SPARTAN CONTROLS

Experience Industrial Innovation

Introduction to Regulator and Industrial Meter Station Design

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May 2026

Course Outline

- **Introduction to Regulator and Industrial Meter Station Design**
  - Workshop discusses meter station design from concept to final customer acceptance.
  - Course will focus on meter and accessory selection.
  - Emphasis on large industrial and custody transfer facilities.

Agenda

- Metered vs. Unmetered Stations
- Metered Station Types
- Station Design
  - Regulators and Overpressure Protection (OPP)
  - Filtration
  - Piping and Isolation Valves
  - Corrosion Protection
  - Noise
  - Meters
  - Analyzers
  - Gas Heaters
  - Odorization
  - Telemetry and RTU
  - Buildings & Available Power

Metered vs. Unmetered Stations

Metered vs. Unmetered Station

- **Metered station** = "We measure this gas because it matters commercially or legally."
- **Unmetered station** = "This gas use is small, predictable, or internal, so we account for it indirectly."

Aspect	Metered station	Unmetered station
Flow measurement	Yes (direct, continuous)	No (assumed or estimated)
Used for billing	Yes	No
Custody transfer	Yes	No
Equipment complexity	Higher	Lower
Regulatory scrutiny	Higher	Lower

Station Types

Metered Stations

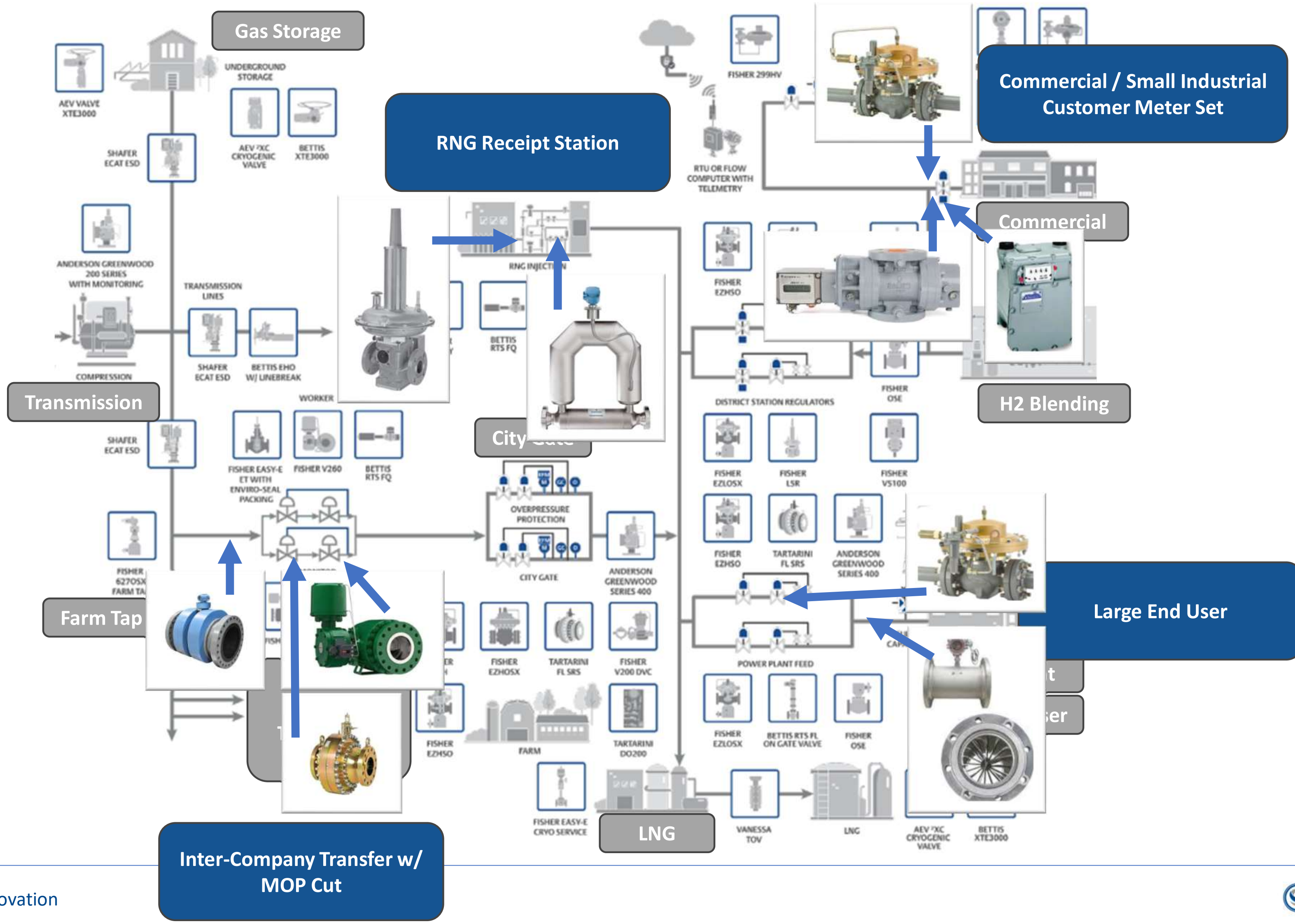
- *Ownership of the gas is transferred*
  - *Custody Transfer*

❑ Large End-User Metered Stations
❑ RNG Receipt Stations
❑ Inter-Company Custody Transfer

Unmetered Stations

- *Ownership of the gas stays with the utility*

❑ City Gate Stations
❑ District Reg Stations
❑ Small Farm Tap Stations
❑ Pipeline Interconnect (MOP)


Gas Storage
RNG Receipt Station
Commercial / Small Industrial Customer Meter Set
Commercial
H2 Blending
Transmission
City Gate
Farm Tap
Large End User
LNG
Inter-Company Transfer w/ MOP Cut
AEV VALVE XTE3000
UNDERGROUND STORAGE
SHAFER ECAT ESD
AEV ²XC CRYOGENIC VALVE
BETTIS XTE3000
ANDERSON GREENWOOD 200 SERIES WITH MONITORING
TRANSMISSION LINES
COMPRESSION
SHAFER ECAT ESD
BETTIS EHO W/ LINEBREAK
WORKER
FISHER EASY-E ET WITH ENVIRO-SEAL PACKING
FISHER V260
BETTIS RTS FQ
RNG INJECTION
FISHER 299HV
RTU OR FLOW COMPUTER WITH TELEMETRY
FISHER EZHSO
DISTRICT STATION REGULATORS
FISHER OSE
FISHER EZLOSX
FISHER LSR
FISHER V5100
OVERPRESSURE PROTECTION
CITY GATE
ANDERSON GREENWOOD SERIES 400
FISHER EZHSO
TARTARINI FL SRS
ANDERSON GREENWOOD SERIES 400
FISHER EZHOSX
TARTARINI FL SRS
FISHER V200 DVC
POWER PLANT FEED
FISHER EZLOSX
BETTIS RTS FL ON GATE VALVE
FISHER OSE
FARM
TARTARINI DO200
FISHER EZHSO
FISHER EASY-E CRYO SERVICE
VANESSA TOV
LNG
AEV ²XC CRYOGENIC VALVE
BETTIS XTE3000

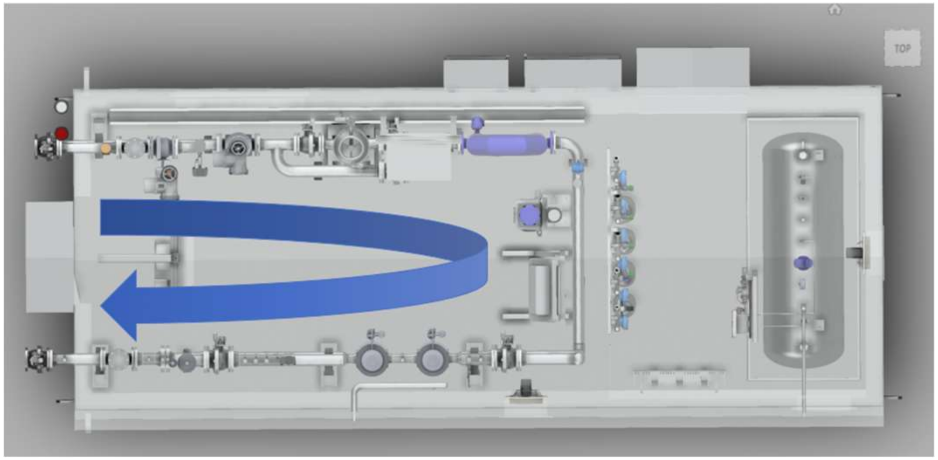
Metered Station Types

Metered Station – Large End-User

- Custody Transfer – metering equipment is required to determine amount of gas that is being fed to customer
- Feed power plant owned by customer (e.g. pulp mills)

