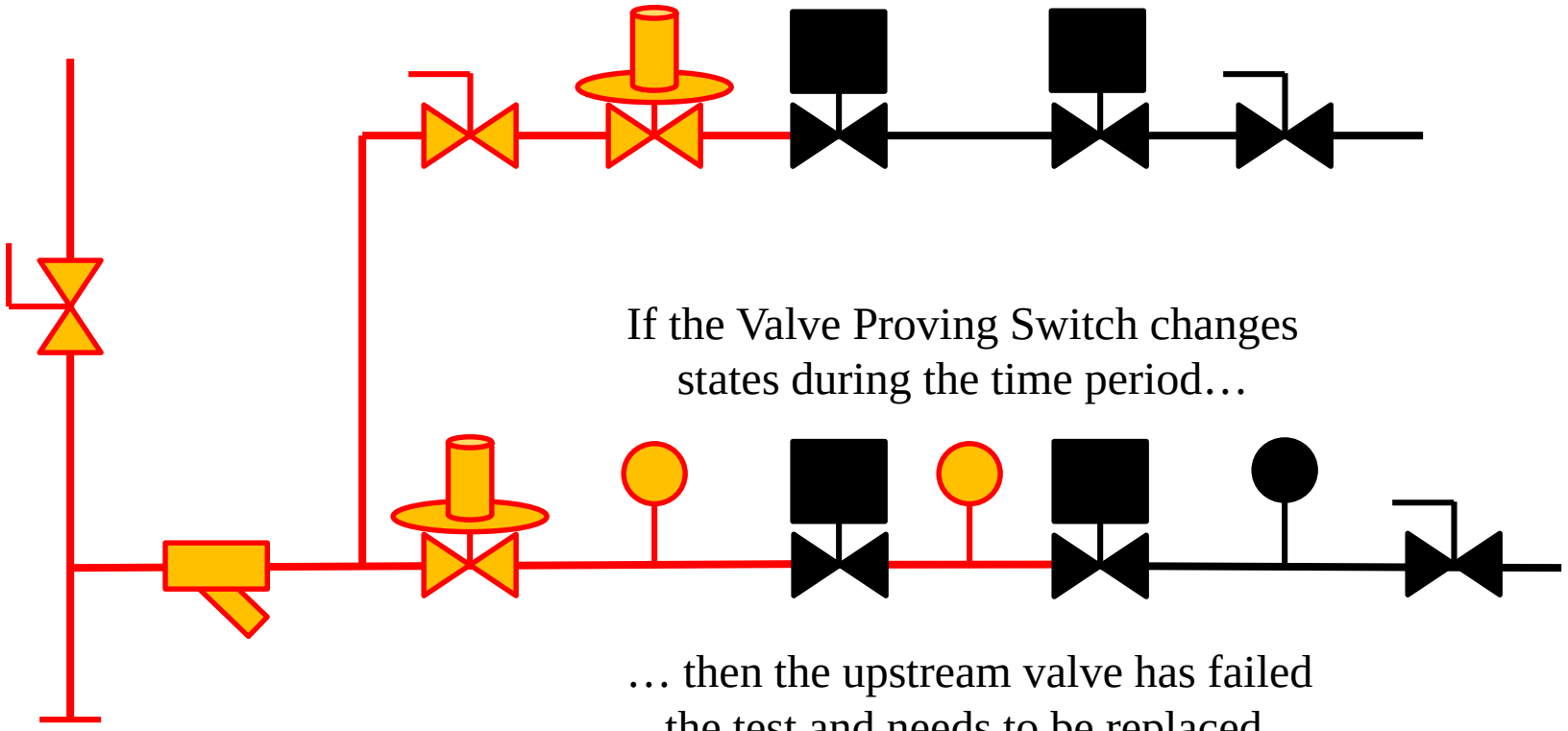
Test of upstream valve



Downstream valve now shuts off, and
a calculated hold time begins.

Time period is determined based on the volume of gas between the shutoff valves. Leakage must be less than 1.76 CFH to pass valve proving test.

