Multi-layer OPP in Natural Gas Systems

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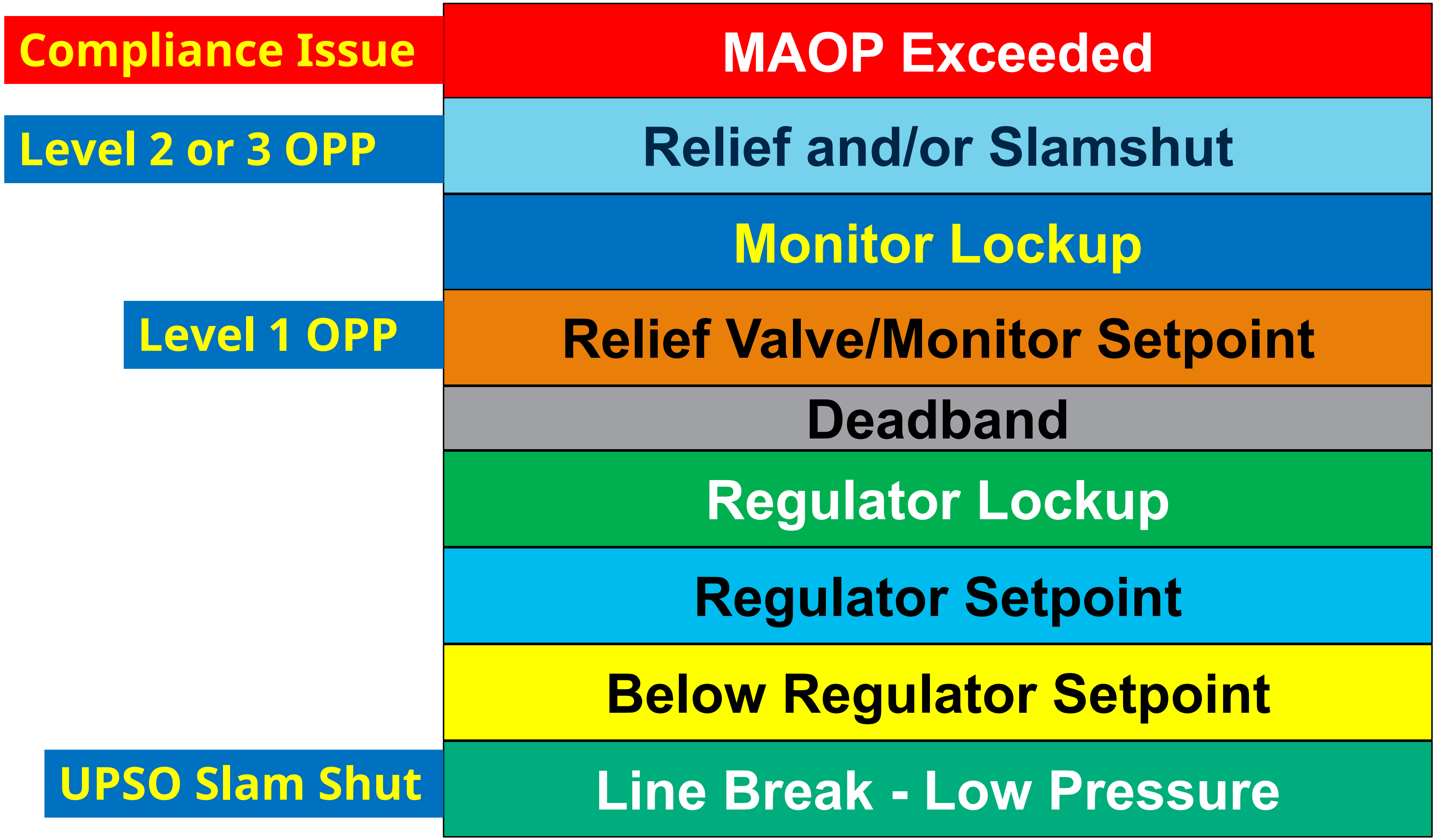
EMERSON

Agenda

- Layers of OPP
- Regulatory Update
- Low Pressure Systems
- Layers of OPP at Station Systems
- Monitoring & Control

Layers of OPP in Gas Distribution



Layers of OPP in Gas Distribution – Another Layer?

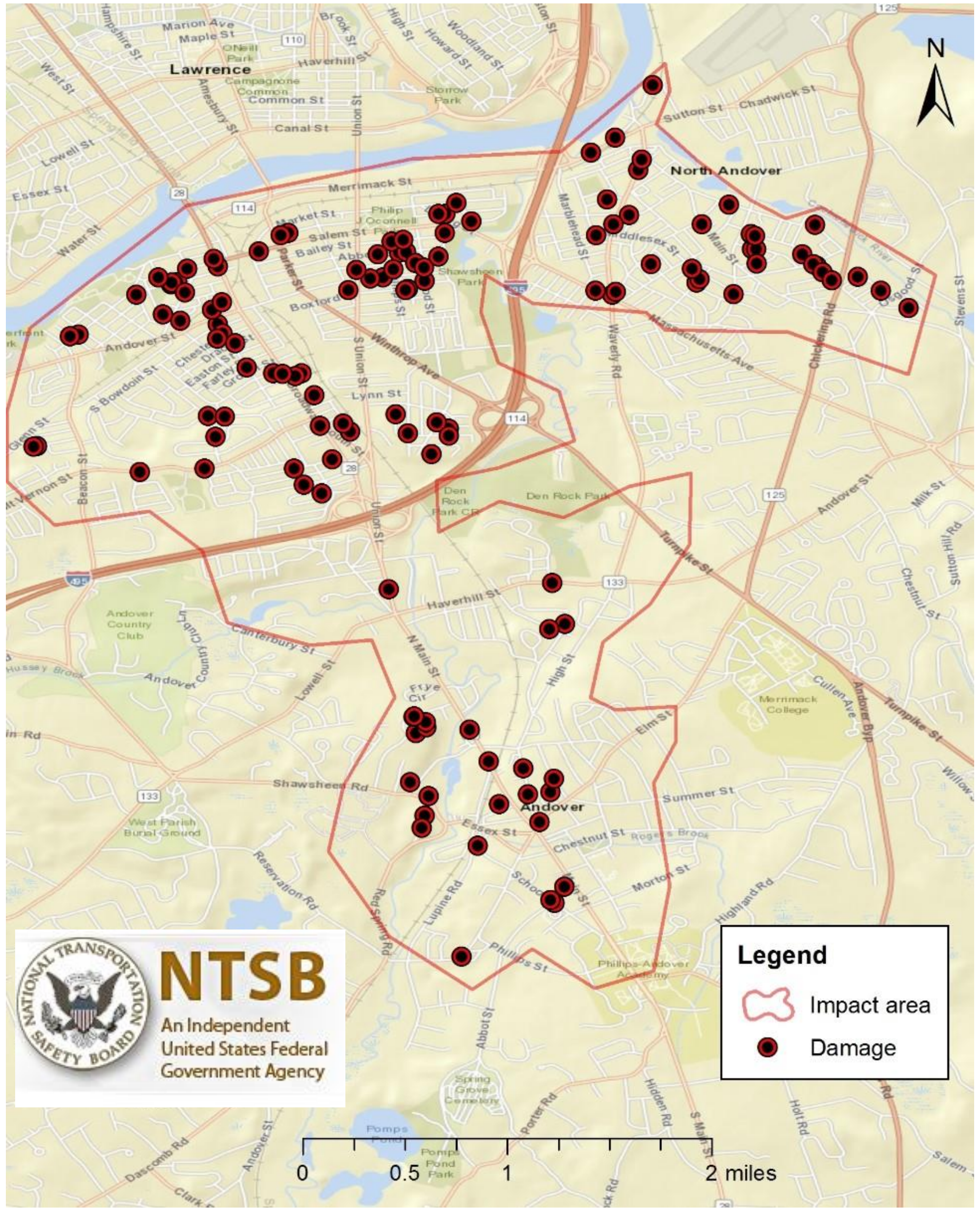
Public Issue	**Catastrophic Event**

The gap between compliance and a catastrophic event..

Compliance Issue	**MAOP Exceeded**
Level 2 or 3 OPP	**Relief and/or Slamshut**
	Monitor Lockup
Level 1 OPP	**Relief Valve/Monitor Setpoint**
	Deadband
	Regulator Lockup
	Regulator Setpoint
	Below Regulator Setpoint
UPSO Slam Shut	**Line Break - Low Pressure**

Structural Damage

- Overpressure of a district station creates a sporadic area of damage whereas a pipeline rupture is isolated



- ***Overpressuring an LP main can be catastrophic***

NTSB Summary – Public Meeting Sept 24th, 2019

- Sept 13th, 2018, around 4:00 PM Merrimack Valley overpressure
  - One death
  - 22 injured including 3 firefighters
  - 131 structures damaged or destroyed
  - Electricity cut off to 11,000 customers
  - Winthrop station shut in around 30 minutes later
  - Max downstream pressure could be as high as 60+ psig
  - Emergency response
    - 167 engines
    - 65 ladder trucks
    - 54 ambulances
    - 1,000+ officers from 141 agencies

NTSB Recommendations, Sept 24th 2019

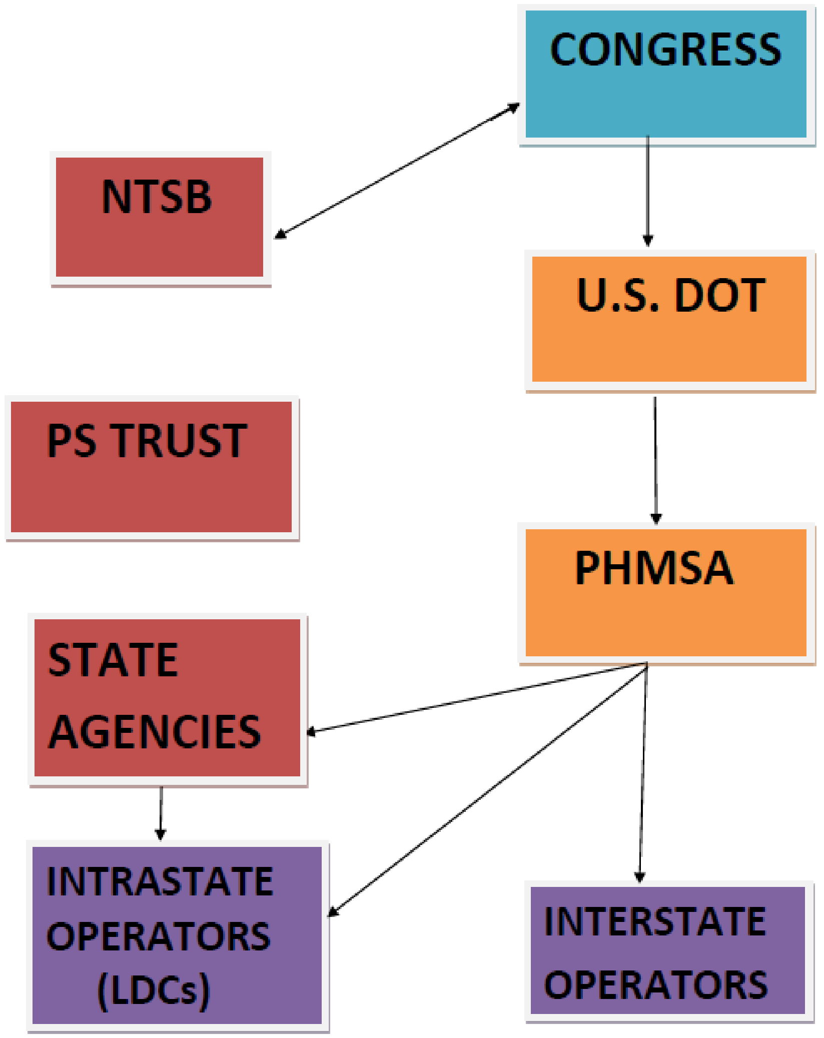
- To PHMSA: (only relevant portions)
  - ***"Revise CFR 49 part 192 to require OPP for low-pressure systems natural gas distribution systems that cannot be defeated by a single operator error or equipment failure."***
  - ***"Remove the exemption so that all future natural gas infrastructure projects require licensed professional engineer approval and stamping."***
- *To NiSource:*
  - ***Review and ensure that all records and documentation of your natural gas systems are traceable, reliable, and complete. (P-18-7) (Urgent)***

https://go.usa.gov/xVdTY

National Transportation Safety Board (NTSB) Overview

- Reports directly to congress
- Investigates and provides reports on transportation related incidents
- Makes recommendations to Congress *(but not binding with the Pipeline and Hazardous Material Safety Administration PHMSA*)
- Pipeline Safety Trust – A nonprofit public input which is non-binding

Pipeline Safety Regulatory Process



National Transportation Safety Board

Pipeline Safety Reauthorization

- Approximately every 4 years PHMSA's pipeline safety program is "reauthorized" by congress
- Using input and reporting from NTSB, Congress adds additional mandates based upon areas where additional oversight, research, or regulations are needed
- Input from all groups drive to a proposed bill

Congress → **PHMSA** → **Gas Pipeline Advisory Committee** → **Final Rule/ Regulation**

Overview of PIPES Act 2020 – Law as of December 2020

Sections outline directives for PHMSA

Regulatory changes will impact AGA members.

American Gas Association

Sec. 201. Short title.
Sec. 202. Distribution integrity management plans.
Sec. 203. Emergency response plans.
Sec. 204. Operations and maintenance manuals.
Sec. 205. Pipeline safety management systems.
Sec. 206. Pipeline safety practices.

Sec. 206. Pipeline safety practices.

- **180 days** – regulations for qualified employee to monitor district regulator station.
- Any project that has the potential to cause a hazardous overpressurization of the distribution system.
- **1 year** – regulations to assess and upgrade as needed distribution regulator stations to eliminate common mode of failure (distribution).
- **2 years** – regulations requiring operators to identify and manage traceable, reliable, and complete records
- <u>Only records critical to ensure proper pressure controls for distribution</u>
- Records should be available to all persons responsible for performing or overseeing relevant work.

Sec. 206. Pipeline safety practices.

Considerations for Operators:

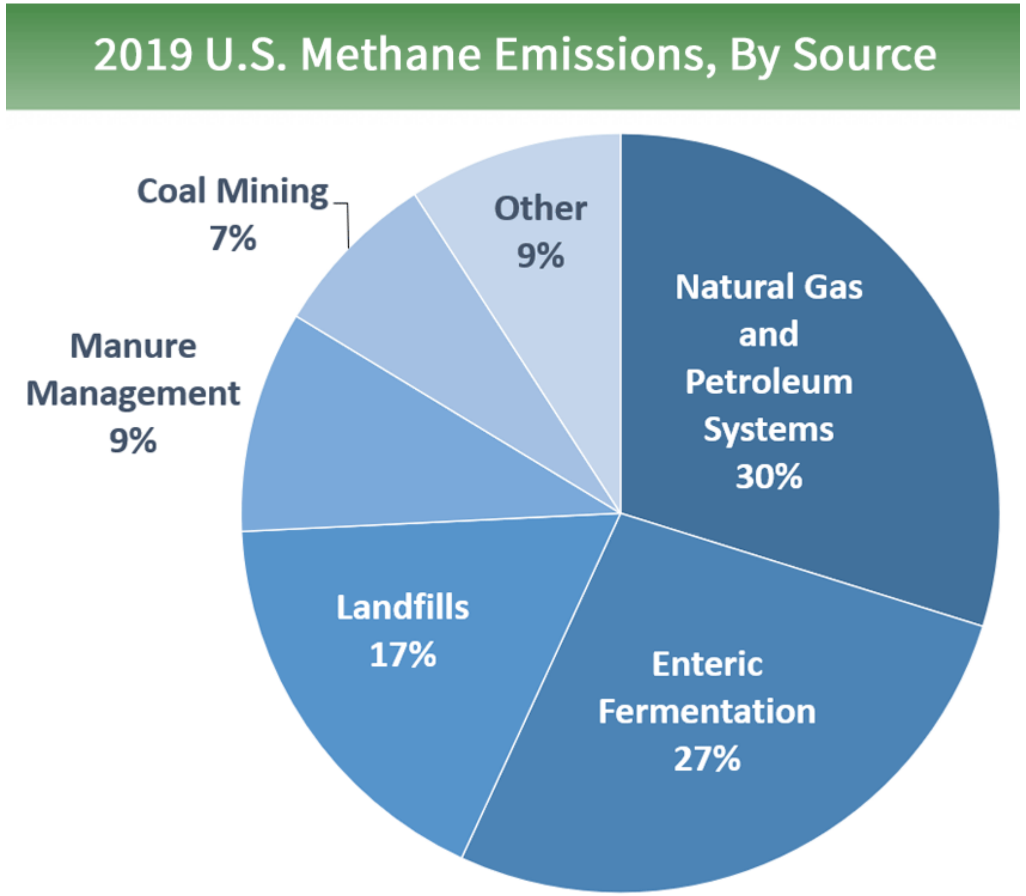
- *Identify and train personnel to monitor gas pressure, including updates to training documents and procedures*
- *Update design review to identify if additional personnel is needed to monitor construction activities or if district regulators have remote capabilities*
- *Update design procedures to include review of monitoring*
- *Review district regulator stations that may need upgrades as identified above*
- *Identify which documents may be considered as records critical for proper pressure controls*
- *Identify system to store and make available to applicable personnel*
- *Review existing documents to ensure they are traceable, reliable, and complete*
- *Update procedures to identify system of record and record storage/retention*