Metered Station – RNG Receipt Station

- RNG Receipt station functions include pressure cut, gas analyzing, gas flow measurement, recirculation loop, and odorization
- Upstream compression is often a struggle, regulators with low or no differential pressure requirement work best

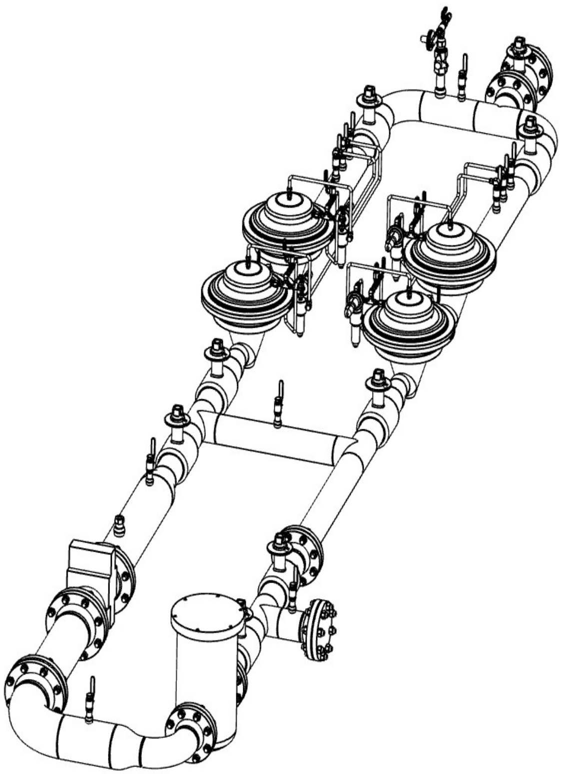


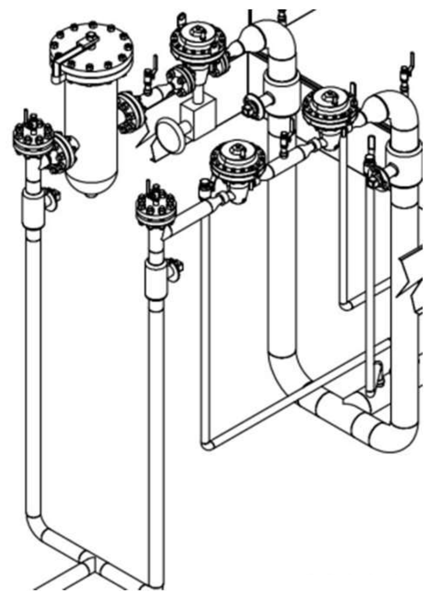
Metered Station – Inter-Company Custody Transfer

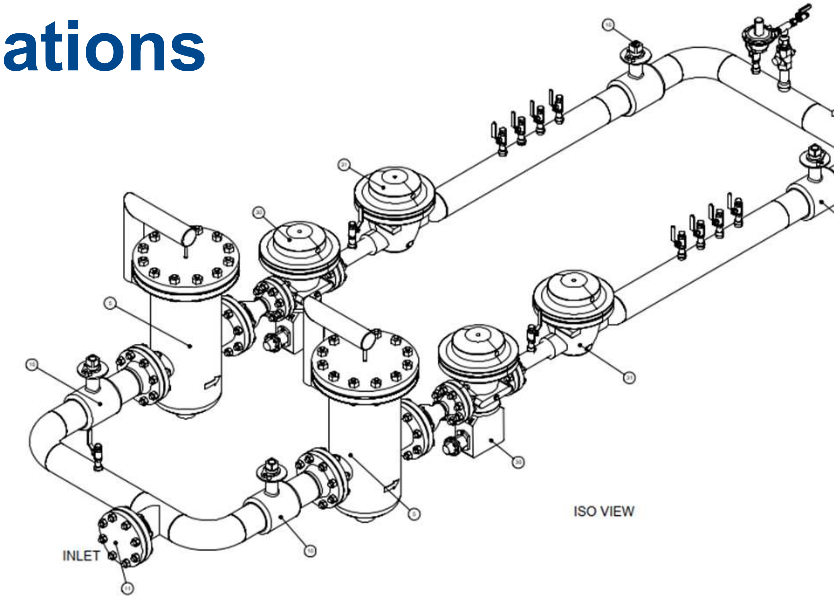
- The formal process by which ownership, responsibility, and financial accountability for natural gas transfer from one company to another at a defined physical point in the system.

Station Design

Station Design – Many Different Variations







Station Design

- Metering Requirements and Selection
- Pressure Regulation and Overpressure Protection
- Station Layout and Site Specifics
- Gas Quality & Composition
- Instrumentation, Control & Communications
- Safety Codes and Compliance
- Operations, Maintenance and Reliability

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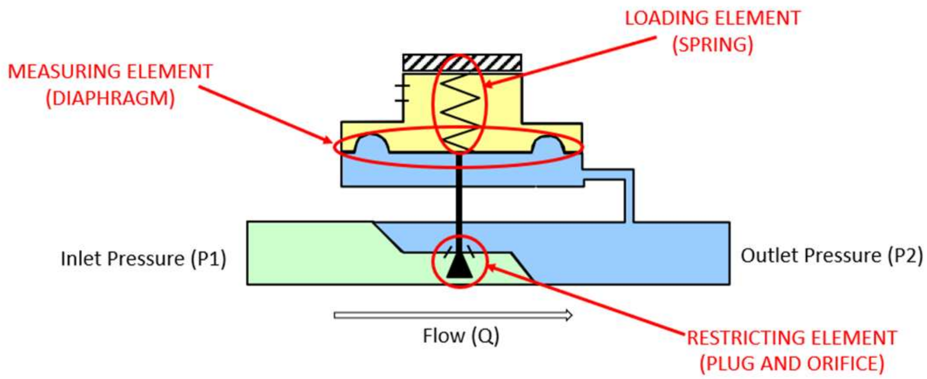
Station Design – Regulators and OPP

Station Design - Regulators

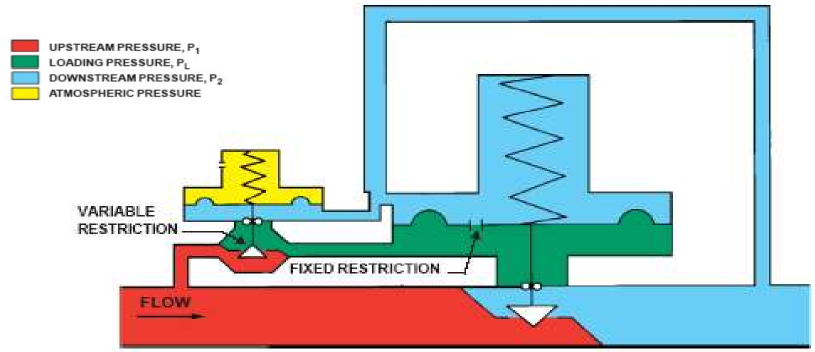
- **Definition**: self-contained, self-operated control devices which use energy from the controlled system to operate (like a valve and actuator combination).

- **Purpose**: To match a flow demand while maintaining a constant pressure.