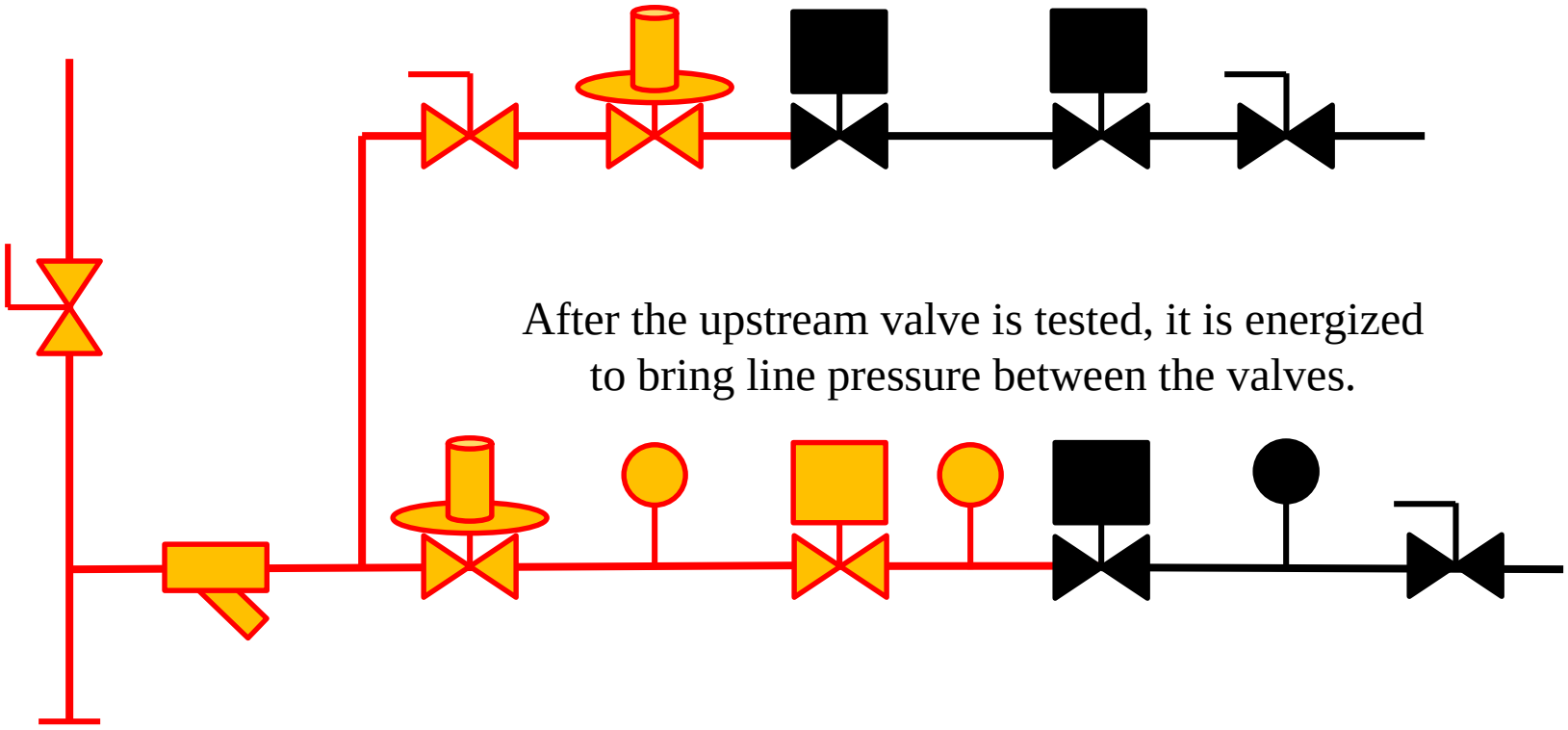
Test of upstream valve



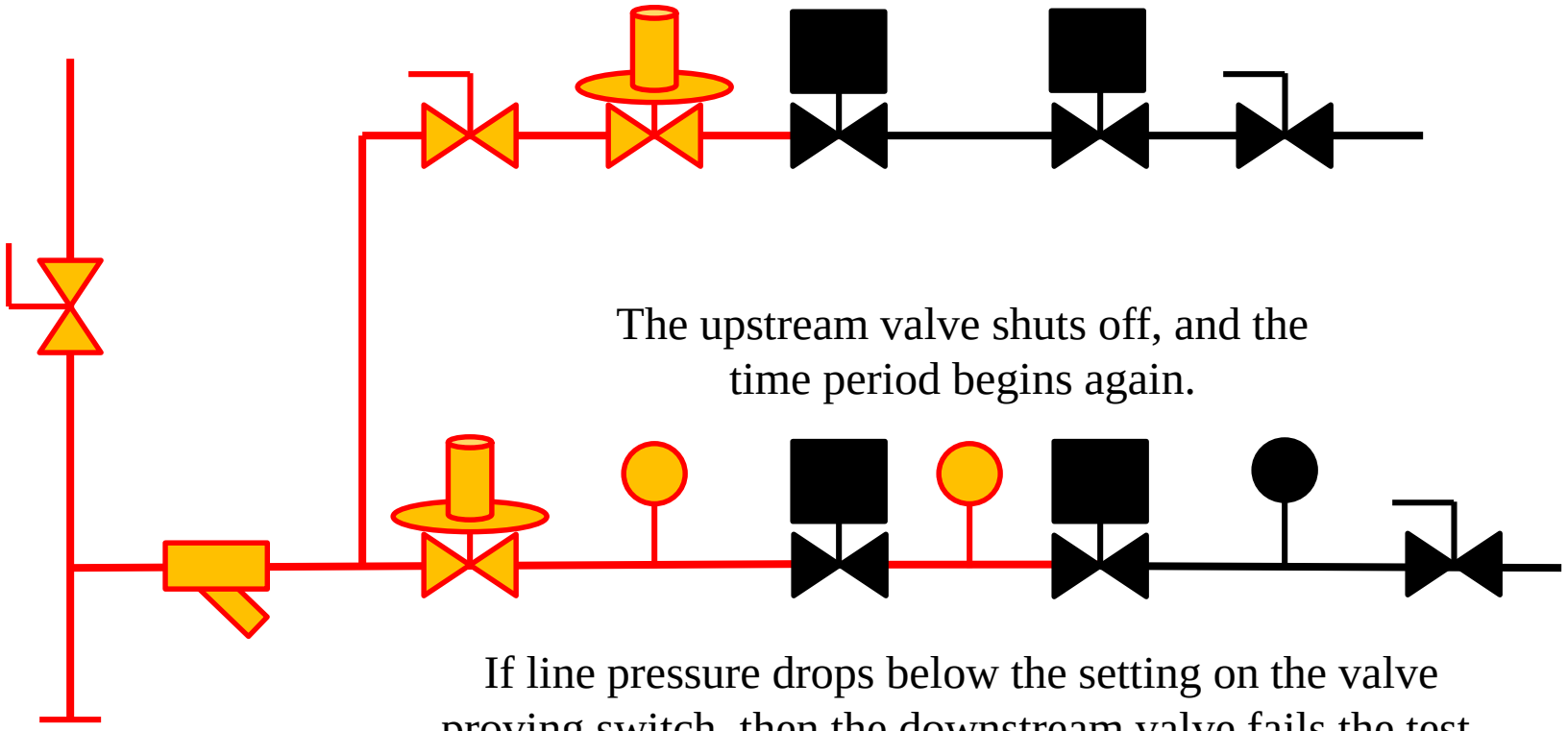
If the Valve Proving Switch changes states during the time period…

… then the upstream valve has failed the test and needs to be replaced.

Test of downstream valve



Test of downstream valve



The upstream valve shuts off, and the time period begins again.

If line pressure drops below the setting on the valve proving switch, then the downstream valve fails the test.

Benefits of Valve Proving System

- Automatic checking of valve integrity between annual leak testing.
- Removal of vent valve and vent line
  - Vent valves can fail undetected, creating a potential hazard if not vented properly as well as lost money in wasted fuel and inefficient combustion.
- Must have proper Flame Safeguard or PLC programming to activate valve proving sequence.