OPP – Direction of Regulations

1. Traceability and trackability of assets
   - Serial #s, CMTRs, test reports, QR codes, RFID continue to be talking points as utilities figure out how to implement
2. Upgrading of OPP at district pressure stations
   - Relief, slam-shut valves, super monitors
   - Studies are being done but slow movement
3. Monitoring at Low Pressure/Intermediate Pressure stations
   - Pressure monitoring, regulator position, other possible points
   - One LDC looking at up to 1,000 district station upgrades to monitor and protect system
   - System security is becoming an issue that can tie in with monitoring

OPP – June 2021 Update – Advisory Bulletin

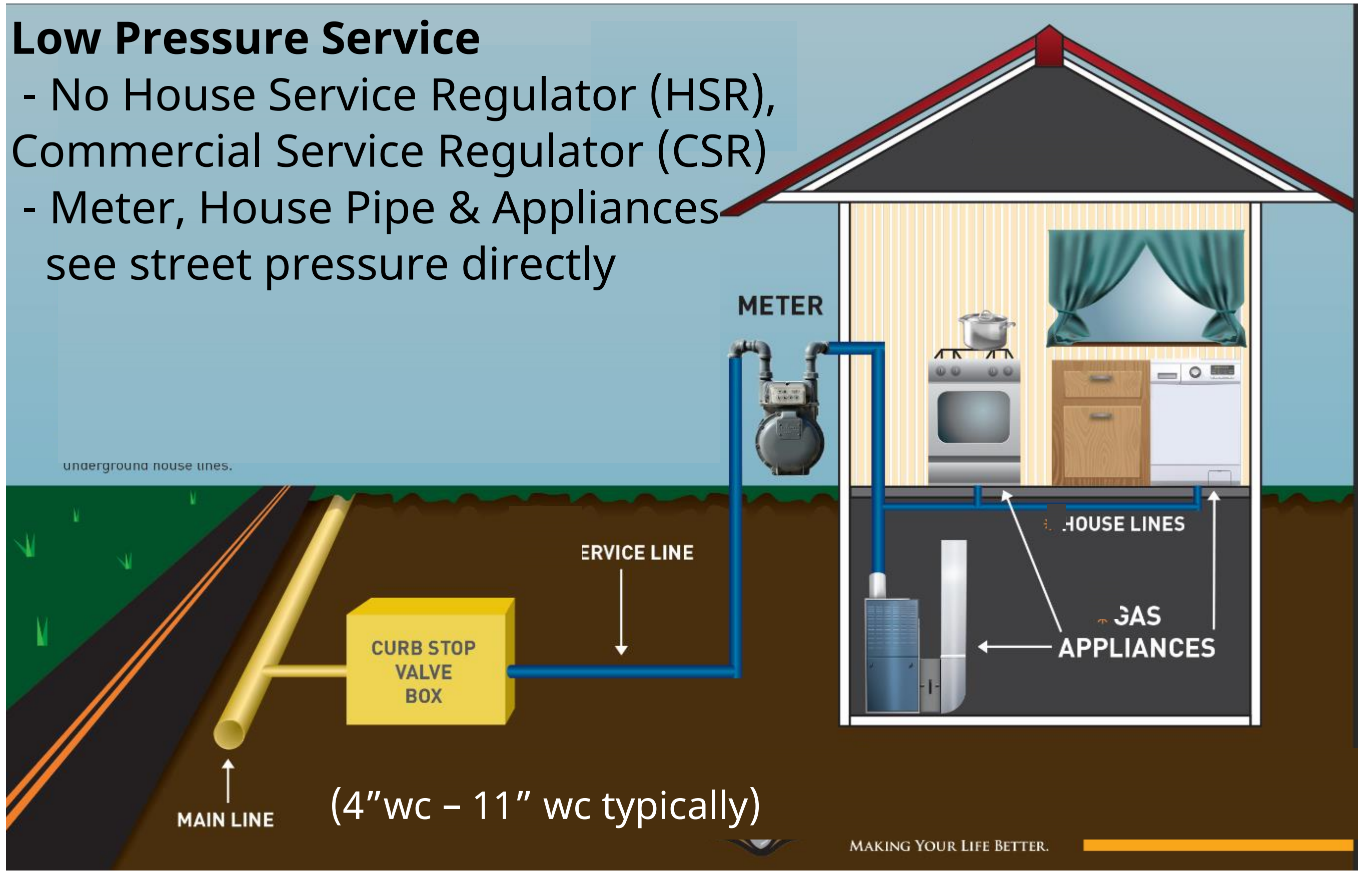
4. Emissions Reductions – contains a self-executing mandate requiring operators to update their inspection and maintenance plans to address eliminating hazardous leaks and minimizing releases of natural gas (including intentional venting during normal operations) from their pipeline facilities. Operators must also revise their plans to address the replacement or remediation of pipeline facilities that are known to leak based on their material, design, or past operating and maintenance history. The statute requires pipeline operators to complete these updates by December 27, 2021.



U.S. Environmental Protection Agency (2021). Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2019

Typical Low Pressure (LP) Systems

- **MAOPs : Typically at 14” w.c or lower**
  - How was this pressure derived? *Tribal knowledge*
- **No service regulator, only meter**
  - Many meter sets are indoors
- **OPP is usually installed at the district station**
  - Does not protect if an IP system is tried into LP system, or if district station regulator fails



Utilization/Low Pressure (LP) Systems

- Considerations for OPP at the services
  - A service regulator serving as a wide-open downstream monitor on the riser identical to an IP system
    - To limit the pressure drop across the regulator, it requires a larger orifice to minimize pressure drop and has to be sized
    - Vent clearances in some installations may be prohibitive
    - Upgrading to IP system in future would be ideal but not financially possible in some systems due to densification/cost.
    - Will it protect from catastrophic failure of district station or accidental tie in of IP/HP line into LP system?
    - Is continuity of service maintained during OPP event at service?
    - Most HSRs have internal relief valves (IRV) for additional OPP back up
  - Slam shut on services
    - Pressure drop across slam shut may reduce capacity so this has to be sized
    - Gas is shut off and requires a manual reset to re-establish service
    - Some slam shuts are upgradable to add regulator in the future to the service
    - More expensive than a service regulator in many cases

LP System OPP –
Residential/Commercial 7-12” wc Deliveries

- Consider raising the operating and MAOP of the distribution system to 21” wc or higher
- Add another layer of OPP at the LP service with an additional service regulator as a wide open monitor
  - Regulating HSR/CSR regulates overpressure excursion for 2^{nd} level OPP in the event the district station fails
  - If regulator fails to close off completely IRV will back it up with a 3^{rd} level OPP
  - Service regulator’s inlet rated typically at 125 psig
- Must consider pressure drop across the device at max flow conditions
- Easy upgrade path when moving to an IP system later
- If district station fails wide open the regulator protects the services like existing IP systems

- ***Simple OPP for low pressure services***

Regulators at LP Services and Service MAOP

- House Service Regulator (HSR) designed to ANSI B109.4
  - Internal relief valve (IRV) that will maintain downstream pressure below MAOP during an overpressure event
- LP system MAOPs
  - Where does it come from and how was it derived
  - Many systems currently run at 14-21” MAOPs
  - Most appliances should be rated to 2 psig max emergency inlet pressure
- IP systems
  - Usually follows ANSI B109.4 for IRV sizing and MAOP constraints
    - **7” wc delivery has a 2 psig MAOP in ANSI B109.4**

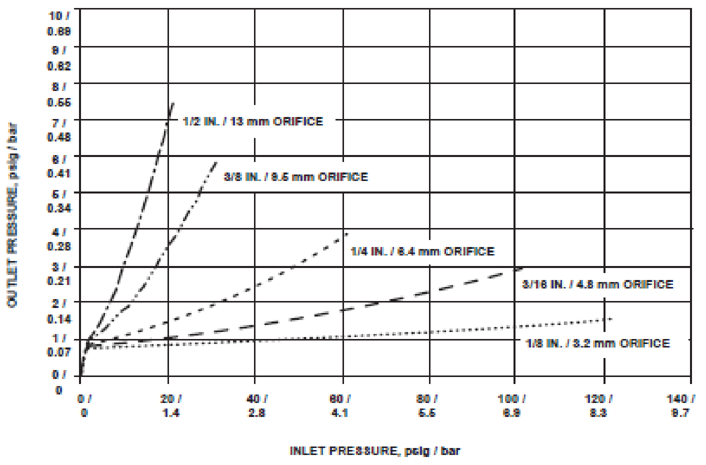
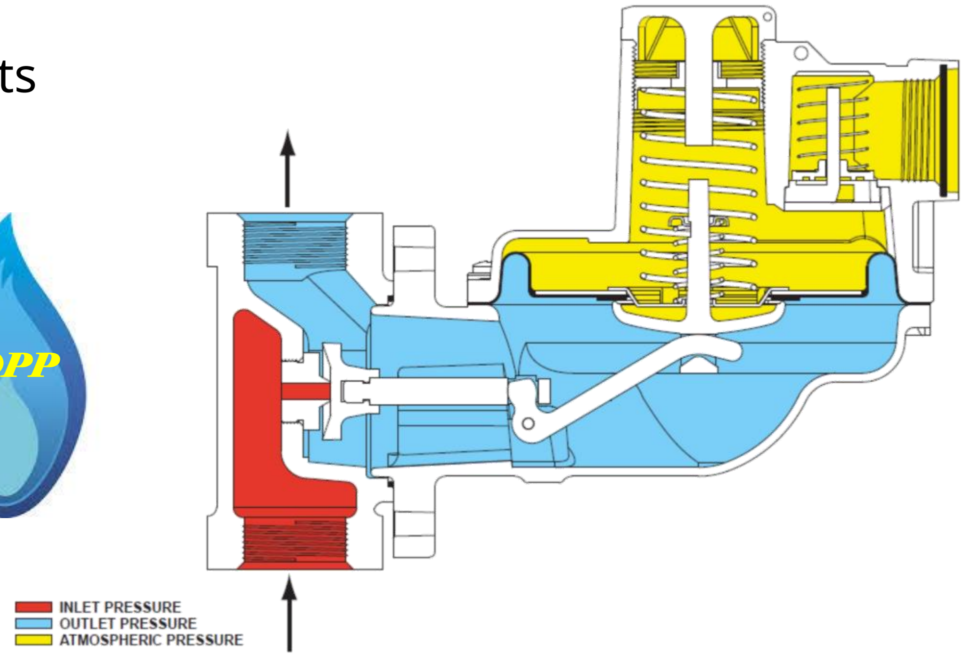


Figure 3. 7 in. w.c. / 17 mbar Setpoint Relief Curves (with Lever Disconnected, No Vent Piping and 3/4 or 1 NPT Vent)



LP System OPP – Residential 7-12” wc

- HSR style regulator considerations when used in utilization pressure systems
  - MAOP can’t be raised
  - Pressure drop across regulator based upon max load conditions
  - Raising system pressures will increase leakage with leak prone piping systems
  - Consider color coding HSR closing caps for techs to immediately recognize a LP pressure system
  - Venting allowances at installation may inhibit install
    - Windows
    - Air intakes
    - Doorways
    - Ignition source

- ***Simple OPP for low pressure services***

LP Pressure Residential Slam Shut – 7-12” wc

- Slam shut used in LP residential applications – shuts service off during over pressure excursion
  - Requires manual reset (code requirement) – service call
  - Will require a higher pressure source in order to set in the field
  - No problems with thermal build up causing accidental trips since it is wide open to the service main.
  - Installed on the upstream side of the meter
  - No venting

2

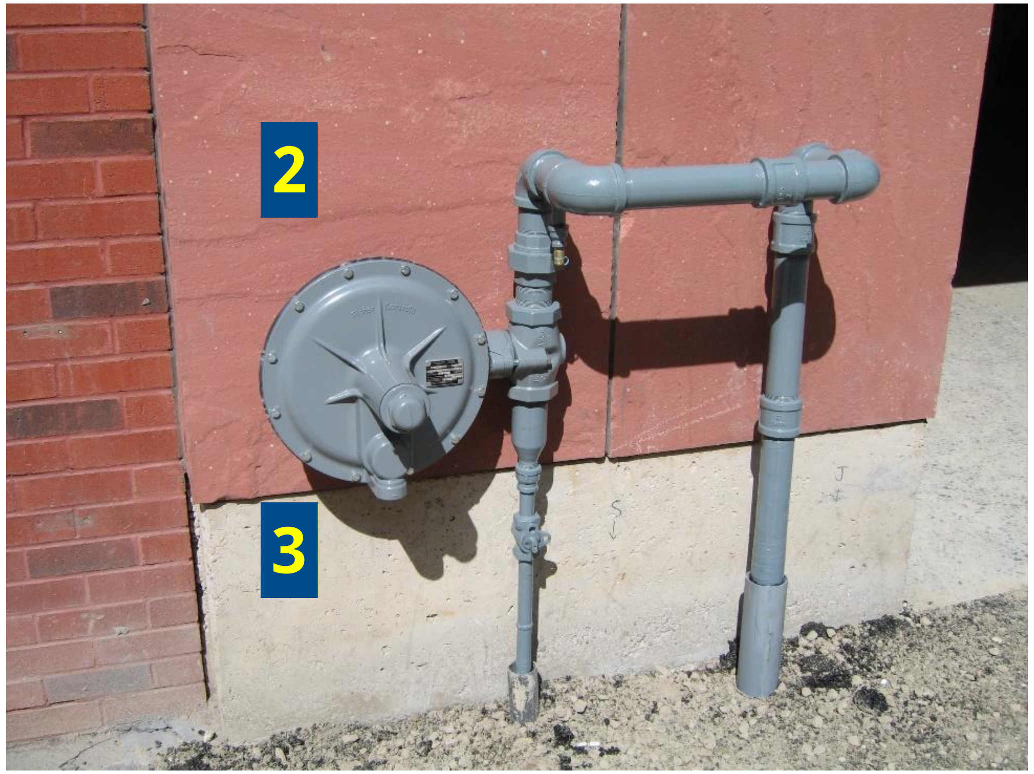
VS110

- ***Slam shuts are commonly used In Europe at services***

CSR LP Services Applications

- Monitoring service regulator with IRV
  - Pressure drop across regulator based upon max load conditions
  - MAOP of upstream and downstream system
  - Venting allowances at installation may inhibit installations
    - Windows
    - Air intakes
    - Doorways
    - Ignition source
  - Accepted form of OPP by many US utilities but some utilities do not want to vent gas in densified areas. No uniform standard for IRV capacity among manufacturers for CSR regulators

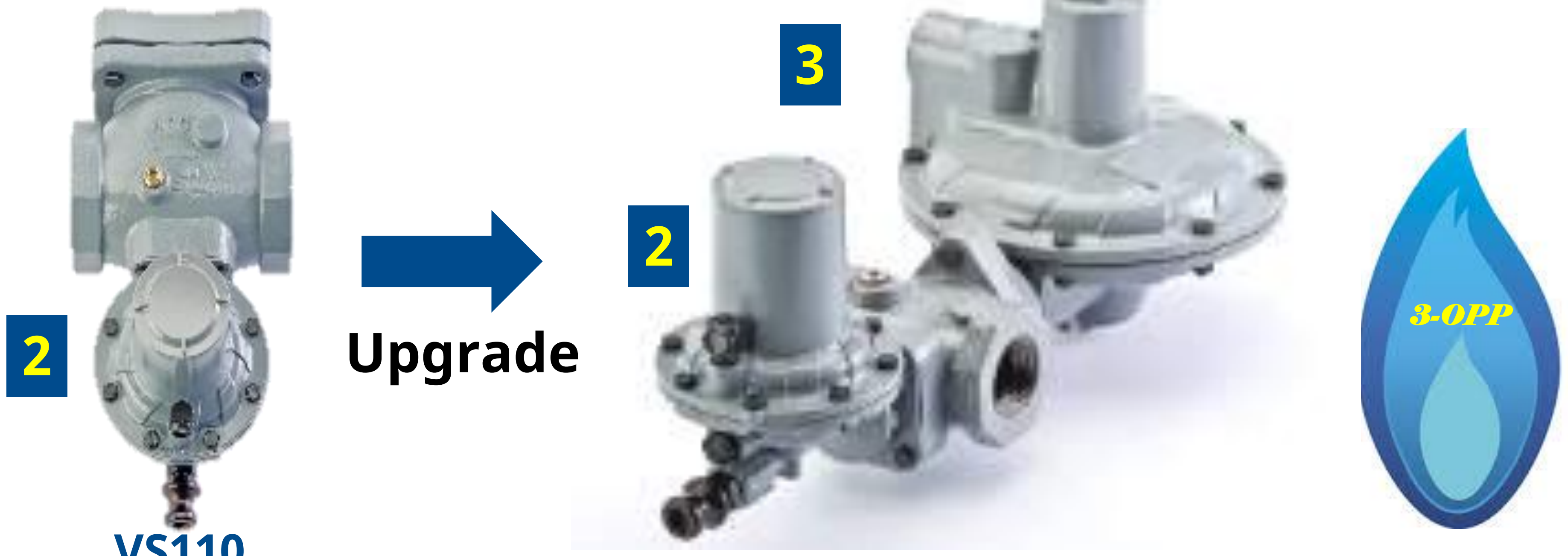
3-OPP



- ***Commercial service LP applications***

LP Residential/Commercial OPP

- Why a slam shut?
  - Can be considered 2 or 3rd level OPP
  - Easy install into the riser of the home/building
  - Protects building even if district station overpressures
  - Requires call out to manually reset
  - Upgradeable when system goes to IP system