Self-Operated Regulator



2-Path Control Pilot Operated Regulator



Main Types of Regulators

- **Pilot Loading** – "2-path Control"
  - ✓ Most accurate style of pilot regulator (1-2% accuracy)
  - ✓ Fastest responding pilot regulator
  - ✓ Independent seat and diaphragm

- **Pilot Unloading** – "Flexible Element, Boot-style"
  - ✓ Most economic style of pilot regulator
  - ✓ Combined seat and diaphragm
  - ✓ Accuracy is slightly lower than 2-path regs (2-5% accuracy)
  - ✓ Slower responding regulator, not for single-use customer stations

- **Self-Operated**
  - ✓ Accuracy is slightly lower than any pilot regs (10-20% accuracy)
  - ✓ Fastest response of any regulator type
  - ✓ Limited inlet pressures
  - ✓ Limited capacity

Station Design - Regulators

Regulator Sizing and Selection

- Pressure (inlet min & MOP, outlet)
- Flow
- Capacity
- Sizing and Selection
  - Min and Max cases for material selection
  - For OPP
    - Using MOP and capacity using min inlet pressure
- Allowable noise

STATION DESIGN CRITERIA SPARTAN CONTROLS

PROJECT IDENTIFICATION

Station Name	Rev	Status	Date (DD-MMM-YY)

PROPOSED REQUIREMENTS

Number of Runs	
Number of Regs on Each Run	
Over-pressure Functionality	
Filter Style Required	
Preferred Run Design Style	
Inlet Pipe Connection Size	
Preferred Pipe Connection Style	
Relief Required?	
Inlet Connection Orientation	
Available Installation Envelope Dimensions	

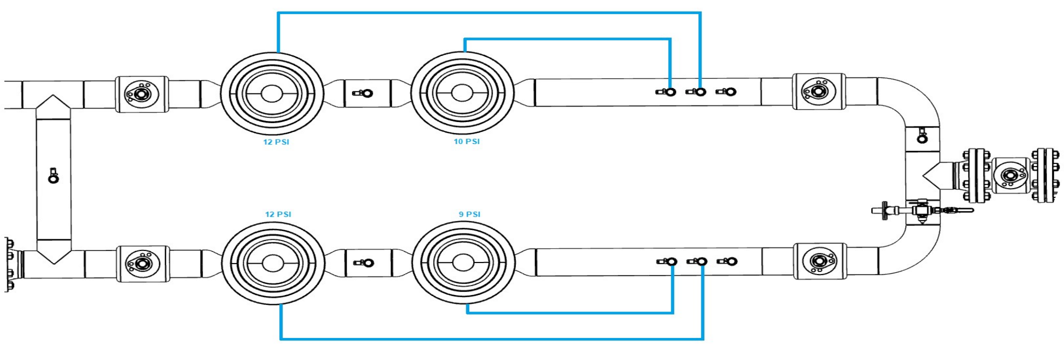
DESIGN CONDITIONS

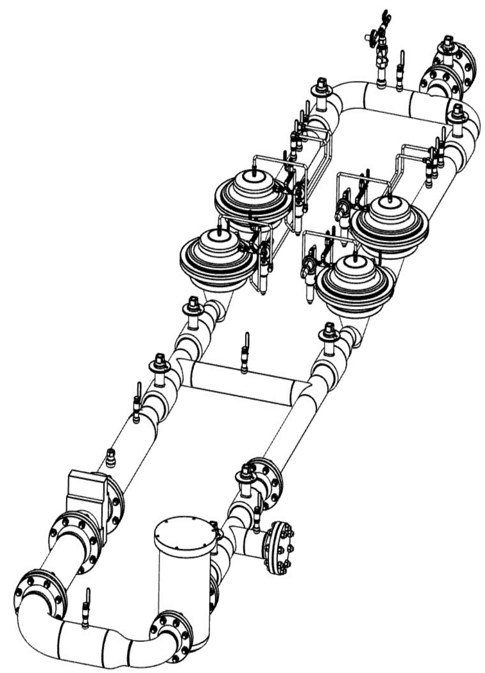
Max Long-term Load		Sm3/hr		scfh
Min Flow turndown (if req'd)		Sm3/hr		scfh
Max Design Inlet Pressure (MAOP)		kPag		PSI
Min Available Pressure		kPag		PSI
Normal Inlet Pressure		kPag		PSI
Outlet Delivery Pressure		kPag		PSI

OTHER NOTES OR CONCERNS

Why are there four regulators in a typical station?

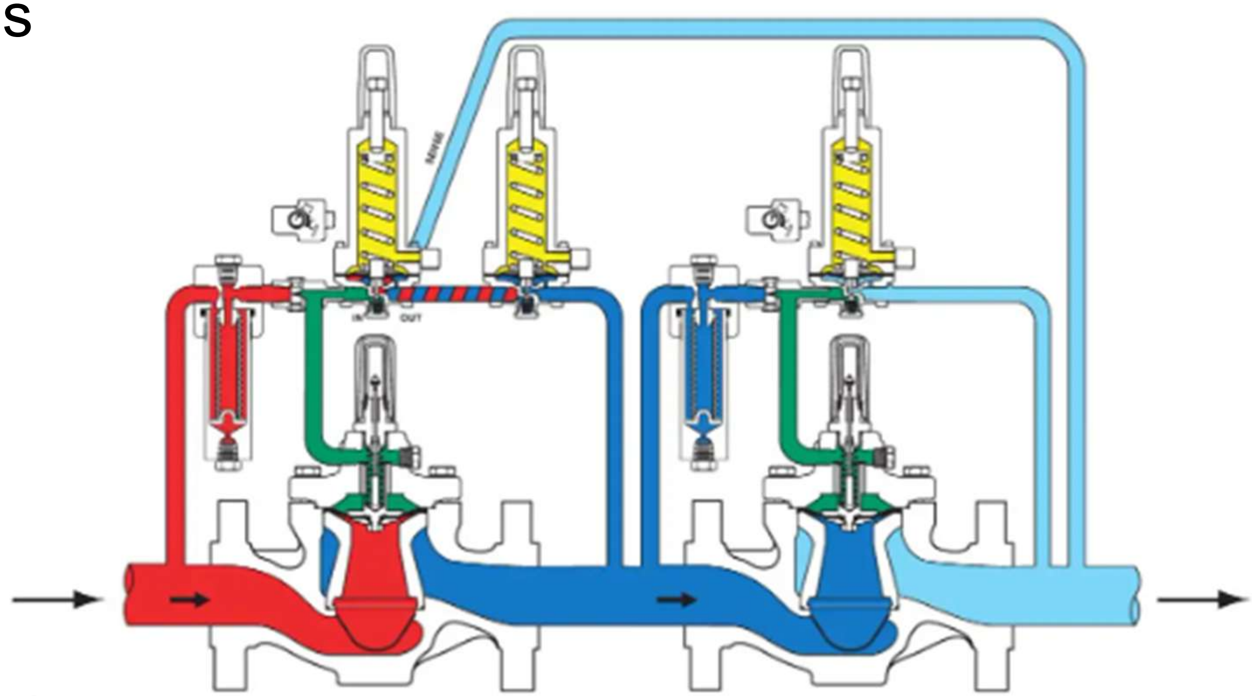
- Redundancy
- We need to be prepared for regulators to fail in both directions
  - Wide open
  - Fully closed