Leak Testing of Shutoff Valves

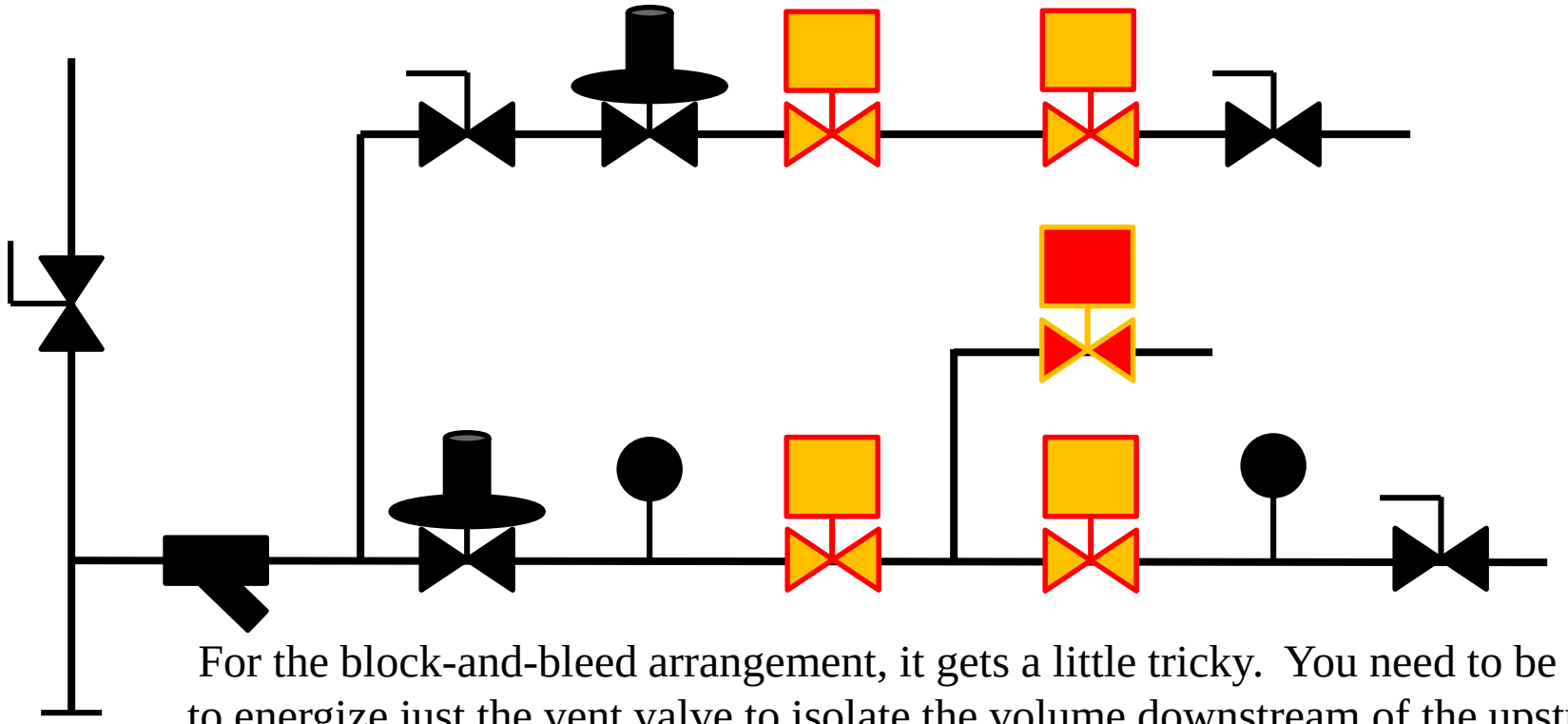
- Valve seat leak testing needs to be preformed per the manufacturer's requirements (typically annually).
- **NFPA 86 8.8.2.3** Means for testing all fuel gas shutoff valves for valve seat leakage shall be installed.
  - If the valve body does not have built-in test ports, then test ports need to be installed in the piping.

Typical Valve Seat Leakage Test Procedure

- Apply line pressure to the upstream side of the de-energized valve.
- Isolate the volume downstream of the valve in question by means of energizing closed a vent valve or by using a manual shutoff.
- Connect ¼” tubing to the test connection, and bring the tubing to the surface of a small pool of water.
- If there are any leaks, you should see bubbles coming out of the tubing. Count the number of bubbles per minute if any are detected.
- Check with the manufacturer/AHJ for allowable seat leakage rates, as these vary depending on line size and manufacturer.
- We will link to Maxon’s leak testing procedure on our training center page for this webinar for your reference.