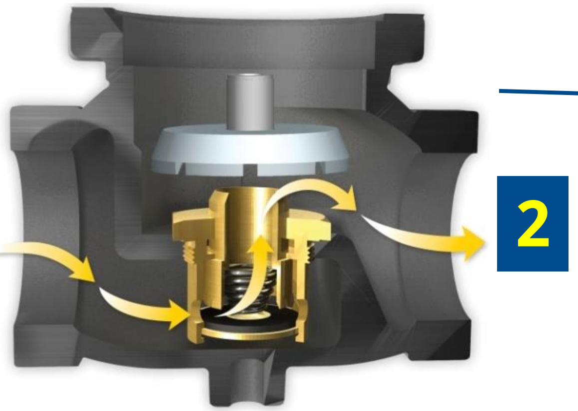


VS110

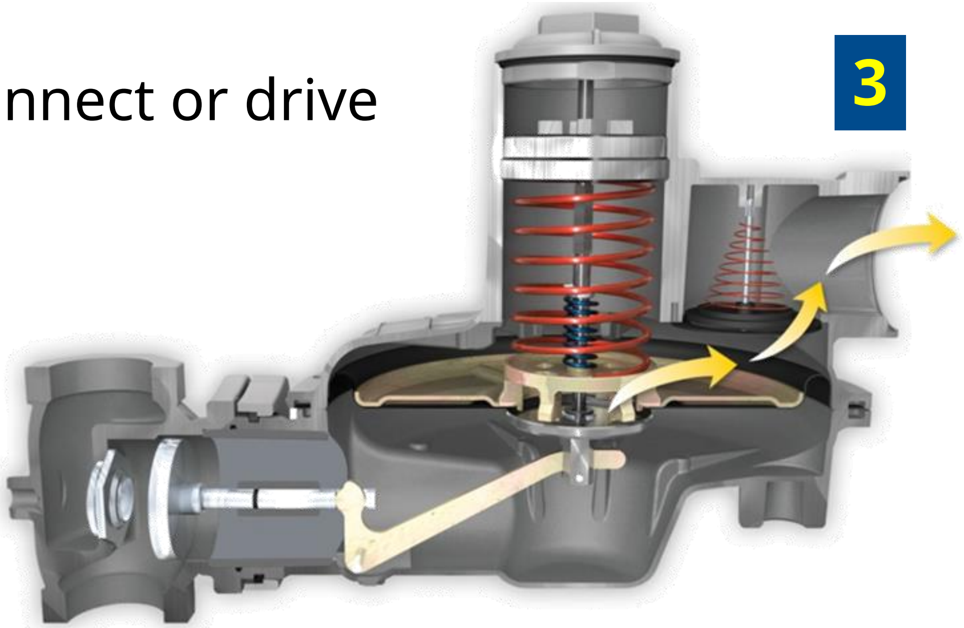
- ***Slam shuts are commonly used In Europe at services***

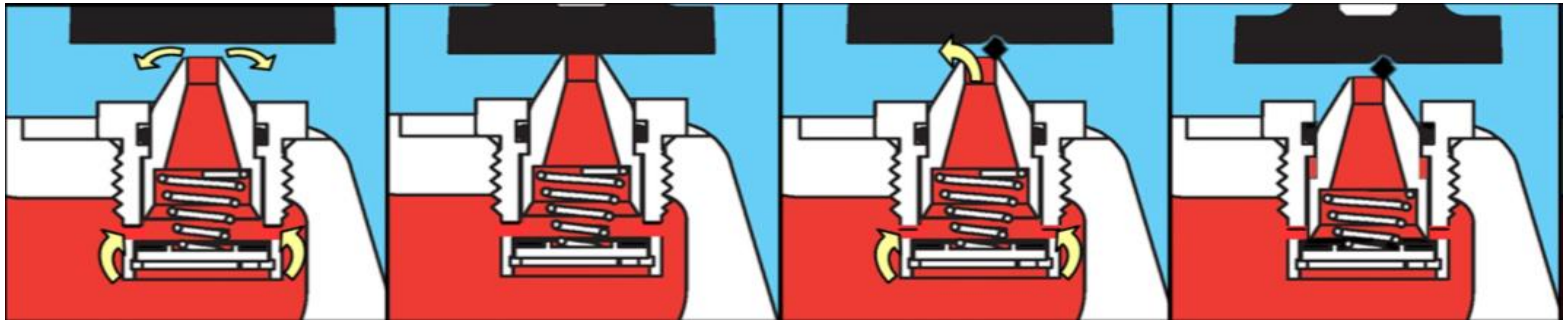
CSR’s Three-Level OPP With Secondary Seat

- Service regulator with sliding orifice (secondary seat or internal monitor) and full capacity IRV
- Sliding orifice OPP is rendered inoperable with lever disconnect or drive train seizure if tested to ANSI B109.4



SECONDARY SEAT

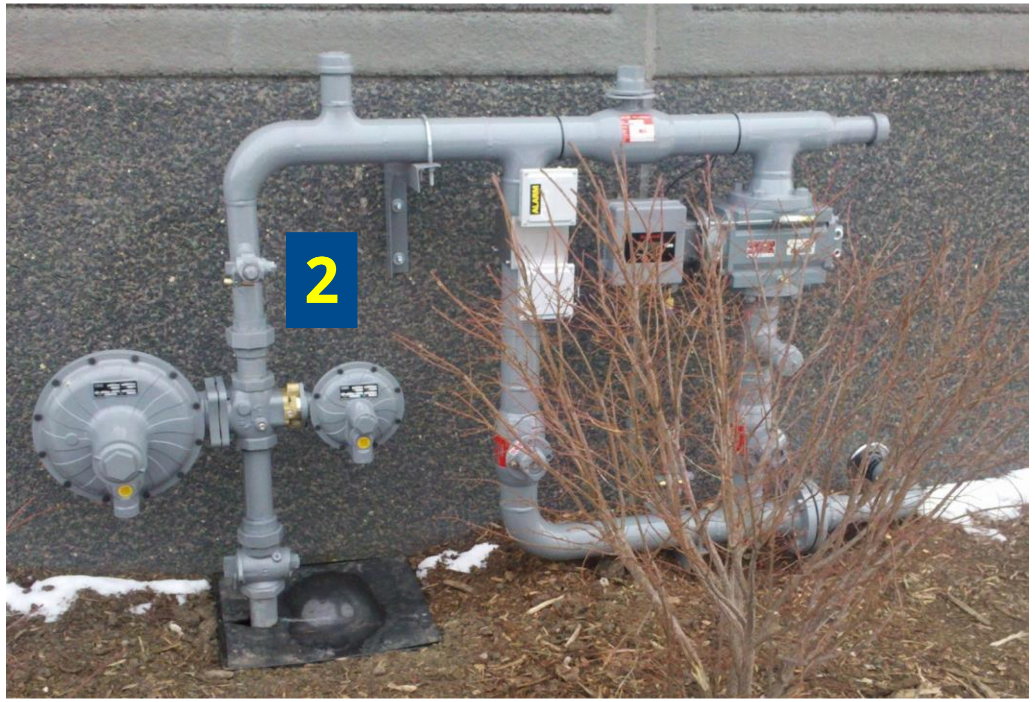




- ***Secondary seats may be considered a method of OPP in the USA***

Two-Level CSR OPP – True Monitor

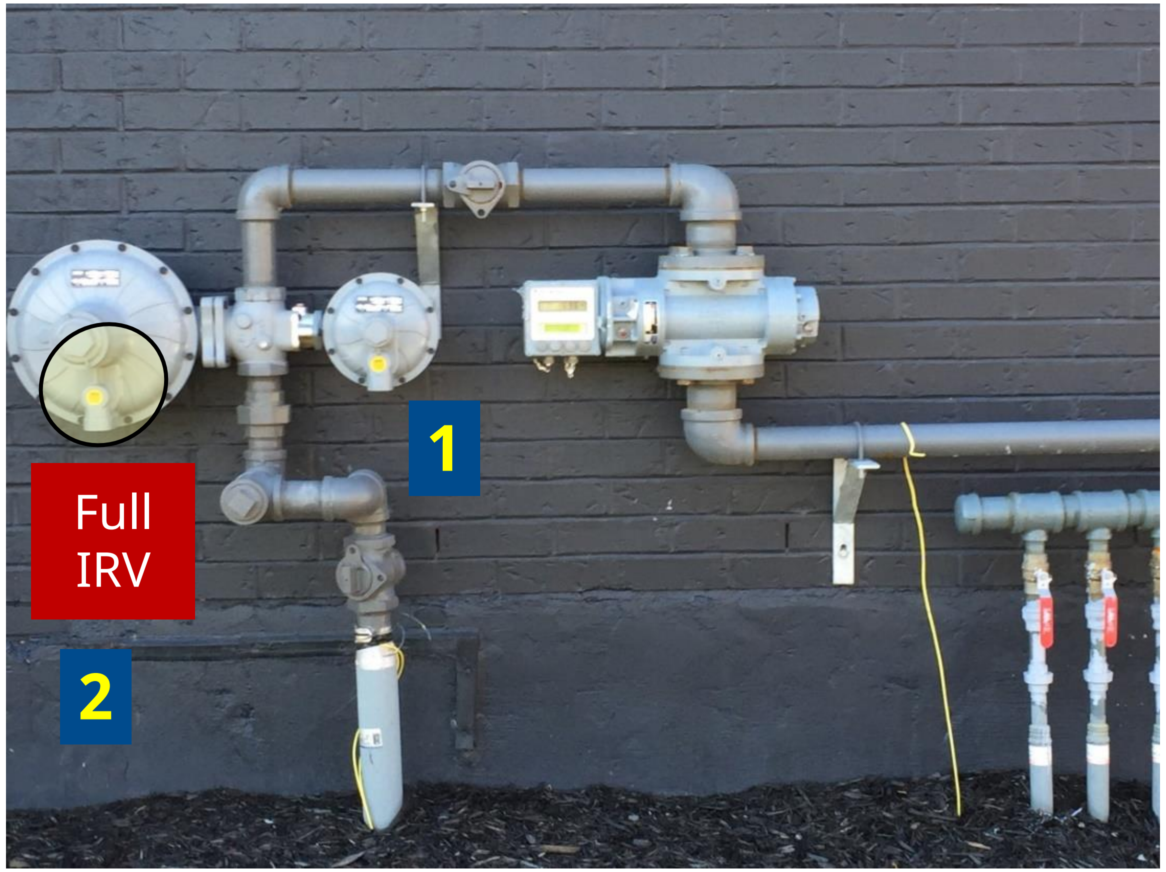
- Service regulator with integral monitor
  - When primary regulator fails, gas supply to downstream is at higher but still safe pressure regulated by an integral monitor
  - Token relief valve with set point between regulator and monitor is recommended for alarm

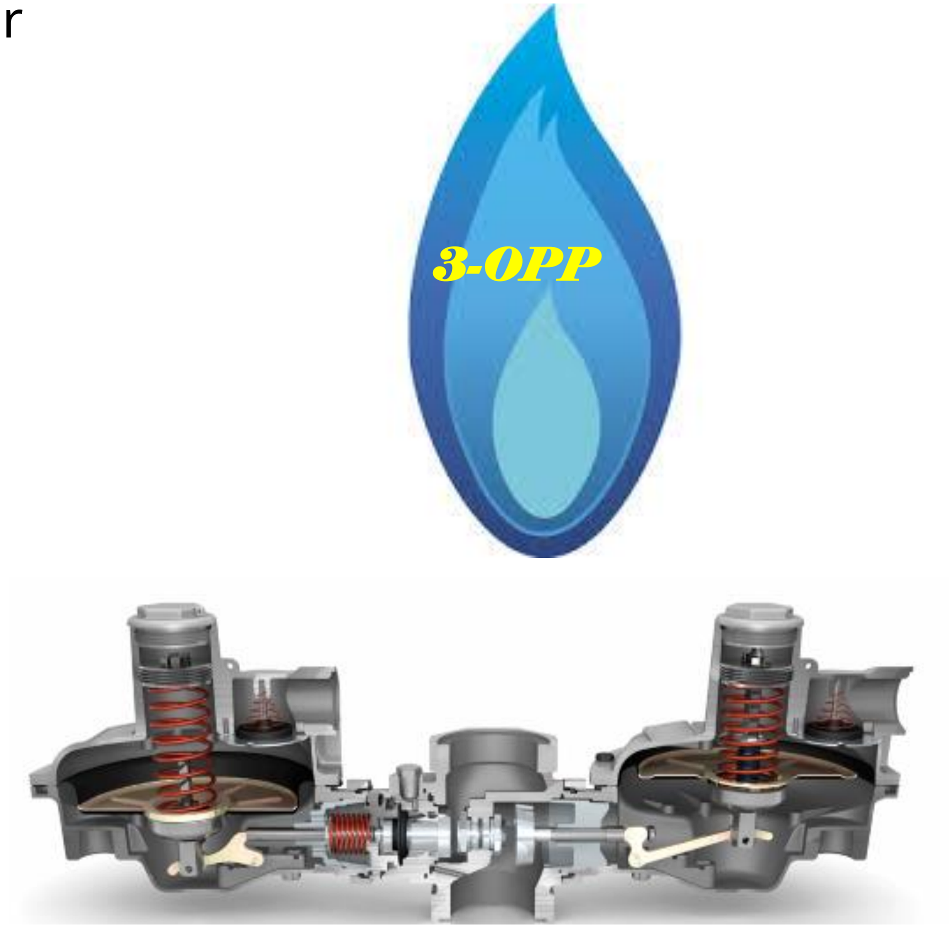


- ***Integral monitor has 2 independent sealing surfaces***

Three-Level Commercial OPP

- Service regulator with integral monitor regulator
  - When primary regulator fails, gas supply to downstream is at higher but still safe pressure
  - If both monitor and worker fail, full capacity IRV will take over

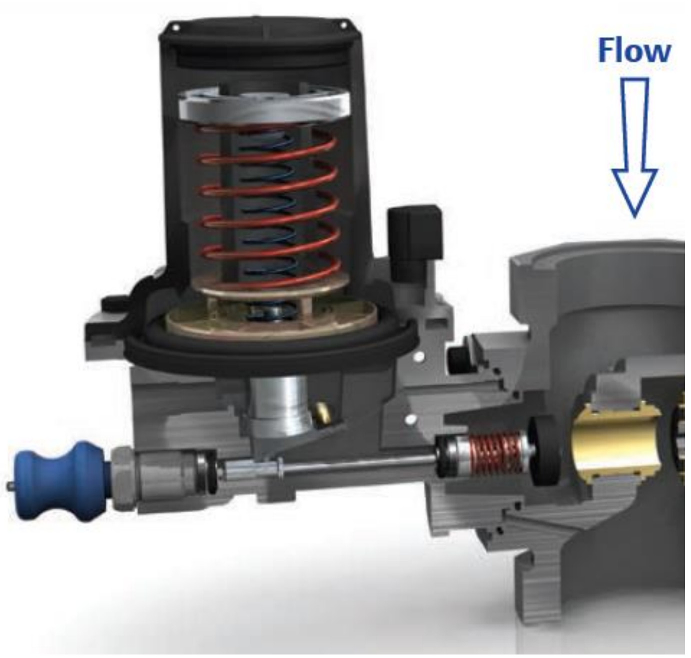


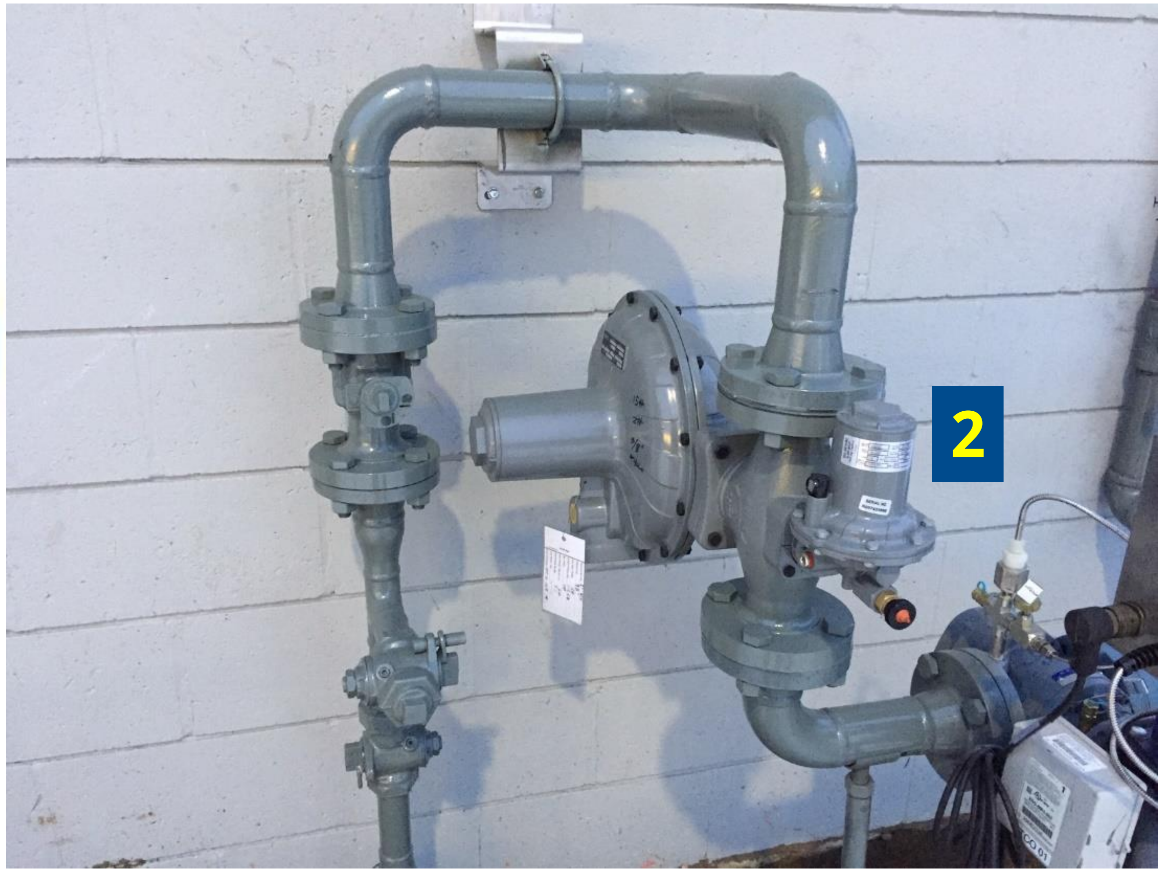


- ***Integral monitor has little to no capacity reduction***

Two-Level OPP

- Service monitor regulator with integral slam shut
  - When primary regulator fails, gas supply to downstream is shut off upon high pressure
  - ***Use a token relief to prevent trips from thermal buildup***
  - Requires manual reset