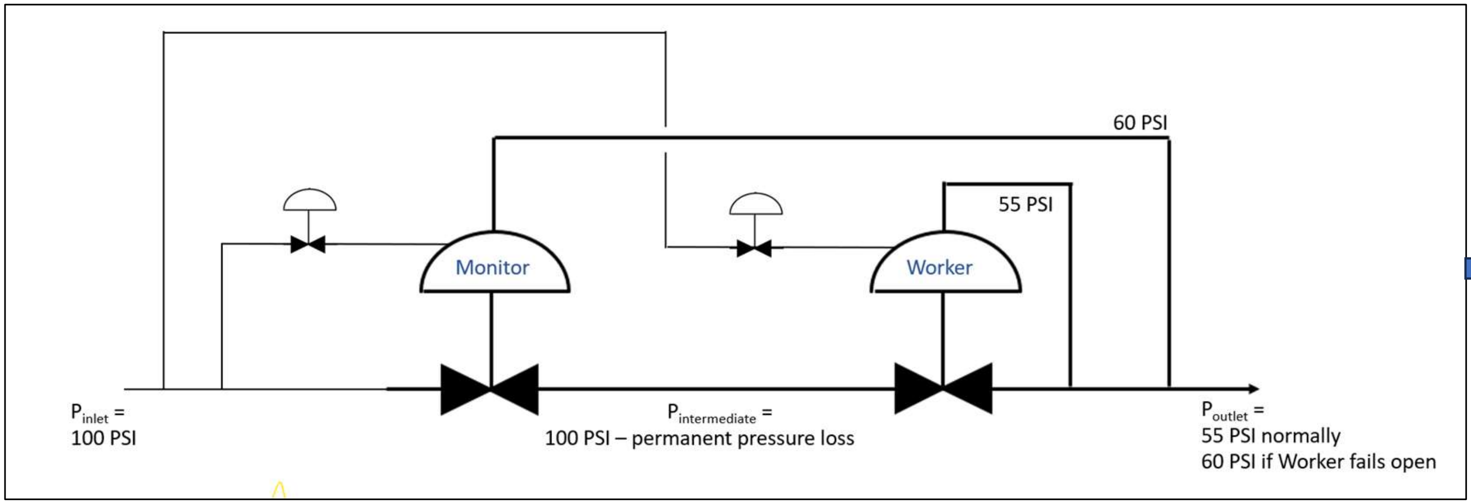


Station Design – Overpressure Protection

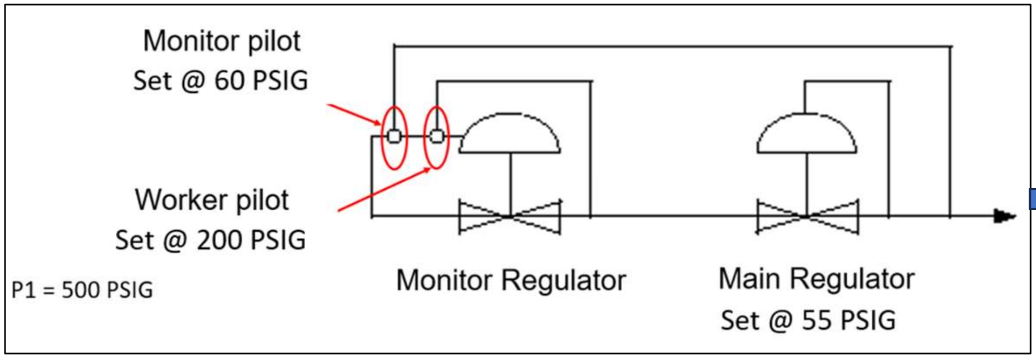
- Overprotection Methods
  - Relief
  - Working Monitor
  - Monitor
  - Series Regulation
  - Shut-off



Wide Open Monitor and Working Monitor



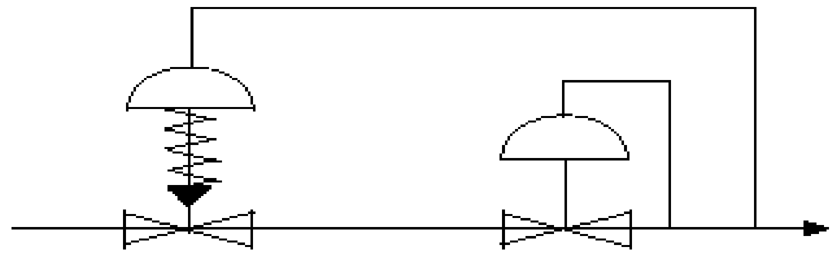
"False Sense" the upstream regulator so that it always thinks it needs more and stays wide-open until an upset event occurs



"False Sense" the just the 1st pilot of the upstream regulator so that it always thinks it needs more and stays wide-open until an upset event occurs, the 2nd pilot operates normally

Slam-Shut Operation

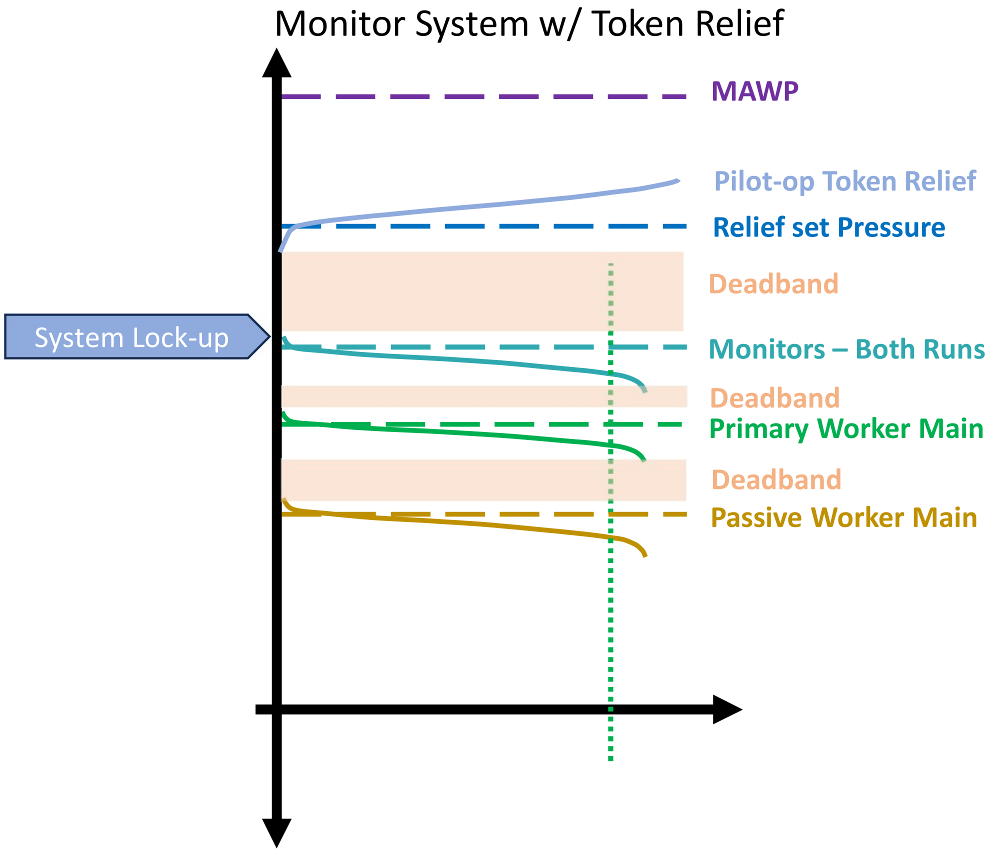
- Slam-shut devices provide over-pressure protection by containment (no venting)
  - however, service is disrupted during an upset until manual reset occurs.
- Slam-shut regulators sense downstream pressure via a control line
- When downstream pressure exceeds slam shut set point a trigger mechanism slams the valve shut cutting off all downstream gas supply
- Can sense over-pressure (OPSO) and under-pressure (UPSO)
- Stand-alone (OSE) or integral slamshut module (OSX) available