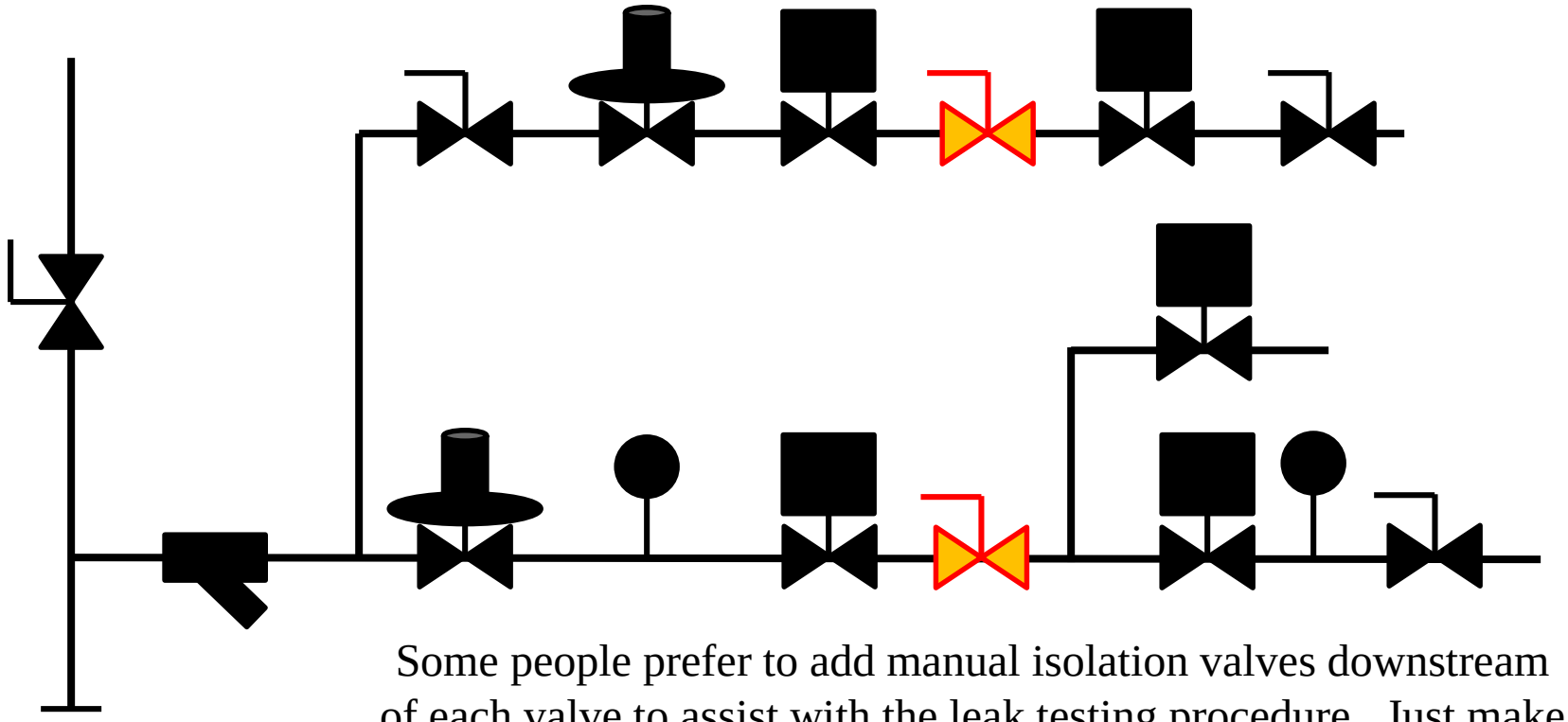
In-line Leak Testing of Shutoff Valves

For the double block arrangement, it's easy to check both of these valves, as long as you can energize the first valve to test the second valve.



For the block-and-bleed arrangement, it gets a little tricky. You need to be able to energize just the vent valve to isolate the volume downstream of the upstream valve, and then energize the upstream valve to test the downstream valve.

In-line Leak Testing of Shutoff Valves



Some people prefer to add manual isolation valves downstream of each valve to assist with the leak testing procedure. Just make sure you don't add a manual shutoff valve to the vent line!

Functional Testing of MAXON Shut-off Valves

Recommended Leak Testing

CAUTION: Valve leak testing should only be attempted by individuals trained or licensed for handling gas combustion systems. Failure to handle combustible gases in a safe, approved manner can create hazards including fire or explosion leading to injury or death.

Instructions provided by the company and/or individuals responsible for the manufacture and / or overall installation of complete system incorporating MAXON valves take precedence over these provided by MAXON. If MAXON instructions conflict with any codes or regulations, contact MAXON before attempting this procedure.