- ***Slam shuts are widely used in Europe***

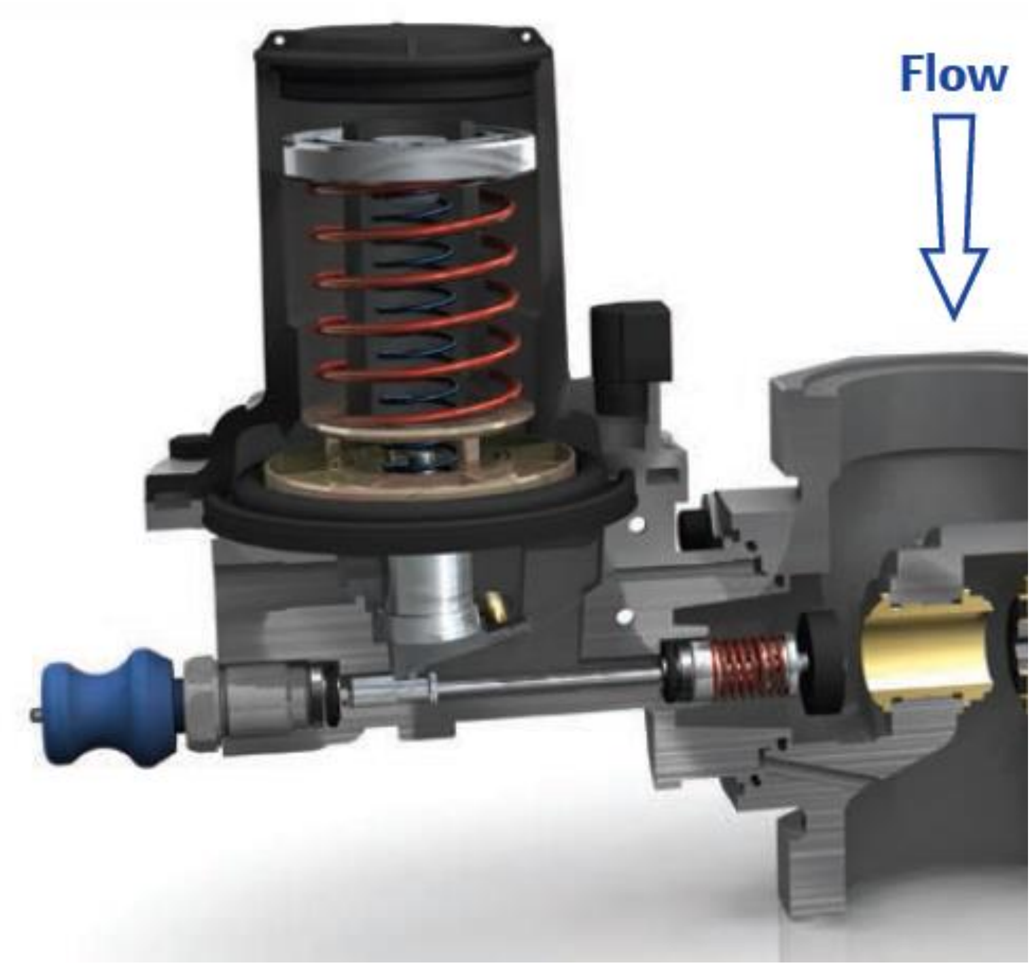
Benefits of Service Regulator on Low Pressure Service

- Benefits
  - Robust and safe
  - 125 psig inlet pressure rating
  - Internal relief valves available
  - Slam shut options
  - Upgradable path
  - Continuity of service
  - Cost
- Disadvantages
  - Venting
  - Can’t raise system pressures

- ***HSR/CSR pressure regulators at low pressure services***

Slam Shuts on Services

- Benefits
  - OPP by containment, no gas to atmosphere
  - Solid technology
- Disadvantages
  - Relights
  - Higher cost
  - Testing



- ***Better to relight than rebuild…***

What Makes A Slam Shut Good?

- Designed to best available and only comprehensive standard which is a global standard ISO/WD 23555/3 (Draft)
- Accuracy to setpoint
- Repeatability to setpoint after multiple trips
- Vibration resistance avoiding accidental trips
- Metal valve plug with soft seats for bubble tight shutoff ANSI Class VIII
- Manual reset
- Minimal pressure drop
- Watertight case
- Temperatures to -40 F/C
- Optional trip indication
- Optional activation/indication via SCADA system/RTU
- Stand alone or integral to the regulator body
- Under pressure shut off options (UPSO)

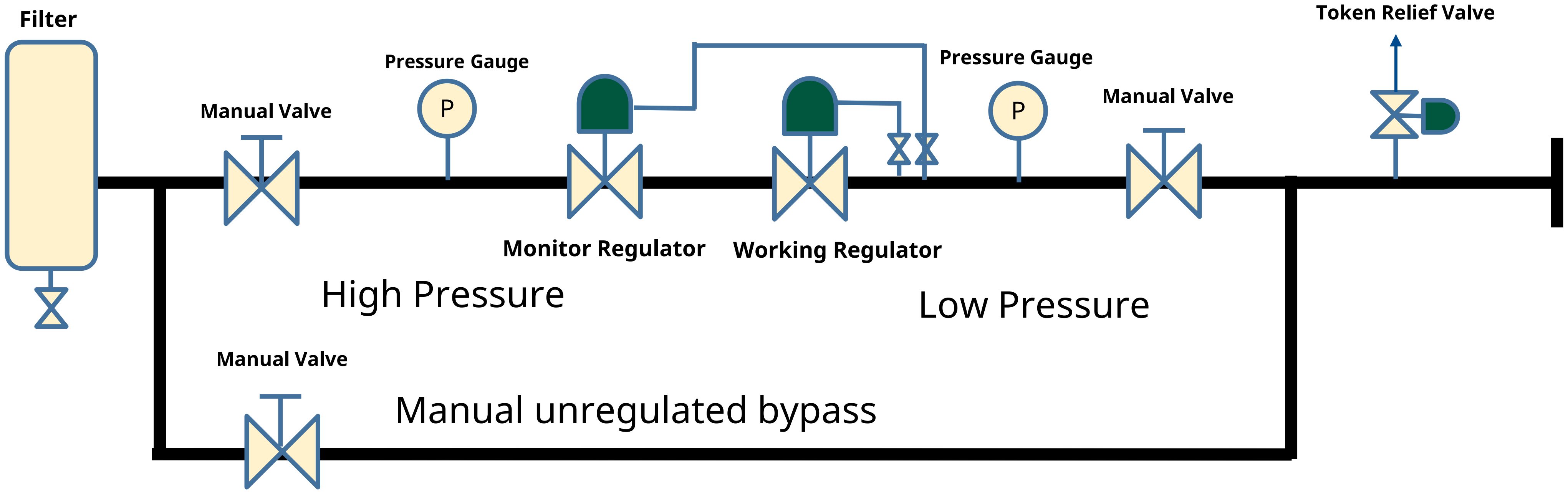
OPP Considerations for Stations

- Single Level Examples – Gate Station/District Station/TBS
  - Need to define the failure scenario the operator is considering and its impact on the overall system
    - MAOP
    - Above or below grade or other environmental such as seacoast, cold weather
    - Station footprint – land availability and/or remote or near densified areas
    - Redundancy
    - Summer/winter run
    - Access to station throughout the year
    - Existing station or will upgrade for newer technology
    - Pressure monitoring and control
    - Can gas be vented in the area – full relief or token relief
    - Could the customer/station be shutdown in the event of an OPP event
    - Control line placement
    - Token reliefs at all monitor stations is a best practice
    - Remote shutdown

- ***Stations can be very complex with many variables***

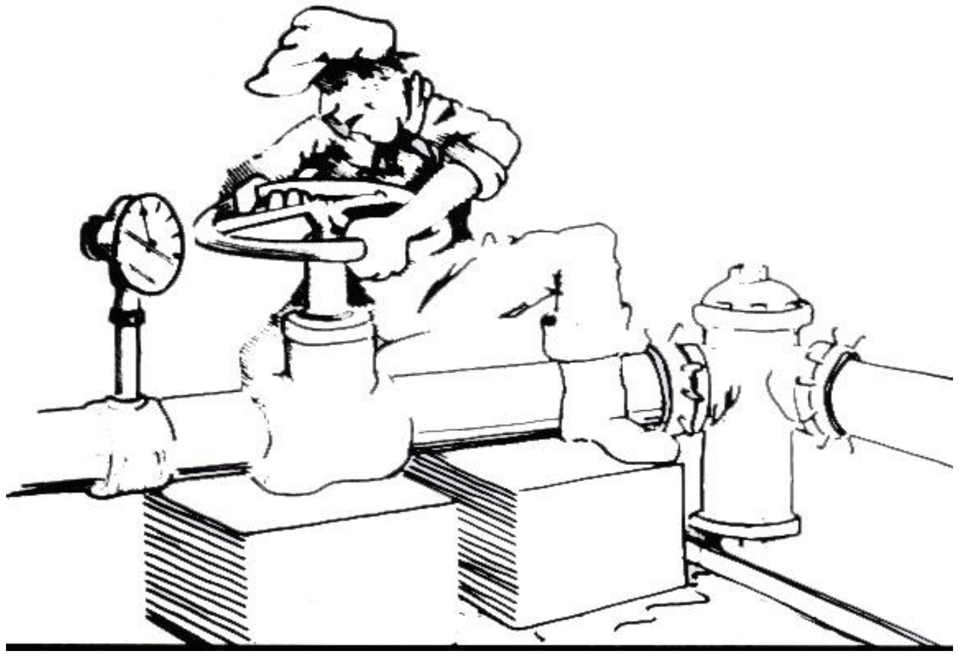
Basic District Station Scenario Today

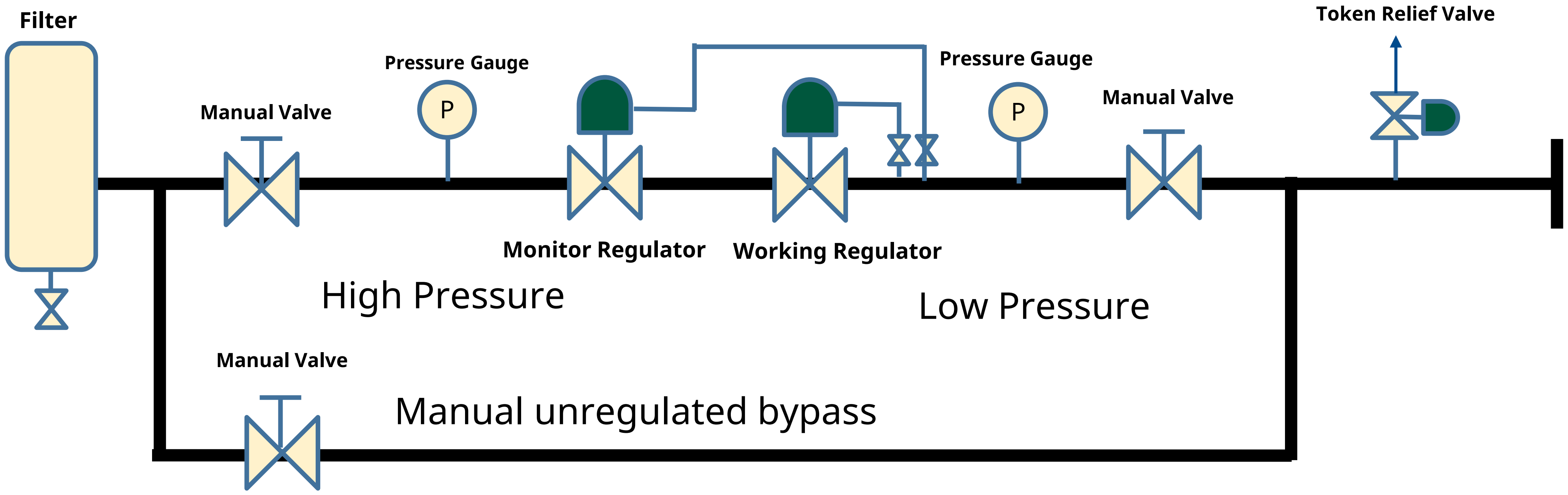
- Worker/monitor as single layer OPP
- Token relief valve ?
- Single manual valve with unregulated bypass



Basic District Station Scenario Today

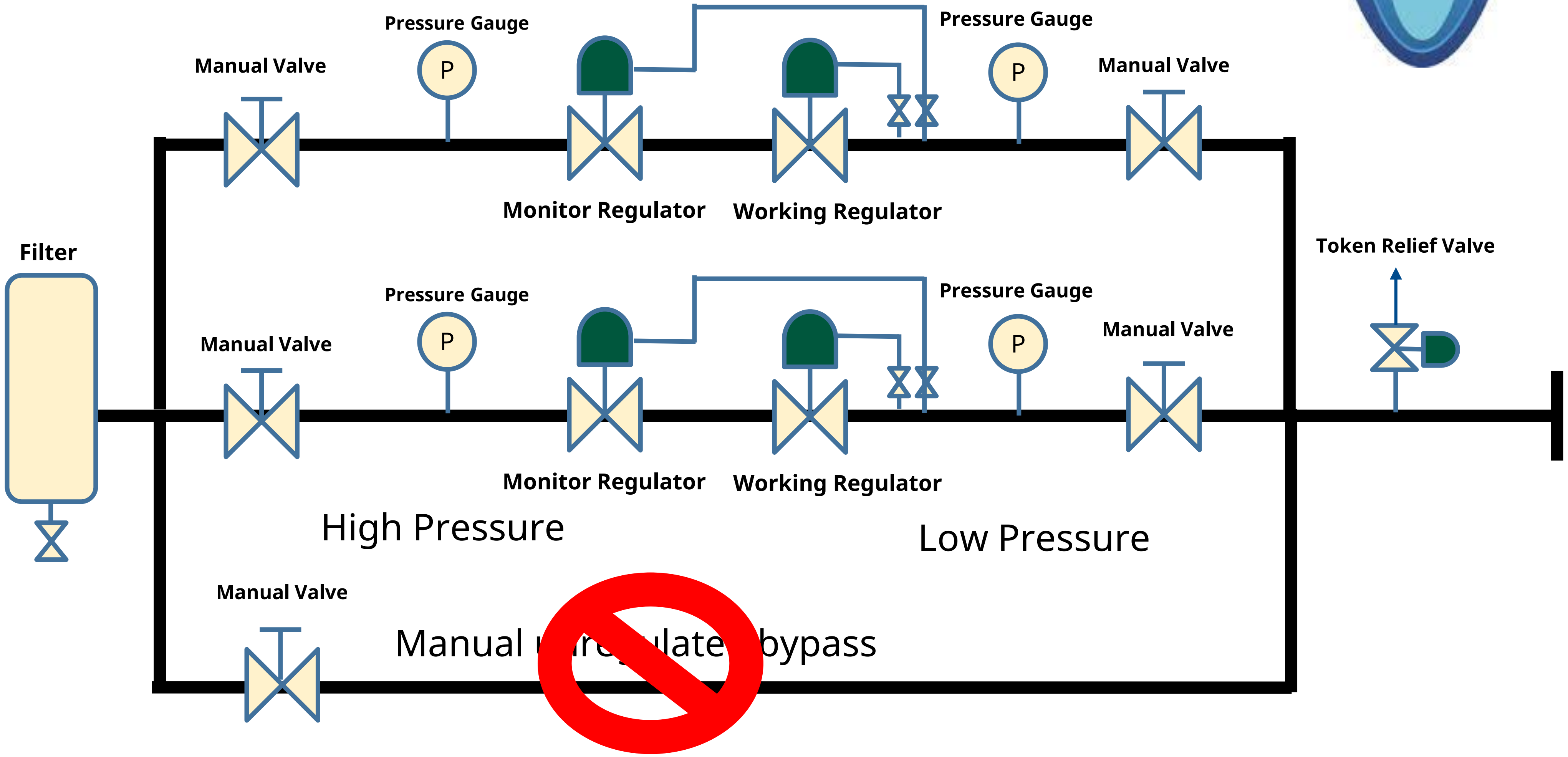
Scenario: Regulator maintenance and technician is on manual bypass. What happens if the operator on the valve breaks or the valve seizes?