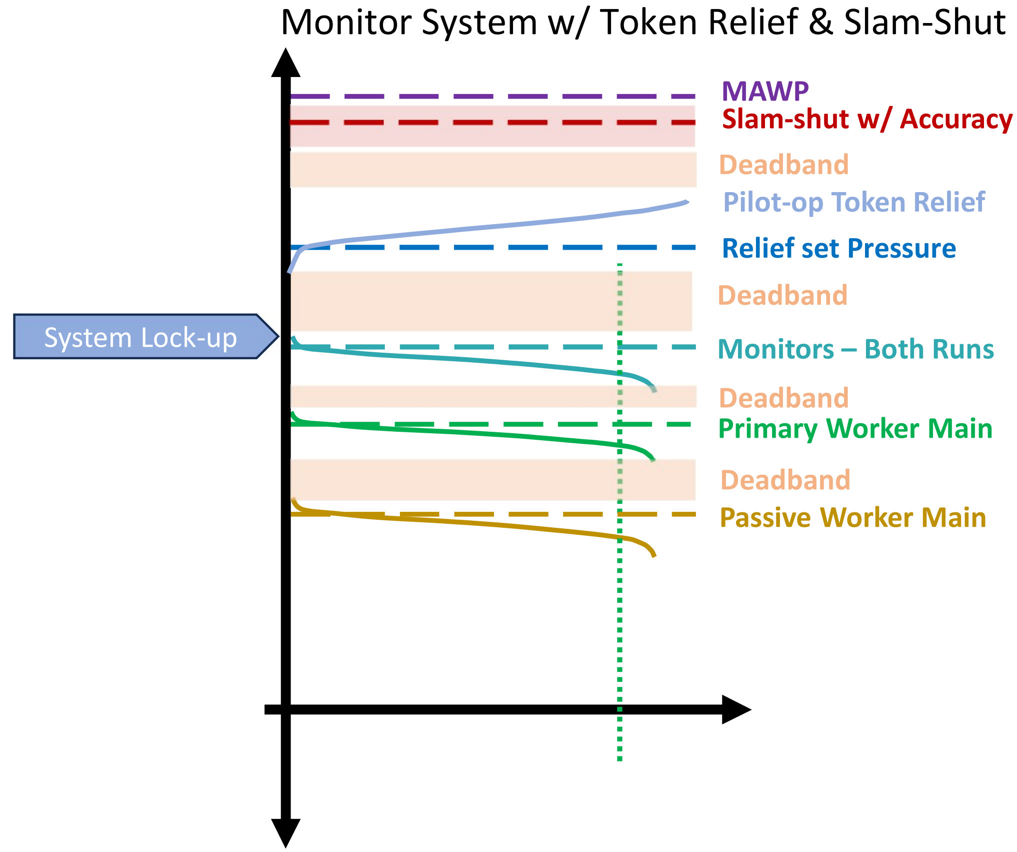


Shut-Off Regulator Set @ 40 psig

Pressure Regulator Set @ 30 psig

Main and Monitor System – Pilot-Loading (2-path)





Overpressure Protection Options

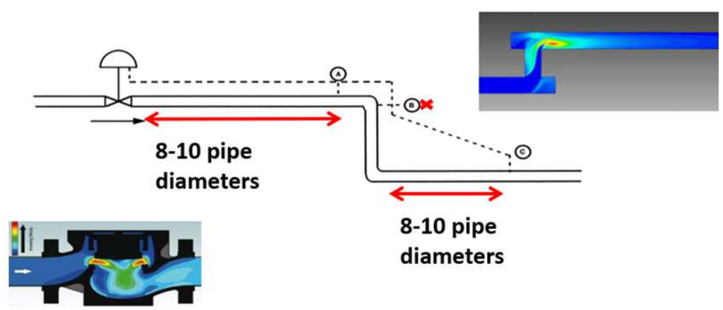
Performance Questions	Relief	Working Monitor	Monitor	Series Regulation	Shut-Off
Keeps application online?	YES	YES	YES	YES	NO
Venting to atmosphere?	YES	NO	NO	NO	NO
Manual resetting required after operation?	NO	NO	NO	NO	YES
Reduces capacity of regulator?	NO	YES	YES	YES	NO
Constantly working during normal operation?	NO	YES	NO	YES	NO
Demands "emergency" action?	YES	NO	NO	NO	YES
Will surveillance of pressure charts indicate partial loss of performance of overpressure devices?	NO	YES	MAYBE	YES	NO
Will surveillance of pressure charts indicate regulator has failed and safety device is in control?	YES	YES	YES	YES	YES

Control Line Installation

Improper control installation can cause a regulator to cycle, control the wrong pressure, or respond slowly. Control lines are also called sense lines and static lines.

Plan the installation ahead of time using these guidelines:

- Make the control line as short and straight as practical
- Connect the control line **optimally 10 pipe diameters downstream of a turbulence generator** (valve, tee, elbow, swage)
- Connect the control line to the point where the pressure is to be controlled



Custom Tubing Options

- Downstream control lines from pilot to be installed in the order of **BLEED**, **BLEED**, then **SENSE, SENSE**

- The sense tap installed optimally <u>10 pipe diameters</u> downstream

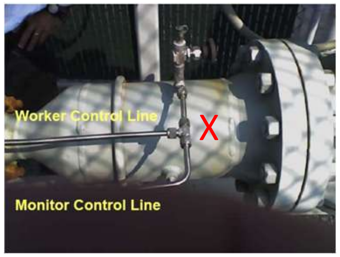
- The inlet supply lines are optimally at least 5 pipe diameters upstream

Needle valve installed providing 1/8" hole in sensing X

- All taps that have isolation use <u>full port</u> ball valves

- Recommended to use ½" nominally for normal length downstream sense lines
  - If longer than 10ft away, upsize to ¾" or 1" pipe

- Do not share taps, by CSA Z662 code (special exception available, needs review)
  - Exception is tap and manifold must be at least 2x the size of the largest tube connected (1" for 2 connections of ½" size)
  - Do not put active bleed lines facing each other, use a manifold and place the lines on the same side



Ease of Maintenance

- Can the technicians easily test the equipment?
- Is it to heavy for 1 or 2 people and are any lifts required?
- Is everything properly vented for safety if inside?
- Is there any confined space requirements?
- Is anything stacked in the way of removal of components for maintenance is obstructed (on a stacked run, a bypass, etc)?

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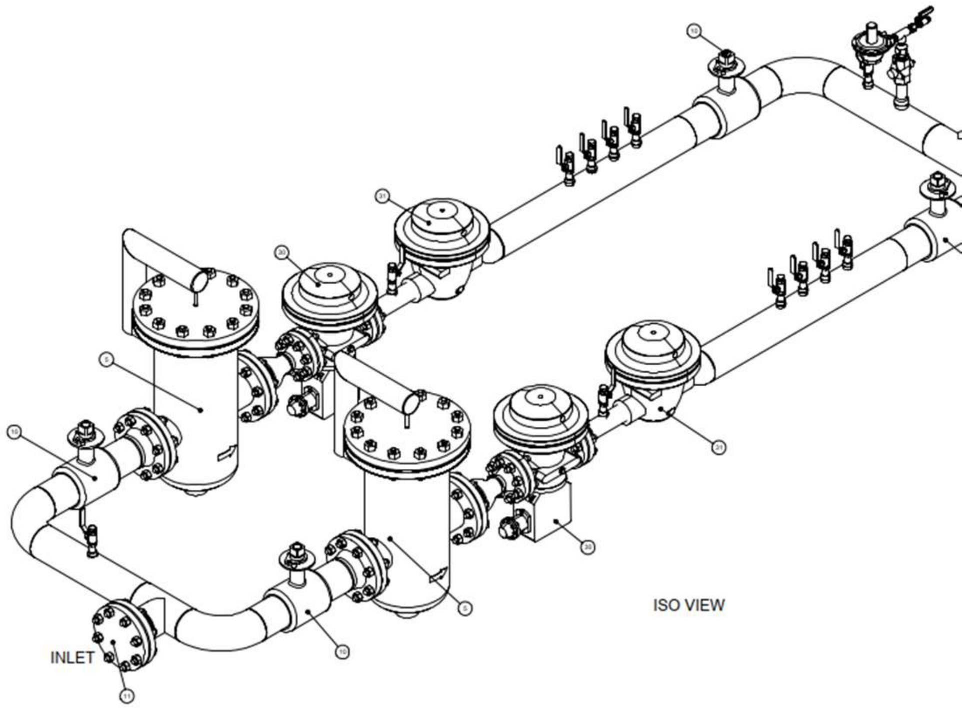
Station Design – Filters and Strainers

Station Design - Filtration

- At a metered station, filtration is focused on protecting measurement accuracy and downstream equipment
- How dirty is the gas?
- Any moisture/liquid present in the gas?
- Type of filter selected is critical
- Strainers to protect valves
- Pipe velocity