Refer to the appropriate product specification pages for operating sequence applying to your specific valve. Never operate valve until all essential allied equipment is inoperative and any necessary purges of flammable gases or vapors is completed. Failure of valve to operate normally indicates that it is not powered or supply air pressure is not adequate. Check this first!

NOTE: Leak testing may often be confused with commercially-available valve proving systems. The degree of leakage detectable between these methods is not equal. At no time should regular valve leakage tests be replaced by leak proving systems due to the inherent hazard of high leakage levels allowed by these systems.

Test Guideline

Each valve should be checked with available line pressure. Absolute zero leakage may not be obtained in the field depending upon service, age and cycling frequency. Any valve that exceeds the allowable leakage, as set forth by your local codes or insurance requirements, should be removed from service. Possible relevant standards to be referenced include but are not limited to:

NFPA 85, NFPA 86, International Fluid Control Institute, CSA, AGA, EC Equipment Directives, specific equipment manufacturers using the MAXON valves

The procedure described in this document may not be appropriate for all areas, situations or installations. Consult with your insurance carrier, local authority for gas codes, or other relevant compliance agency for testing requirements.

Contact MAXON for service or replacement.

Suggested leak test procedure for double blocking shut-off valves (without vent line)

NOTE: This procedure is a suggested procedure commonly used in the USA. For other markets, other test procedures may be preferable.

(a) Shut down combustion system per manufacturer's recommended procedure.

(b) Close manual valves A and B.

(c) Visually inspect to verify that shut-off valves #1 and #2 are closed.

(d) Remove the 1/4" pipe plug from downstream side of shut-off valve #1. Install leak test apparatus.

(e) Safely vent any trapped gas pressure between valve #1 and valve #2.

(f) Open manual shut-off valve A, then close leak test apparatus. Insert tube into a container of water just below the surface.

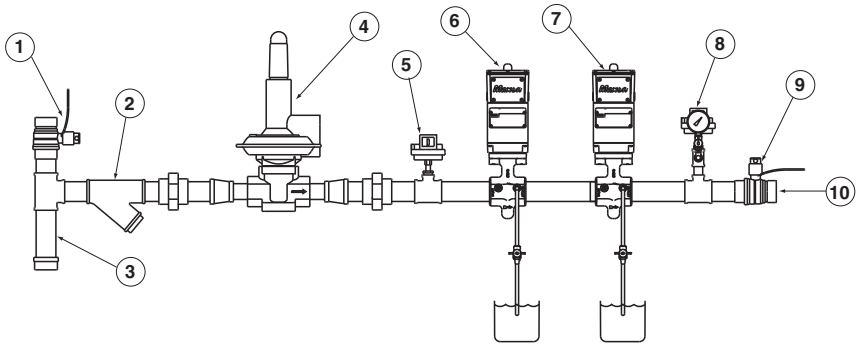
(g) Open test apparatus and test valve #1 for leakage

As a guideline, valve should be tested for 2 minutes per inch of pipe diameter. Large diameter pipes or long piping runs between shut-off valves may need additional testing time.

If valve testing indicates leakage in excess of applicable standards, perform pre-operational exercising as outlined in Valve Cycling section on Page 10-35.1-1 and retest the valve. If valve continues to exceed allowable leakage limit, remove from service and contact MAXON.

1) Manual valve A
2) Strainer
3) Drip leg
4) Gas pressure regulator
5) LGP switch
6) Shut-off valve #1
7) Shut-off valve #2
8) HGP switch
9) Manual valve B
10) To combustion system

Example of a gas piping diagram for leak test without vent line



(h) Secure test apparatus on valve #1 and reinstall pipe plug in the test port.

(i) Remove the 1/4” pipe plug from downstream side of shut-off valve #2. Install leak test apparatus.

(j) With an auxiliary or other power supply connected to valve #1, cycle valve #1 open leaving valve #2 shut.

(k) Open test apparatus to test valve #2 for leakage as described in (g).

(l) Secure test apparatus on valve #2 and reinstall pipe plug in the test port.

(m) Restore combustion system to operational condition. Be sure to remove all auxiliary power supplies and jumpers that may have been used during testing. Open manual valves A and B and resume operation according to equipment manufacturer’s recommended practices.

Suggested leak test procedure for double blocking shut-off valves (with vent line)

NOTE: This procedure is a suggested procedure commonly used in the USA. For other markets, other test procedures may be preferable.

(a) Shut down combustion system per manufacturer's recommended procedure.

(b) Close manual valves A and B.