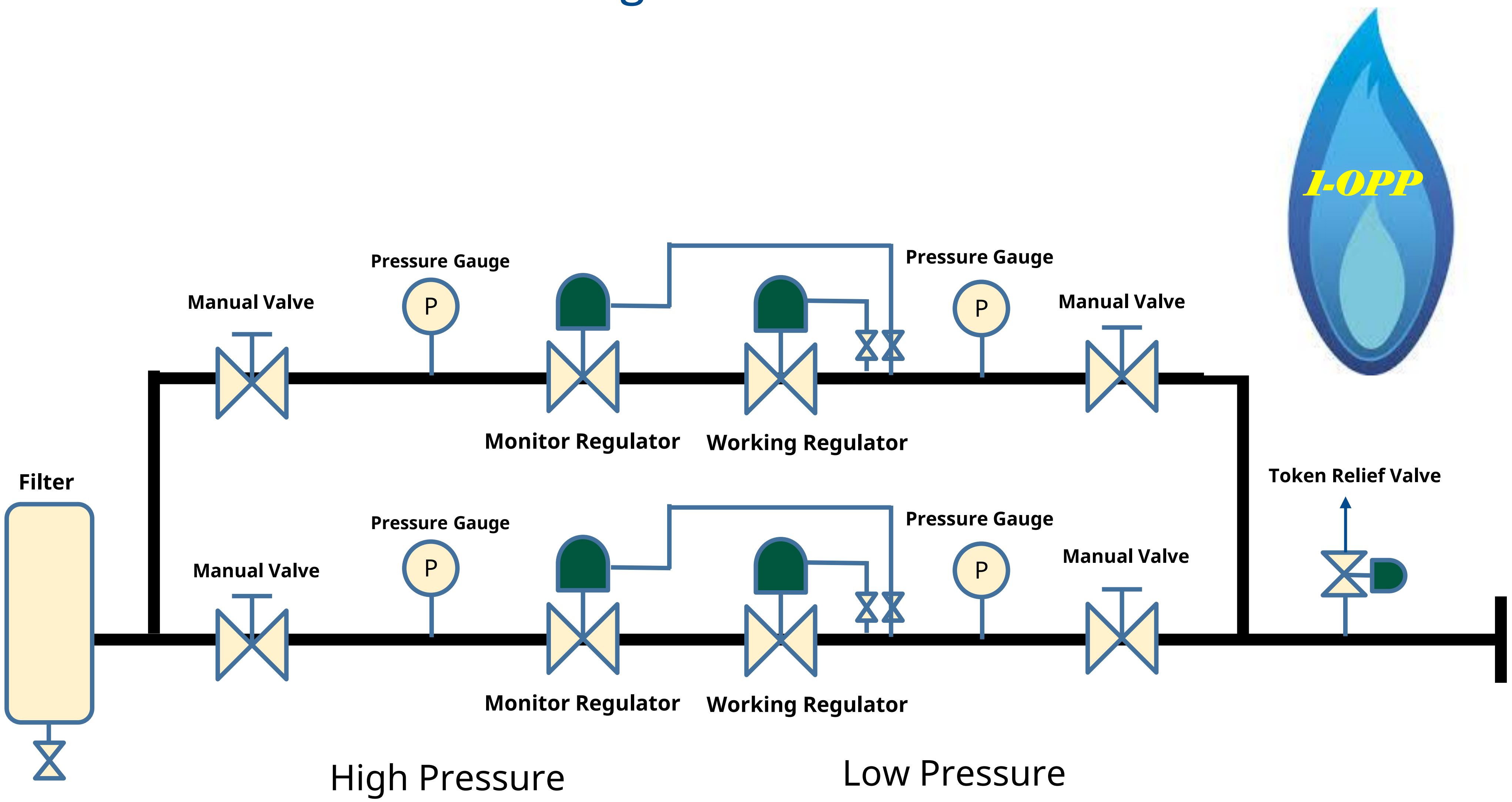


Basic District Station Scenario Today

- Wide Open Monitor as single layer OPP
- Full capacity redundant standby run
- Token relief valve

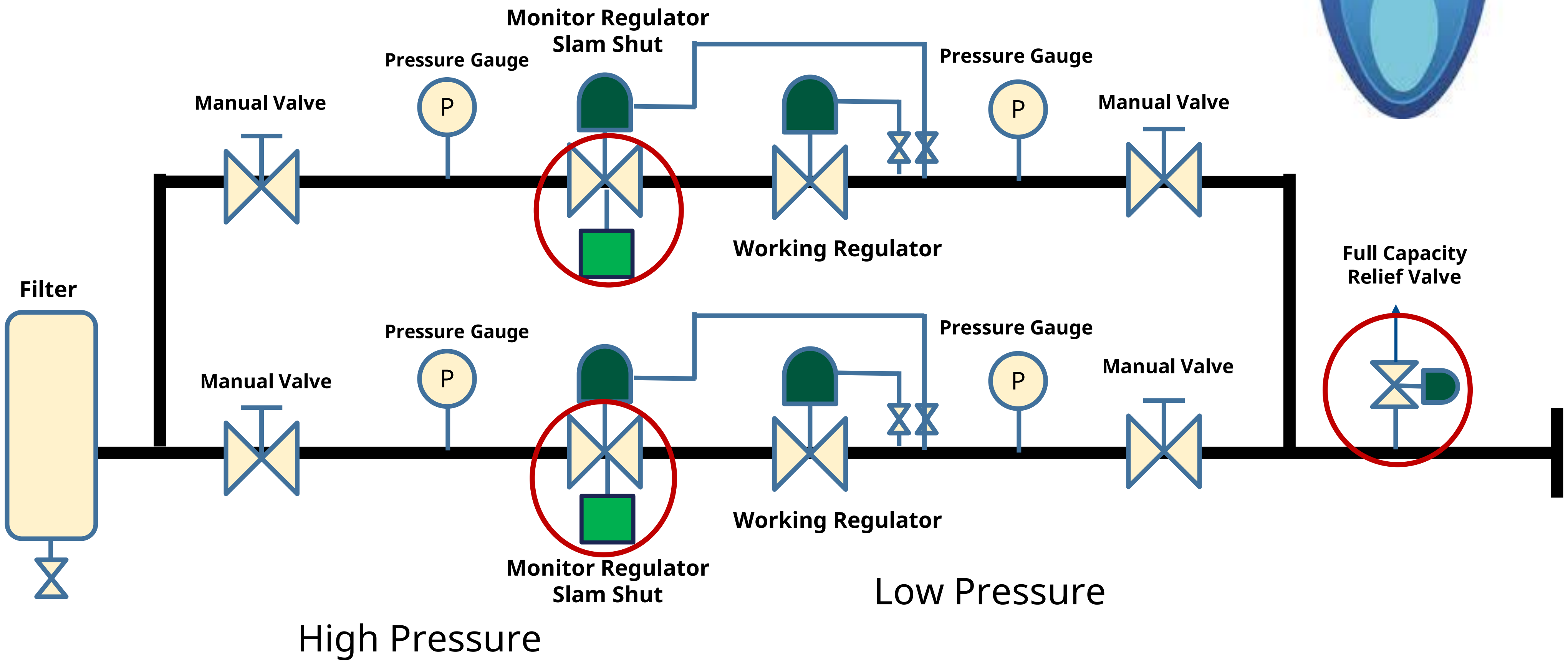


Basic District Station: What's Coming Next?



District Stations of the Future

- Double layer OPP achieved 2 ways
  - Slam shut monitoring regulators
  - Relief valves



The Question :
Which Part of the System Should We Protect?

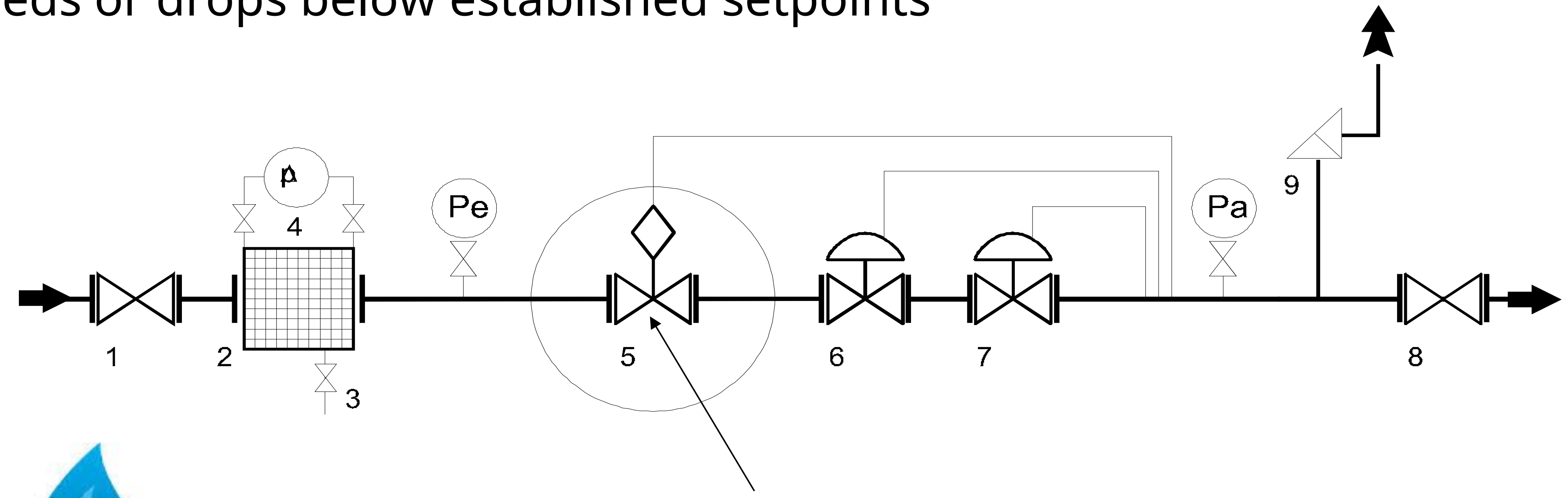
- District Regulator(DR) Station OPP
  - What technology should we consider?
  - How many layers?
  - Do we need monitoring of our DR?
  - Is a remote shut off valve required?
- End User OPP
  - What technology should we consider?
  - Have we considered a regulated bypass?
  - How many layers of OPP?

LDC Direction : Prediction

- Low pressure will be regulated to add two layer OPP at all district stations
- All other stations will be under **risk assessment** because if a LP station could have a failure what about all the other district and city gate stations?
  - Scenario: P1 = 800-1,000 psig and P2 = 60 psig delivery
    - What happens if 1,000 psig ends up in a 60 psig distribution system?
      - Is it catastrophic?
      - What are the implications?
      - What is the best way to protect this system?

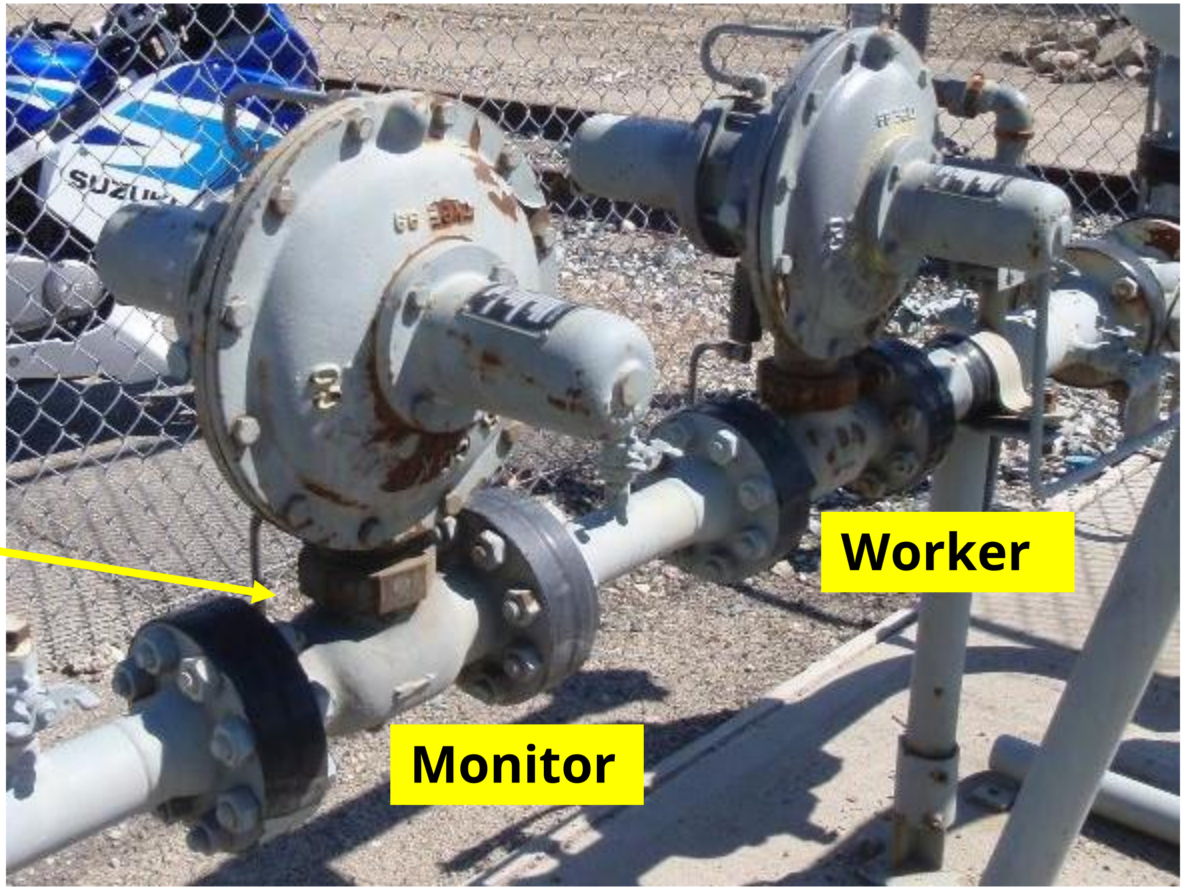
Slam-Shut Valves: Purpose & Installation

- The slam-shut valves will cut off the gas flow when the inlet and/or outlet pressure in the system exceeds or drops below established setpoints



The slamshut is usually installed upstream of the regulators to minimize pressure drop across station or it can be integral to the regulator.