Station Design – Filtration & Strainers

- Filter Separator (Primary Inlet Protection)
  - Used when: There is any possibility of liquids or mixed contamination in the gas stream
- Particulate (Dry Gas) Filter
  - Used when: Gas is expected to be dry, or as final polishing filtration
- Coalescing Filter (Application-Specific)
  - Used when: Liquid aerosols or oil mist may be present, but solids loading is low
- Strainer
  - Used when: You need to protect equipment from large solids (such as regulators and control valves)
- Analyzer / Sample Line Filters (Local Filtration)
  - Used when: Gas chromatographs or analyzers are installed

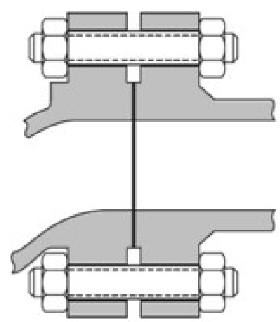
Station Design – Piping and Isolation Valves

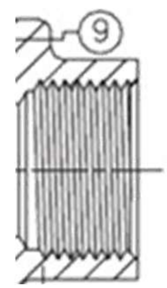
Station Design - Piping, Isolation Valves

- Follow piping codes
- Pressure class (e.g. ASME CL150, 600, 900, etc.)
- End connections
- Pipe size and associated pressure loss
- Bypass and redundant runs?
- Sufficient station isolation
  - Manual or actuated
  - Where do we need to isolate a section of piping?

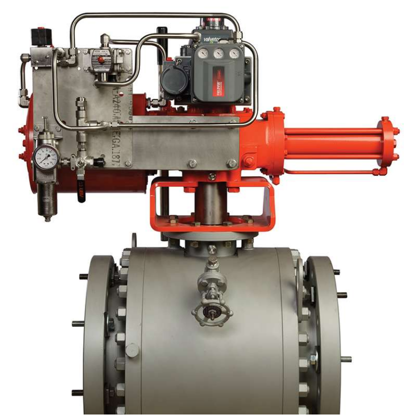
Pressure-Temperature Ratings for Standard Class ASTM A216 Grade WCC Valves
(in accordance with ASME B16.34-1996)

TEMPERATURE, °F	WORKING PRESSURES BY CLASS, PSIG				
	150	300	600	900	1500
	Psig				
-20 to 100	290	750	1,500	2,250	3,750
200	260	750	1,500	2,250	3,750
300	230	730	1,455	2,185	3,640
400	200	705	1,410	2,115	3,530
500	170	665	1,330	1,995	3,325
600	140	605	1,210	1,815	3,025
650	125	590	1,175	1,765	2,940
700	110	570	1,135	1,705	2,840
750	95	505	1,010	1,510	2,520
800	80	410	825	1,235	2,060


RF Flanged



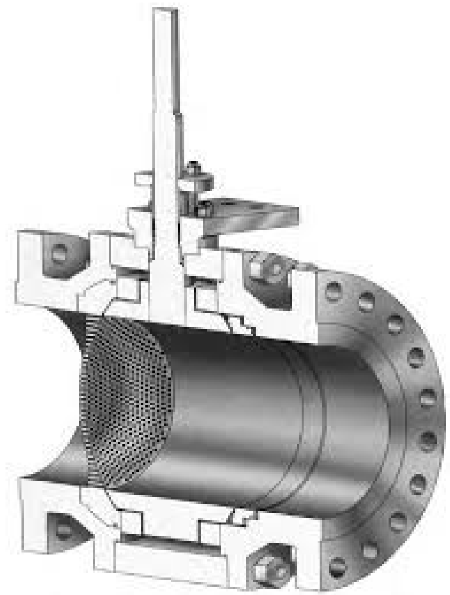
Threaded

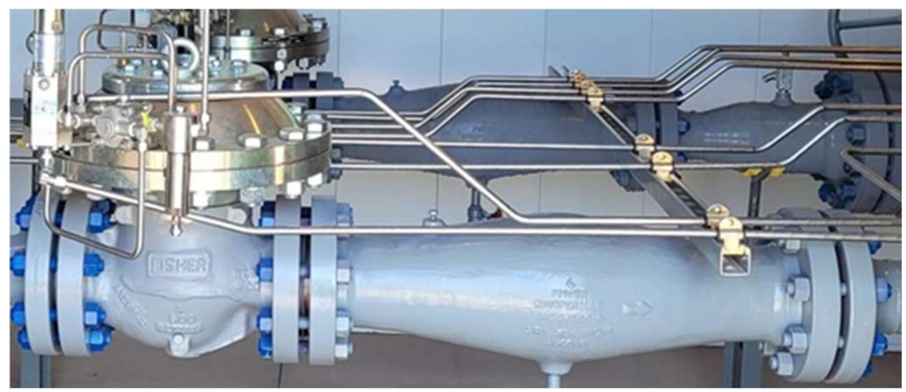


Station Design – Noise

Station Design - Noise

- Restricted piping
  - Too many valves, orifices, small diameter piping before the load
- Turbulent Piping
  - Swages, elbows, meters can interject backpressure
- Noise – 110-115 DbA max allowable
  - Source Treatment – At valve orifice
  - Path Treatment – After valve outlet





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Station Design – Corrosion Protection