(c) Visually inspect to verify that shut-off valves #1 and #2 are closed.

(d) Remove the 1/4" pipe plug from downstream side of shut-off valve #1. Install leak test apparatus.

(e) Vent valve will safely remove any gas between shut-off valve #1 and shut-off valve #2. With an auxiliary or other power source connected to the vent valve, power the vent valve closed.

(f) Open manual shut-off valve A, then close leak test apparatus. Insert tube into a container of water just below the surface.

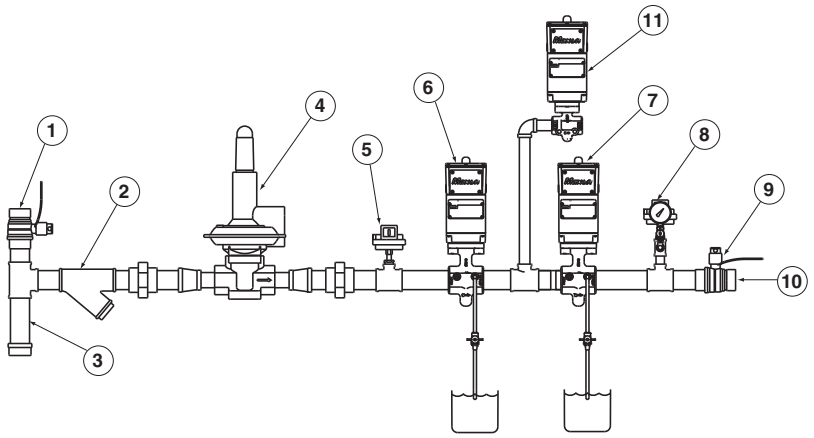
(g) Open test apparatus and test valve #1 for leakage

As a guideline, valve should be tested for 2 minutes per inch of pipe diameter. Large diameter pipes or long piping runs between shut-off valves may need additional testing time.

If valve testing indicates leakage in excess of applicable standards, perform pre-operational exercising as outlined in Valve Cycling section on Page 10-35.1-1 and retest the valve. If valve continues to exceed allowable leakage limit, remove from service and contact MAXON.

Example of a gas piping diagram for leak test with vent line

1) Manual valve A
2) Strainer
3) Drip leg
4) Gas pressure regulator
5) LGP switch
6) Shut-off valve #1
7) Shut-off valve #2
8) HGP switch
9) Manual valve B
10) To combustion system
11) Vent valve



(h) Secure test apparatus on valve #1 and reinstall pipe plug in the test port.

(i) Remove the 1/4” pipe plug from downstream side of shut-off valve #2. Install leak test apparatus.

(j) With an auxiliary or other power supply connected to valve #1, cycle valve #1 open leaving valve #2 shut.

(k) Open test apparatus to test valve #2 for leakage as described in (g).

(l) Secure test apparatus on valve #2 and reinstall pipe plug in the test port.

(m) Remove the 1/4” pipe plug from downstream side of vent valve. Install leak test apparatus.

(n) With an auxiliary or other power supply connected to shut-off valve #1 and vent valve, cycle valve #1 open and cycle vent valve shut leaving valve #2 shut.

(o) Open test apparatus to test vent valve for leakage as described in (g).

(p) Secure test apparatus on vent valve and reinstall pipe plug in the test port.

(q) Restore combustion system to operational condition. Be sure to remove all auxiliary power supplies and jumpers that may have been used during testing. Open manual valves A and B and resume operation according to equipment manufacturer’s recommended practices.

Thank You for Your Time

Any Questions???

Get Social with Lesman

Lesman
www.lesman.com
Instruments • Valves • Controls

LinkedIn

twitter

YouTube

- Our Website
  - www.lesman.com
- Dan's Tips blog
  - blog.lesman.com
- Follow us on LinkedIn
  - www.linkedin.com/company/lesman-instrument-company
- Follow us on Twitter
  - @Lesman_Inst
- Check Out our YouTube Channel
  - www.youtube.com/user/LesmanInstrumentCo

Lesman
www.lesman.com
Instruments • Valves • Controls

Instruments, Valves, and Controls

Upcoming Webinar:

Selecting The Right Radar Antenna

Thursday, March 17 9am CST

Featured Speaker

Mark Klee

Senior Application Engineer,
Level and Weighing Products
Siemens

Webinar invitation e-mail coming soon...