Upgrading Existing Stations to 2 Level OPP

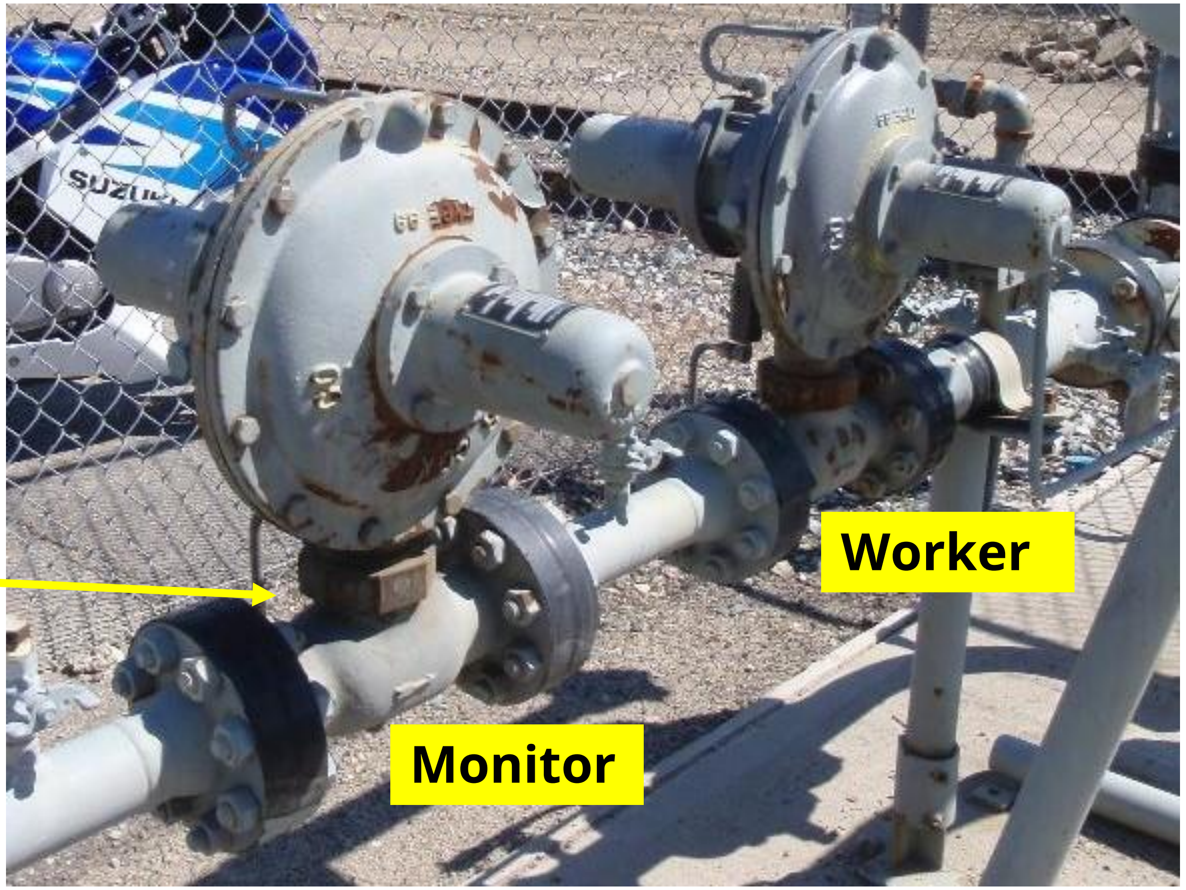


- **299HV but use flanged body (not pictured)**

- ***Drop in monitor with slam shut to upgrade to 2 level OPP***

Upgrading Existing Stations to 2 Level OPP

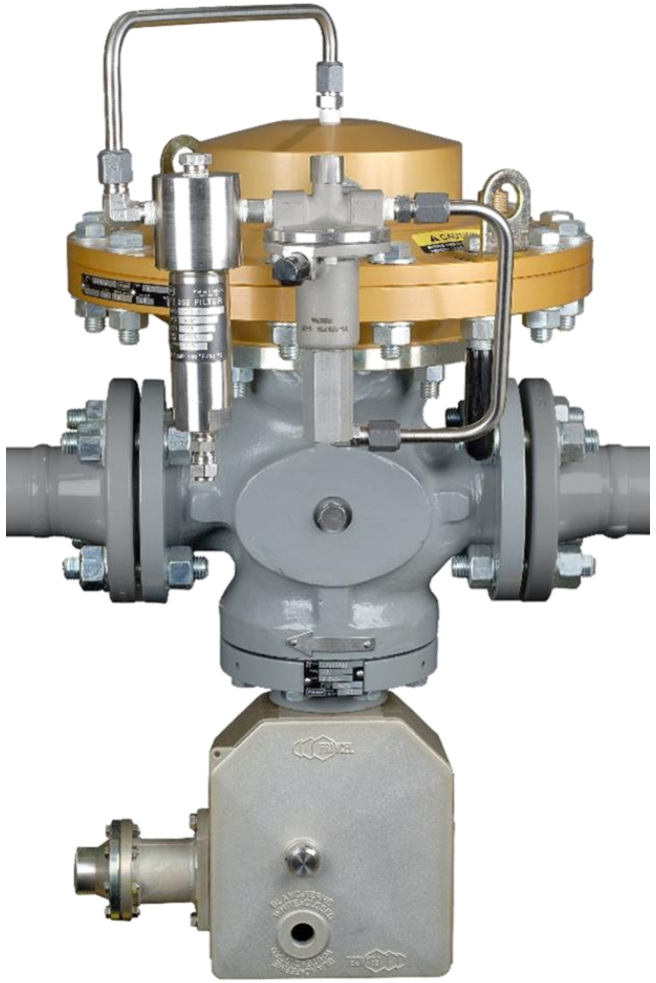
- Flanged wide-open upstream monitors can easily be retrofitted with minimal piping changes
- Following ANSI face to face dimensions for flanges accommodates this change
- Integral device avoids capacity reduction



- ***Drop in monitor with slam shut to upgrade to 2 level OPP***

OPP Gate Station/District Station

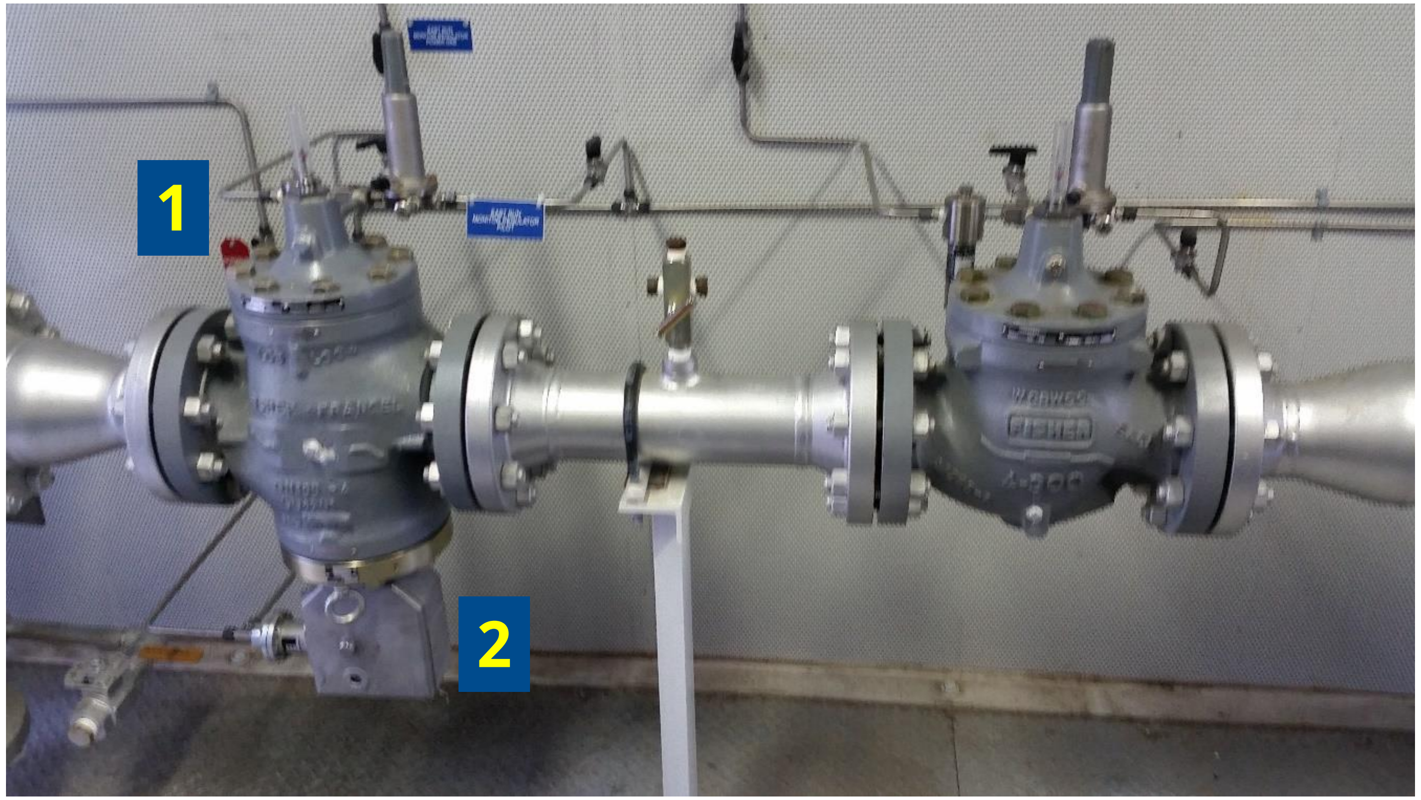
- Single level OPP with regulator and integral slam shut



- ***Integral slam shut with wide open monitor standby***

OPP Gate Station/District Station

- Two level OPP Wide open monitor with integrated slam shut
  - Worker/Monitor is a flexible element
  - Slam shut is a metal plug
  - Token relief
    - Set at monitor pressure



- ***Two levels will add another piece of equipment for OPP***

Considerations for OPP in Vaults at District Stations

- State requirements for separation of devices
- Explosions and fire prevention
  - Boot style or metal plug regulators
- Water in vaults
  - Float switches
- Control line placement to prevent excavation damage
- Intrusion alarms
- Gas detection
- Slam shut monitoring
- Remote setpoint control
- Remote shutdown of regulators
- Remote operated valves

OPP Utilization Pressure District Station Using Reliefs

- Two level OPP monitoring regulator station with low differential pressure full capacity relief valve
  - It is a modulating design only to open as much as necessary to keep the downstream pressure to a safe value
  - Remote trip indication should be considered to know when the relief valve has opened

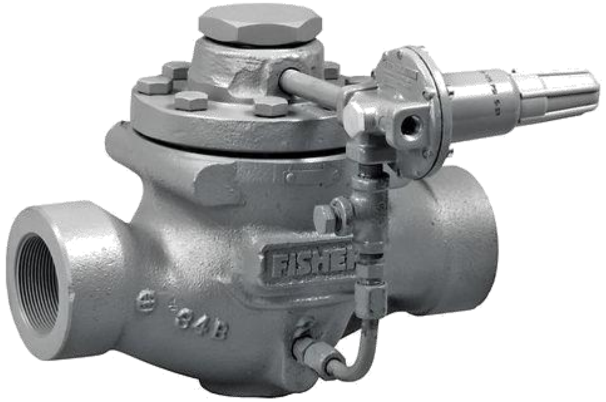
Main valve open discrete indicator

- ***Low Pressure Reliefs***

Benefits of an ASME Code Stamp

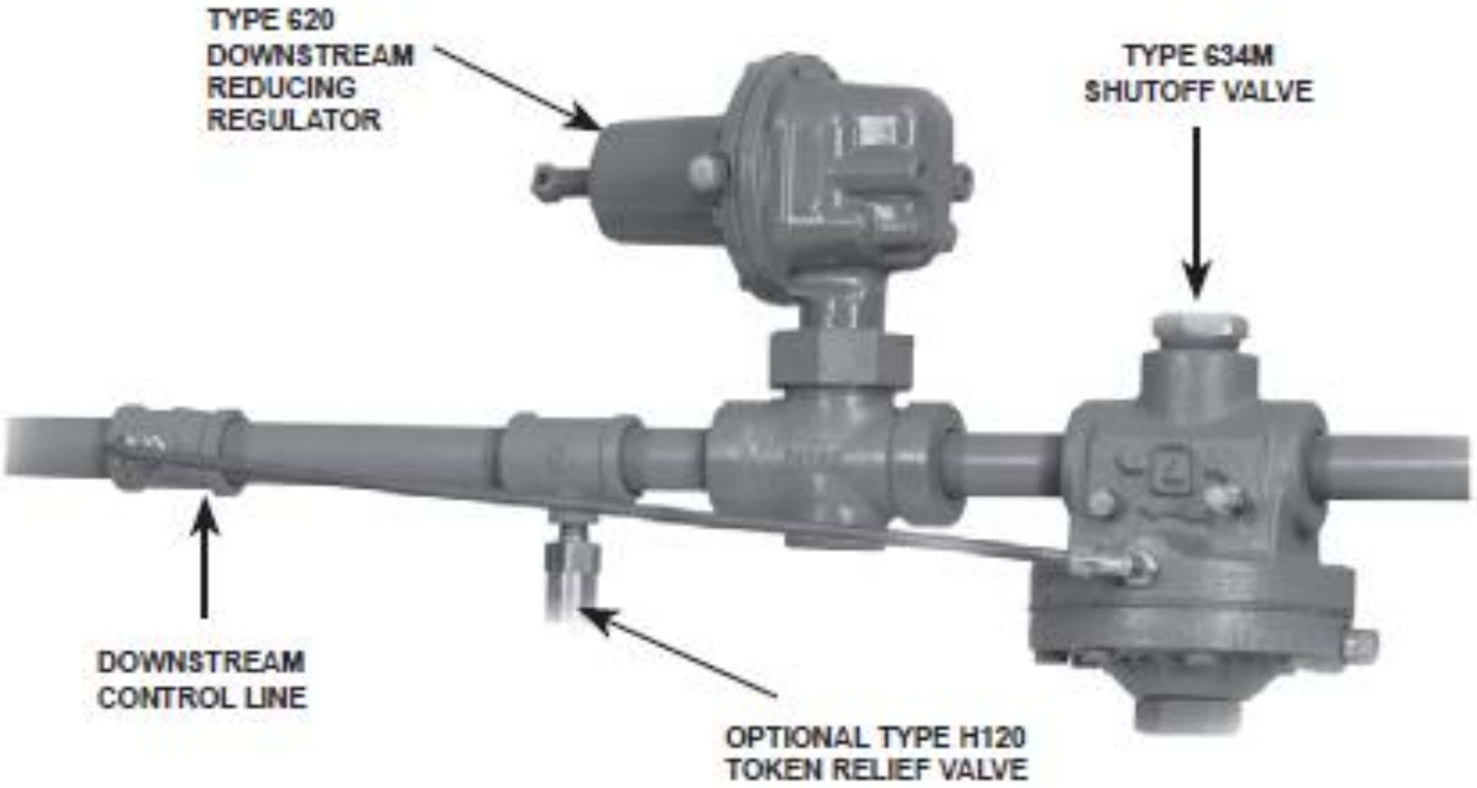
- Certified capacities
- Guaranteed performance
  - 10% or less overpressure required
  - Recorded blowdown
- Material standards and required traceability of pressure containing components
- Mandatory hydrostatic testing of pressure containing parts
- Valves shipped with a seal wire to reduce chance of accidental adjustment or tampering
- All ASME valves are serialized for traceability
- Snap acting vs modulating

Non-Section VIII Fisher Relief Valves



OPP at High-Pressure Farm Tap Station

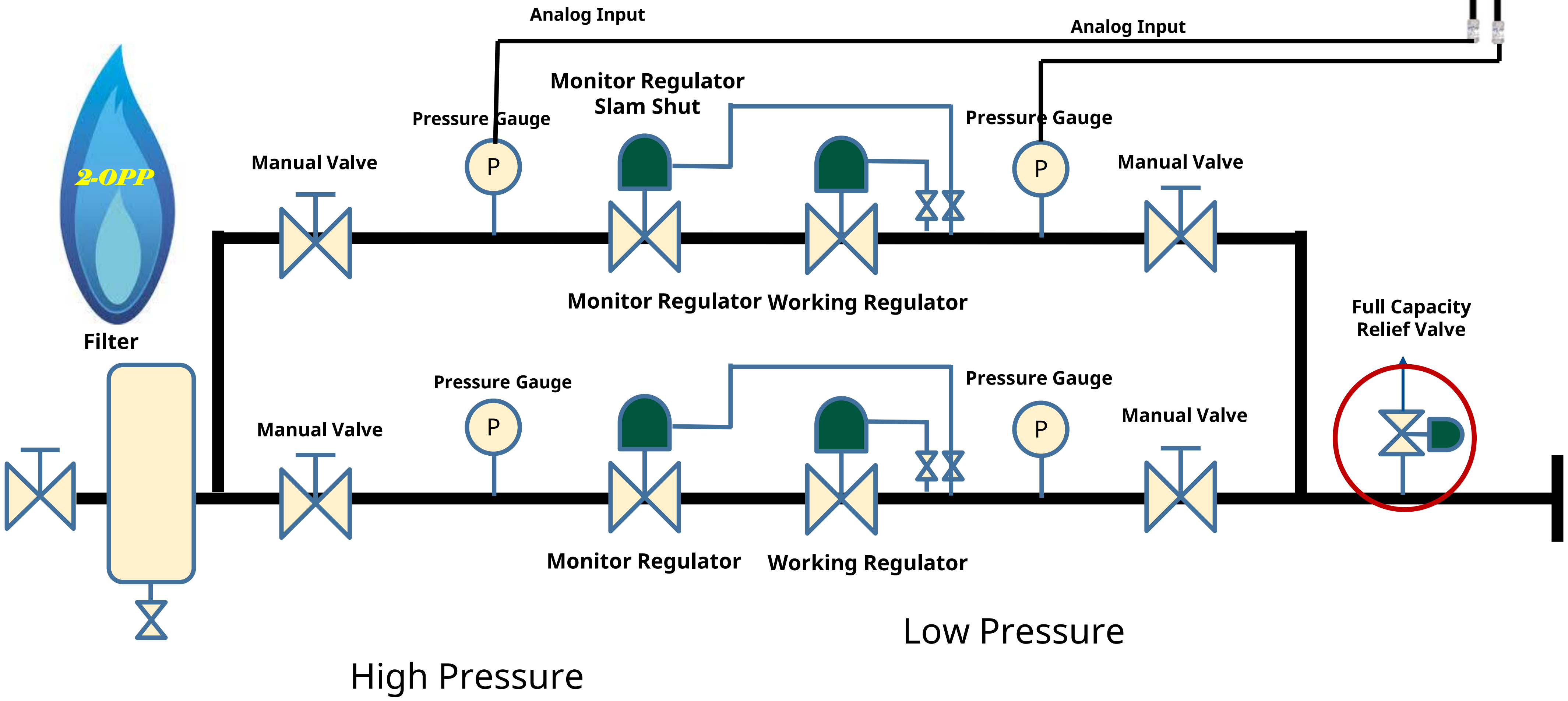
- Single level OPP at farm tap station using fracture disc slam shut