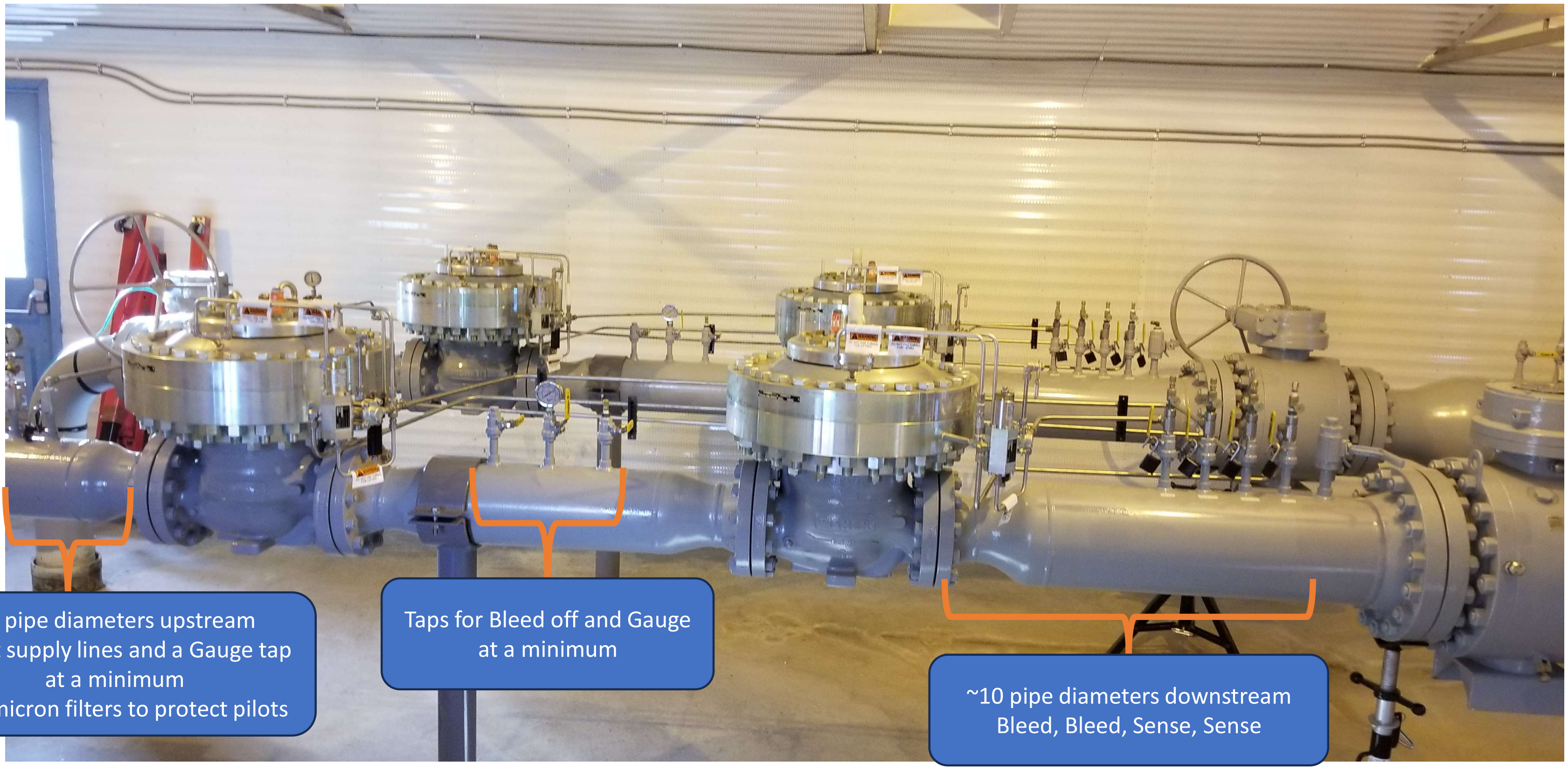
Station Design – Corrosion Protection

- **External (Buried Assets)**
  - Protective pipe coatings
  - Cathodic protection (sacrificial or impressed current)
  - Electrical isolation (insulating joints)
- **Internal (Gas-Side)**
  - Gas conditioning to remove water and corrosive contaminants
  - Corrosion-resistant materials or internal coatings as required
- **Atmospheric (Above-Ground)**
  - Protective paint/coating systems
  - Corrosion-resistant materials
  - Design to avoid water traps and standing moisture
- **Electrical Bonding & Grounding**
  - Controlled bonding to preserve cathodic protection
  - Prevent stray current–induced corrosion and meter damage

SPARTAN CONTROLS

Example – City Gate Station

City Gate Station Example



Station Design – Meters

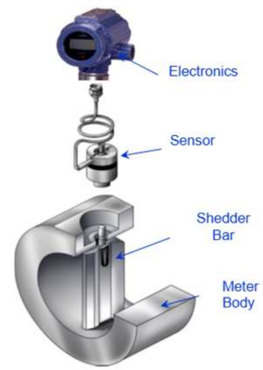
Station Design – Metering Requirements and Selection

- **Purpose:**
  - Metering provides an accurate measurement of gas quantity and energy content to support custody transfer, billing, and regulatory compliance.

- **What metering accomplishes:**
  - Measures gas flow rate and total volume
  - Applies pressure and temperature compensation for accurate standard-condition reporting
  - Supports energy-based accounting when combined with gas quality analysis (e.g., BTU via gas chromatography)

Types of Meters

- **Ultrasonic (USM)** – Non-intrusive, no moving parts; dominant choice for large-diameter custody transfer
- **Turbine** – Mechanical, high accuracy in clean gas; common in small- to mid-size custody transfer
- **Orifice / DP** – Measures pressure drop across a restriction; traditional, robust, widely standardized
- **Coriolis** – Direct mass flow measurement; very high accuracy for smaller lines or specialty service
- **Positive Displacement (PD)** – Measures fixed volumes; accurate at low flows and small line sizes
- **Vortex** – Uses vortex shedding from a bluff body; no moving parts, suited for clean, steady gas and non-custody process measurement



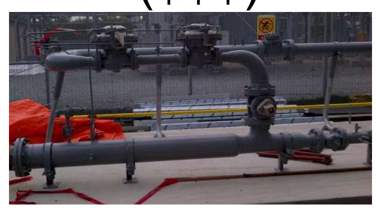
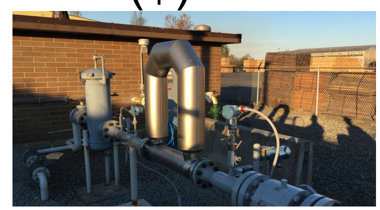
Meter Selection

- Low flow + low pressure → Ultrasonic Solid State ($$) or Diaphragm ($)
  - Residential Meter

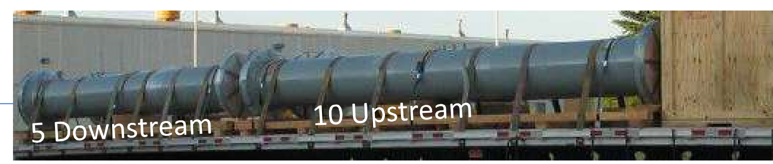

- Low pressure + mid flow→ Rotary ($) / Positive Displacement ($)
  - Commercial Applications



- High flow or high pressure → Coriolis ($$$) or Turbine ($)
  - Industrial and Institutional

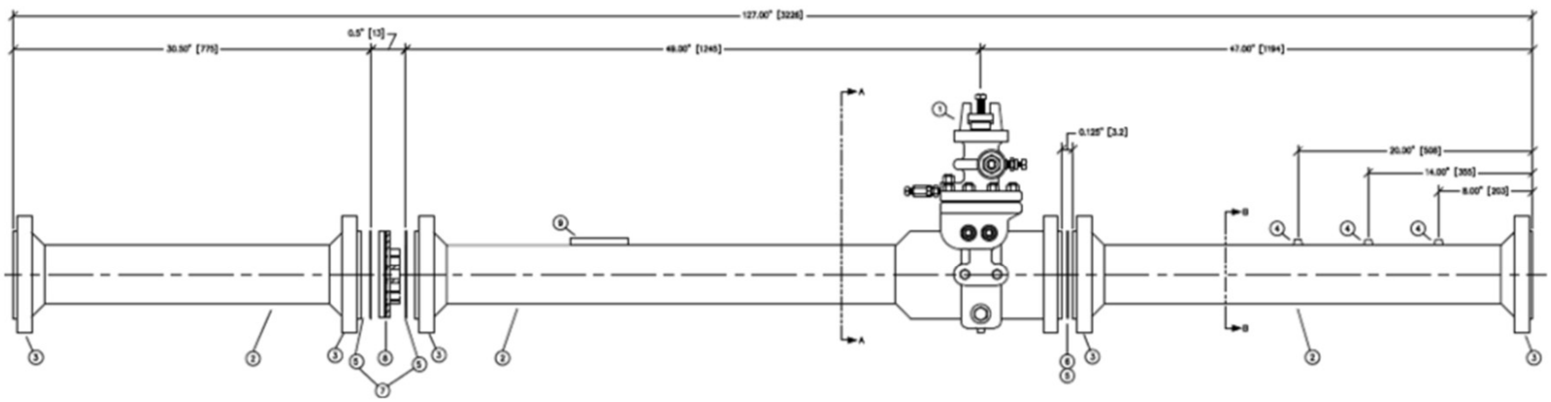



- Custody transfer / transmission → Ultrasonic ($$$) or Orifice ($)