- ***Fracture Disc Slam Shut***

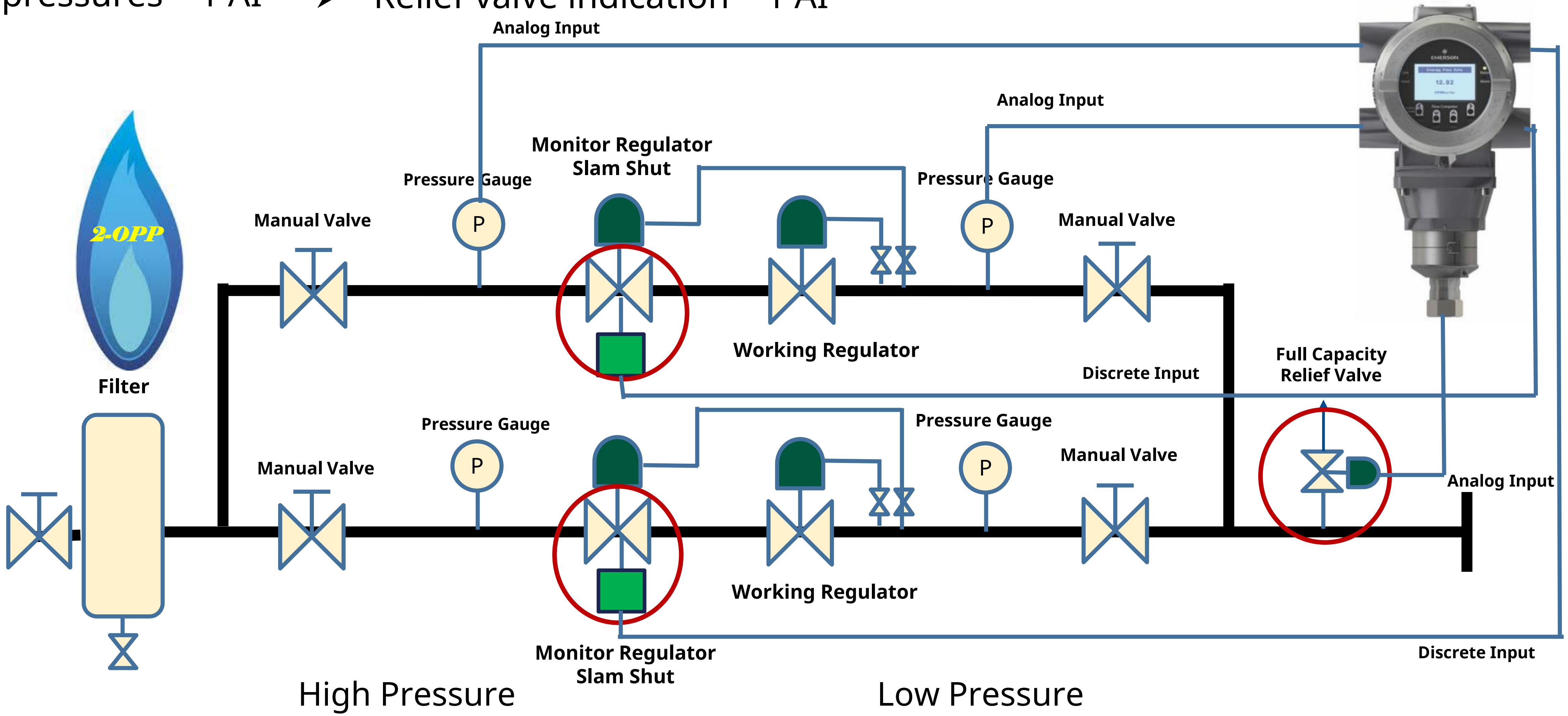
District Stations of the Future - Monitoring

- Inlet pressure – 1 AI
- Outlet pressure – 1 AI



District Stations of the Future - Monitoring

- Inlet pressures – 1 AI
- Outlet pressures – 1 AI
- Slam shut trip indication - 2 DI
- Relief valve indication – 1 AI



Slam Shut Trip Indication

OSE discrete switch

VSX8 reed switch

Real Time Pressure Relief Valve (PRV) Monitoring

- Immediate detection of relief events is extremely important when exhausting gas to atmosphere in populated areas
- Real-time PRV monitoring
  - Timestamp and duration
  - Calculated flow rates possible during relief events for EPA reporting
  - Set pressure verification

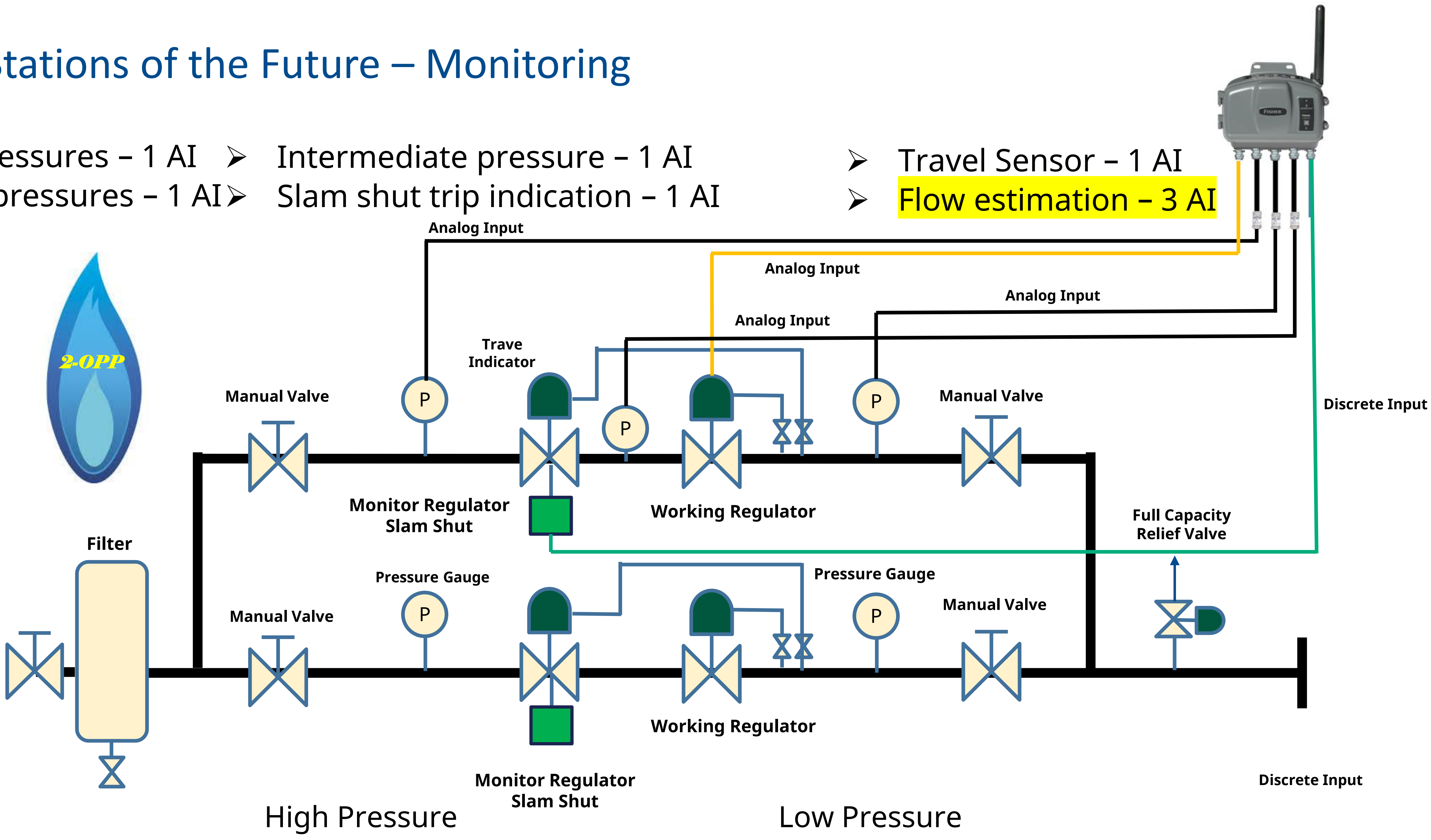
Future Relief Valve Integration Into the System

- Install ΔP transmitter on relief inlet and loading pressure
  - Measuring ΔP can determine travel
  - Flow characterization can predict flow based on ΔP
  - RTU can collect data on how long the relief valve was open
  - In historical record document how much gas was relieved
- Also RTU can record pop tests in event and historical logs
  - Time stamped and how much it opened.

- ***Unaccounted for Gas (UAG) can be estimated more accurately***

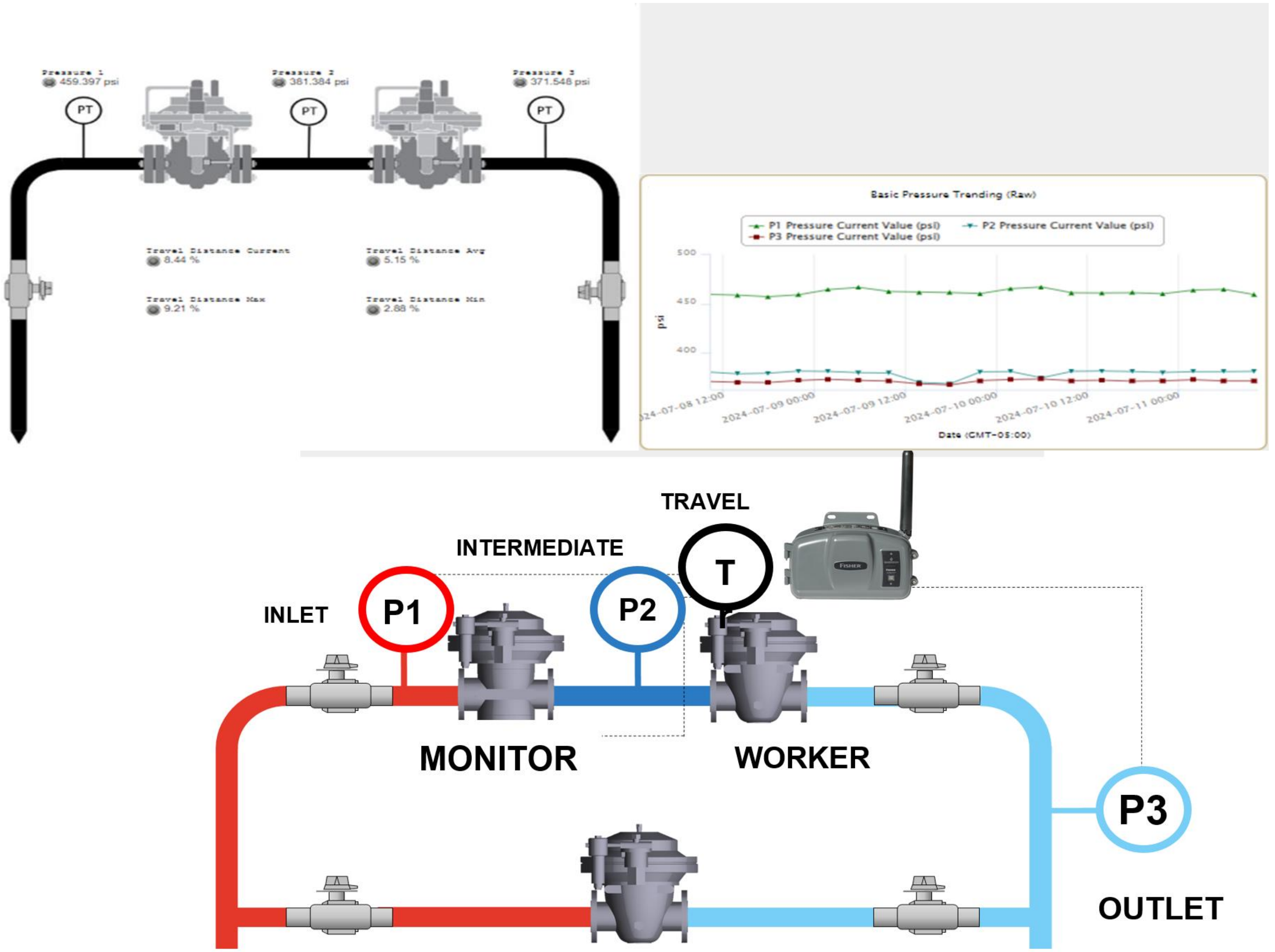
District Stations of the Future – Monitoring

- Inlet pressures – 1 AI
- Outlet pressures – 1 AI
- Intermediate pressure – 1 AI
- Slam shut trip indication – 1 AI
- Travel Sensor – 1 AI
- Flow estimation – 3 AI



District Station Flow Computer

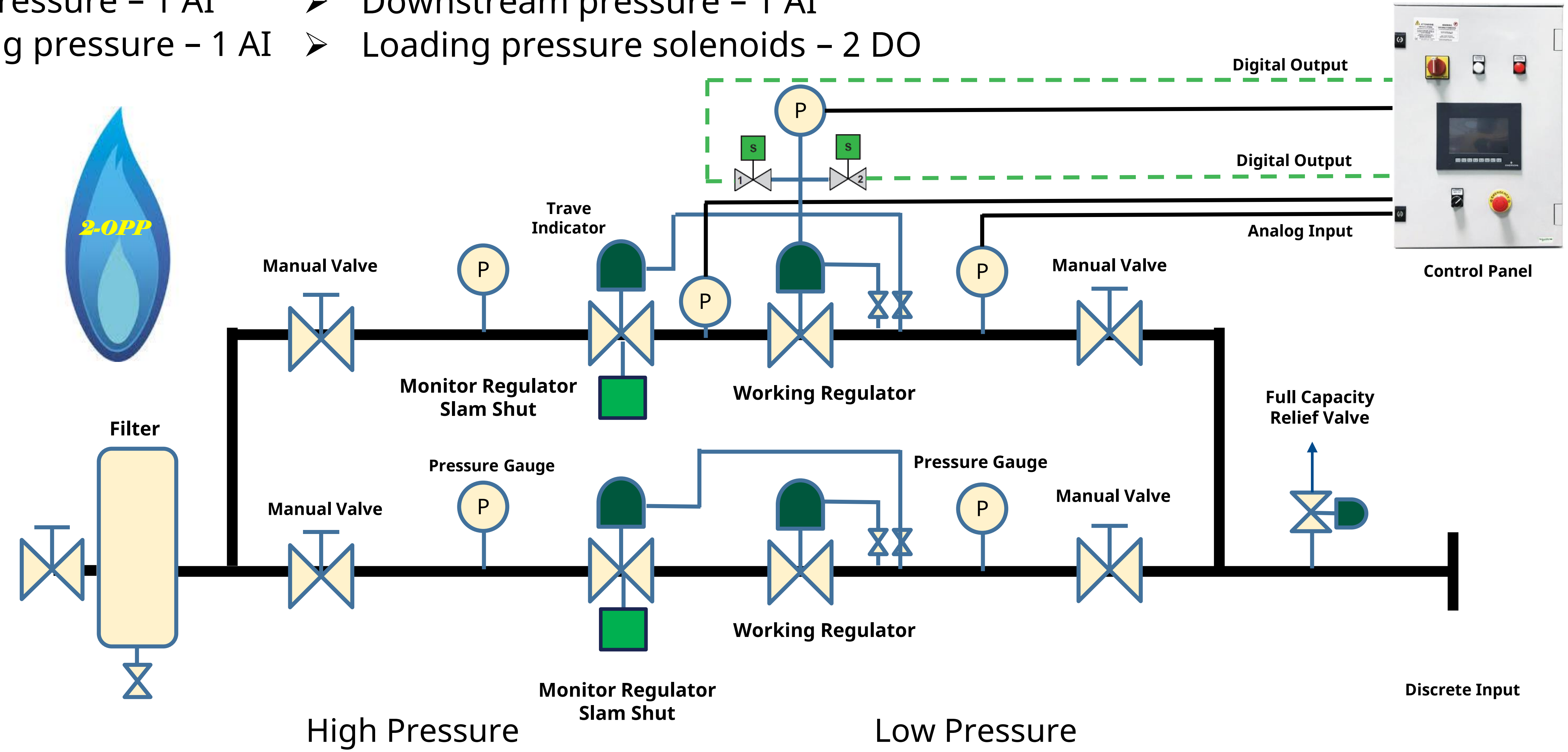
- Monitor inlet, outlet and intermediate pressures for basic and advanced assessment of critical or remote Regulator Station assets
- **If Worker (or Both) Regulators are Fisher Brand, utilize Travel sensor to assess Regulator and Station Health**
- Set basic alarms around min/max/avg to view by exception or more build calculated values such as rate of change to deliver new insights into operational health of your Regulator Asset
- Utilize DI for Slam-shut, security fence, or PRV signal



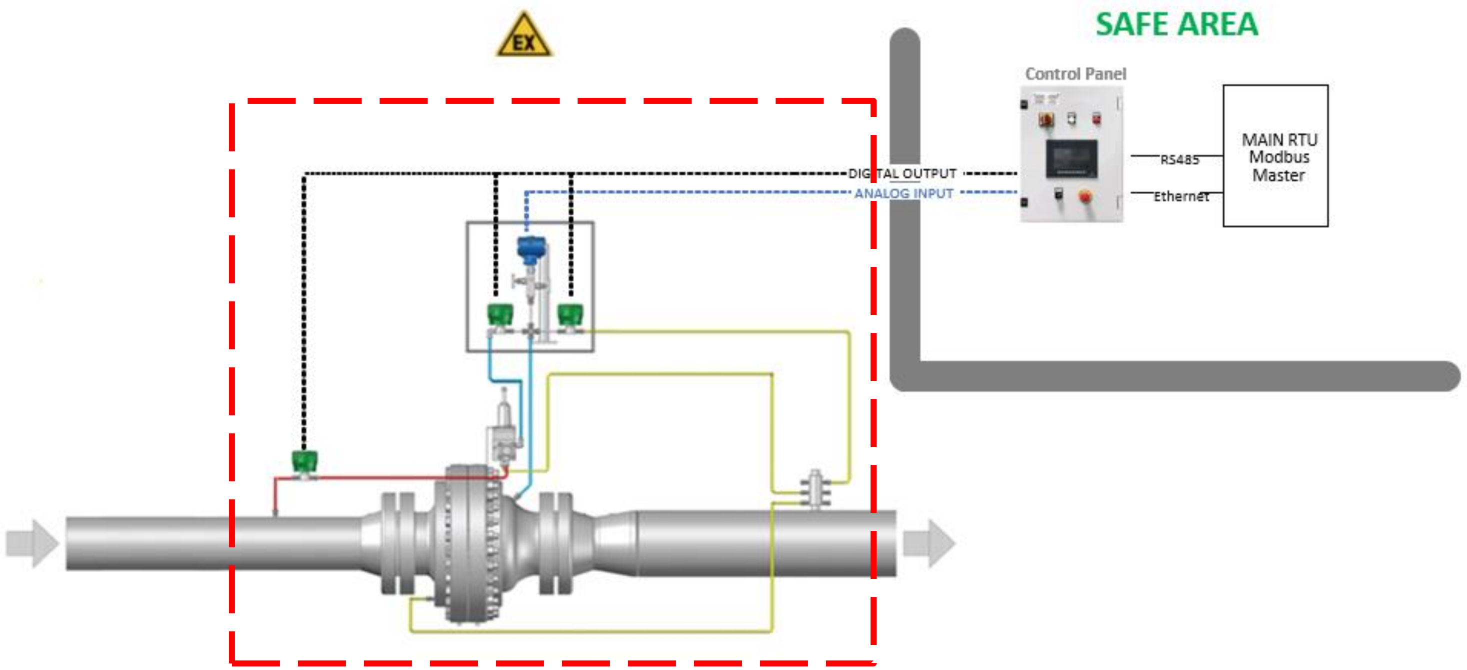
Remote Monitoring & Flow Estimation

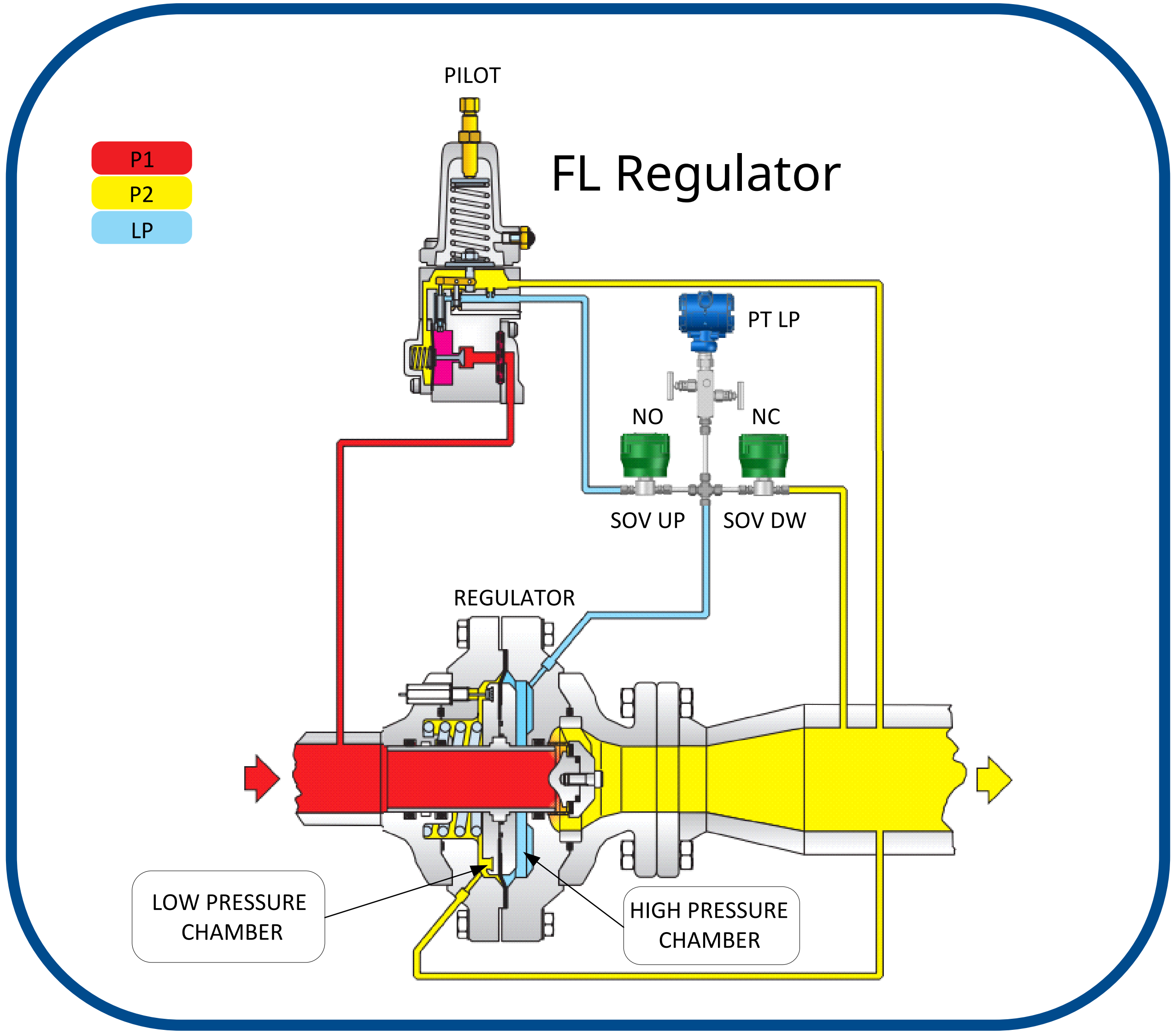
District Stations of the Future – Monitoring/Control

- Inlet pressure – 1 AI
- Loading pressure – 1 AI
- Downstream pressure – 1 AI
- Loading pressure solenoids – 2 DO



RAF – Setpoint Control

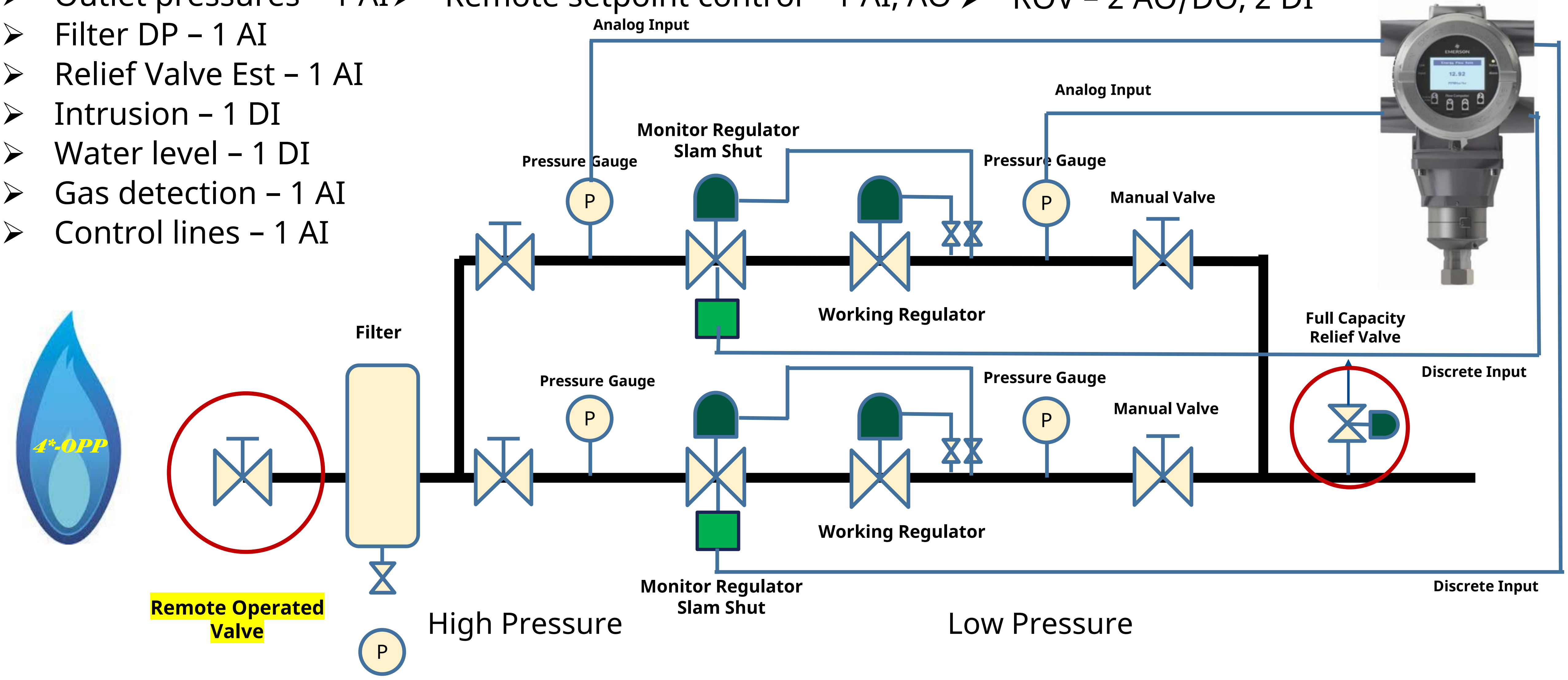




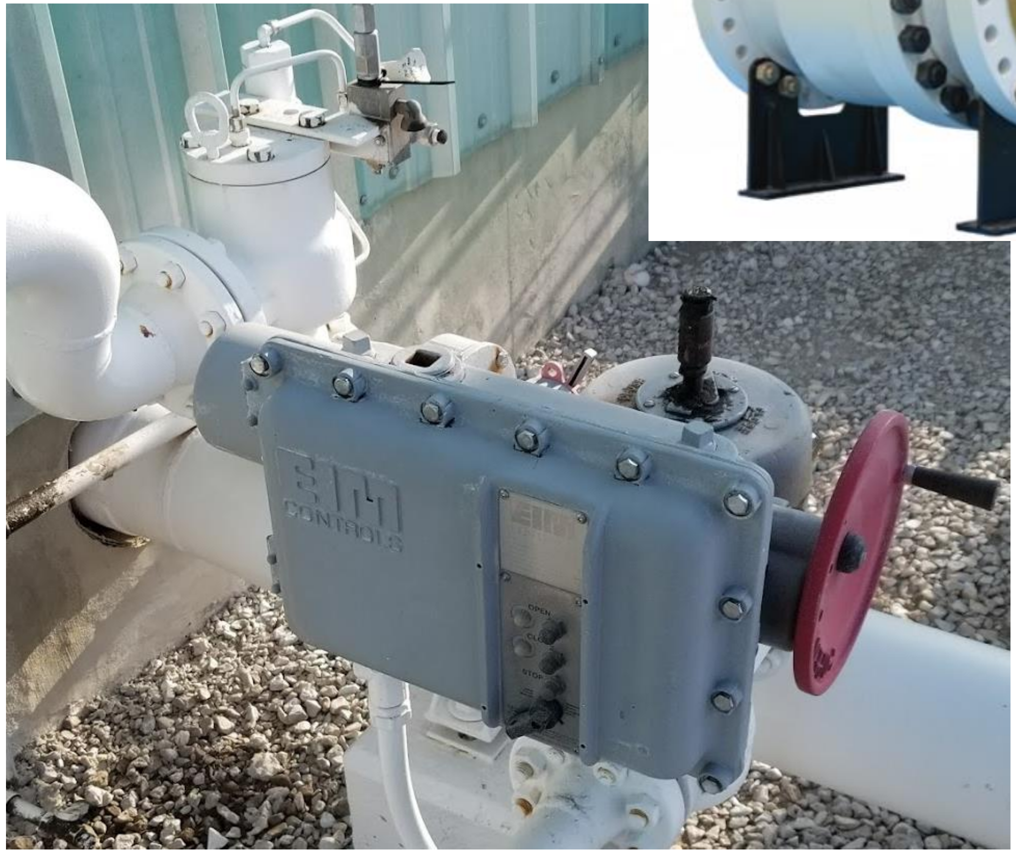
Complete No Bleed System

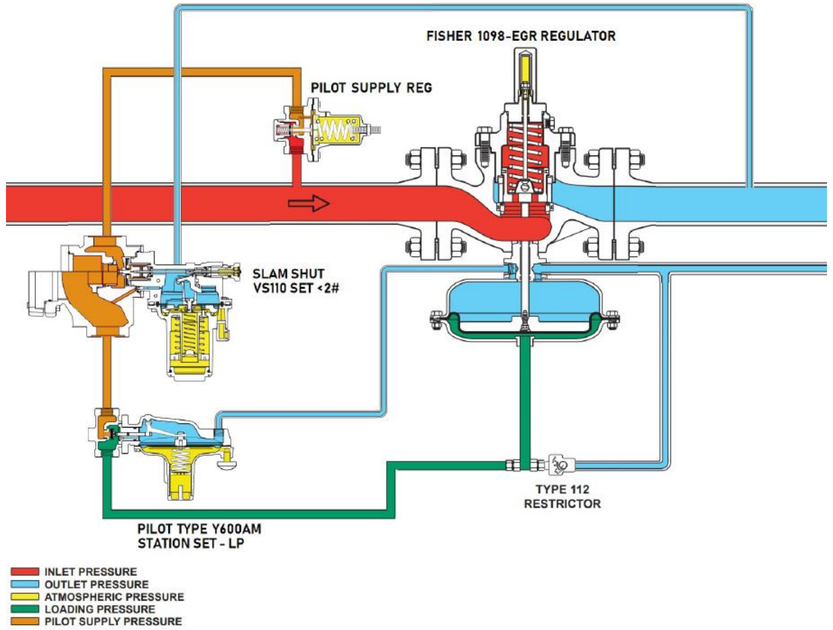
District Stations of the Future – Monitoring/Control

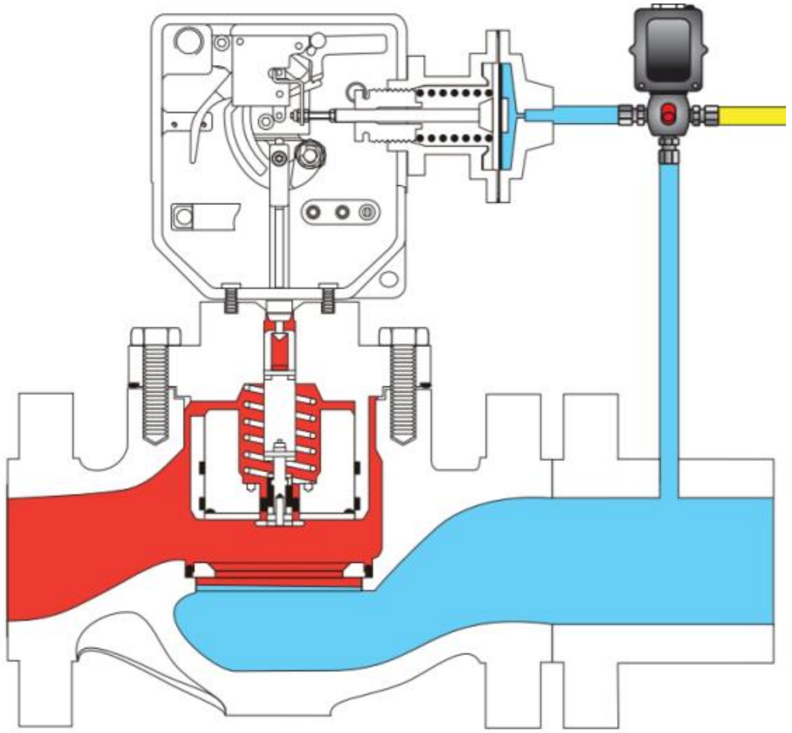
- Inlet pressures – 1 AI
- Outlet pressures – 1 AI
- Filter DP – 1 AI
- Relief Valve Est – 1 AI
- Intrusion – 1 DI
- Water level – 1 DI
- Gas detection – 1 AI
- Control lines – 1 AI
- Slam shut trip indication - 2 DI
- Remote setpoint control – 1 AI, AO
- Station flow est – 1 AI
- ROV – 2 AO/DO, 2 DI



Remote Shutoff Valves







- ***What is the best way to shut off the system?***

System and Station Security Infrastructure Concerns Are Developing; At Issue: Reliability of Infrastructure

State of Emergency Declared in 17 States and D.C. After Pipeline Cyberattack (May 10th, 2021)

- ***"'the most significant and successful attack on energy infrastructure we know of in the United States" occurred Friday when a ransomware cyberattack was launched on the Colonial Pipeline. The pipeline stretches from New Jersey to Texas and provides 45% of the gasoline, diesel, and jet fuel used on the East Coast. While the attack was on the pipeline's business systems, the pipeline itself was shut down as a precaution while a third party investigates the attack."[1]***

- **Aspen, Colorado – Possible Terrorism Dec. 30th, 2020**

FBI Investigating Possible Attack On Natural Gas Line In Aspen, "Earth First" Graffiti On Pipe[1]

- **2021 Texas Winter Storm Shuts Down Energy Grid**

- ***"Failures across Texas' natural gas operations and supply chains due to extreme temperatures are the most significant cause of the power crisis that has left millions of Texans without heat and electricity during the winter storm sweeping the U.S. From frozen natural gas wells to frozen wind turbines, all sources of power generation have faced difficulties during the winter storm. But Texans largely rely on natural gas for power and heat generation, especially during peak usage, experts said."[2]***

- Physical asset protection and cybersecurity
- Operational certainty through extreme weather events