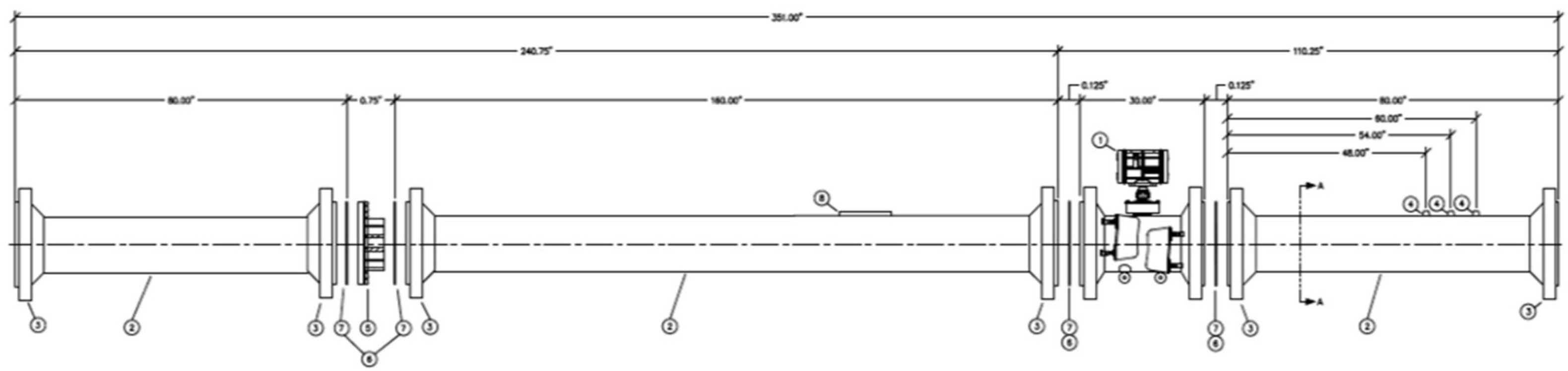


Orifice Meter Installation

Recommended Installation Best Practices



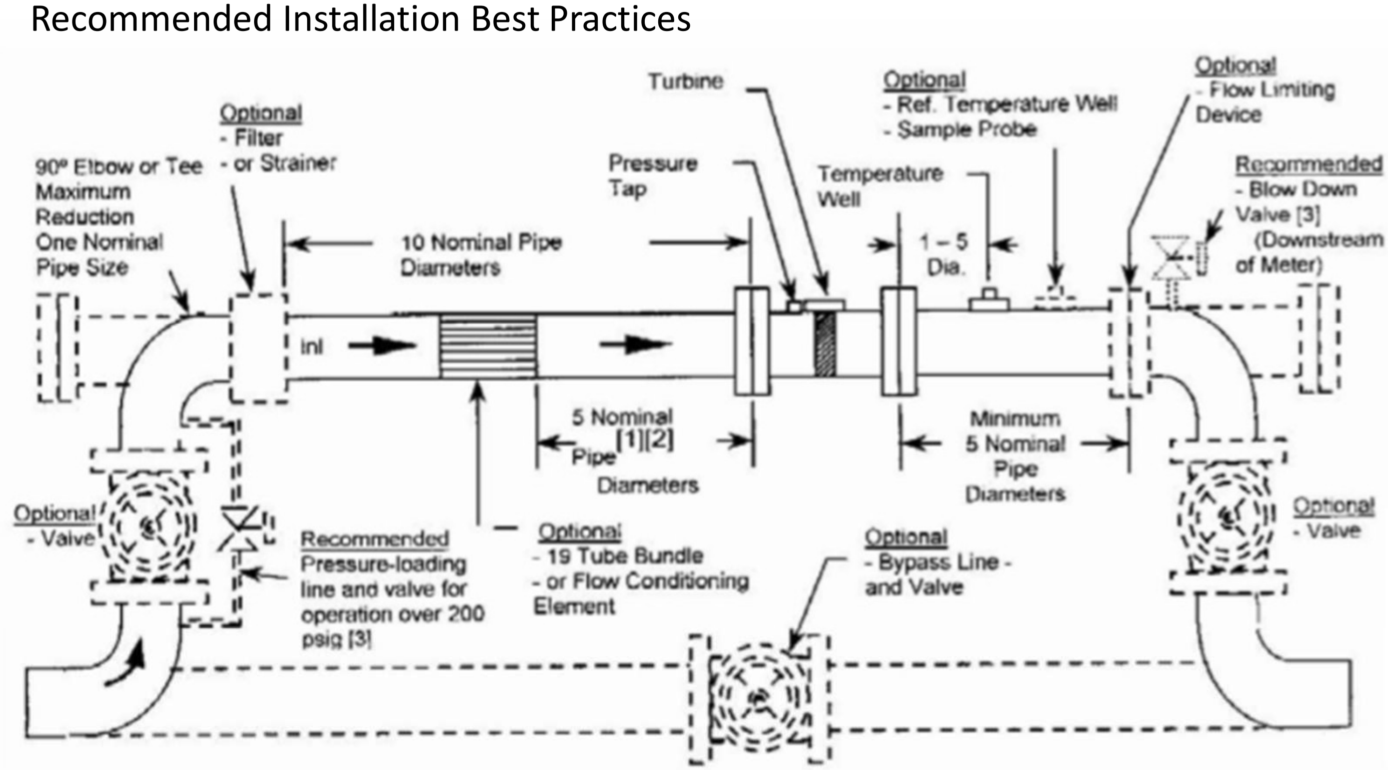
16" S/80 600# RF SENIOR SONIC ORIFICE METER RUN SUB-ASSEMBLY



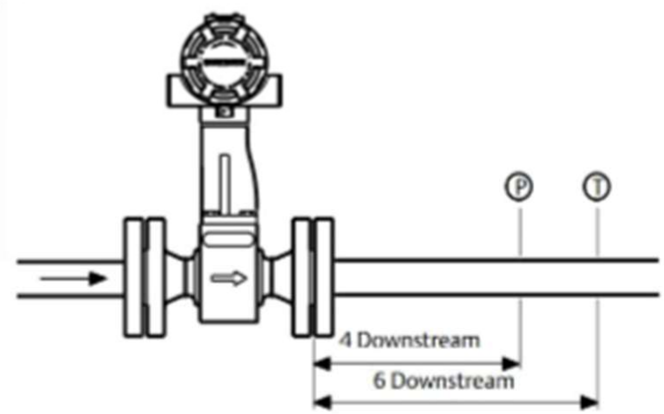
Straight pipe lengths of 20 or more pipe diameters (or a flow conditioner) upstream of the meter and 5 pipe diameters downstream of the meter may provide effective conditioning, unless the meter manufacturer's recommendations or tests support different lengths

Turbine Meter Installation

Recommended Installation Best Practices

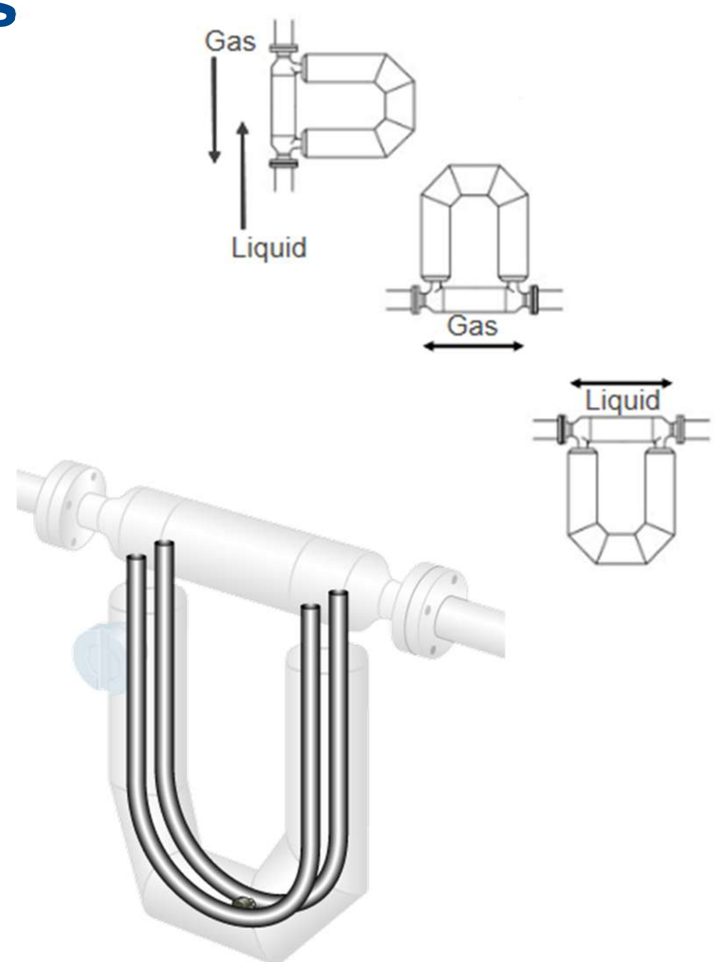


Straight pipe lengths of 10 or more pipe diameters (or a flow conditioner) upstream of the meter and 5 pipe diameters downstream of the meter may provide effective conditioning, unless the meter manufacturer's recommendations or tests support different lengths



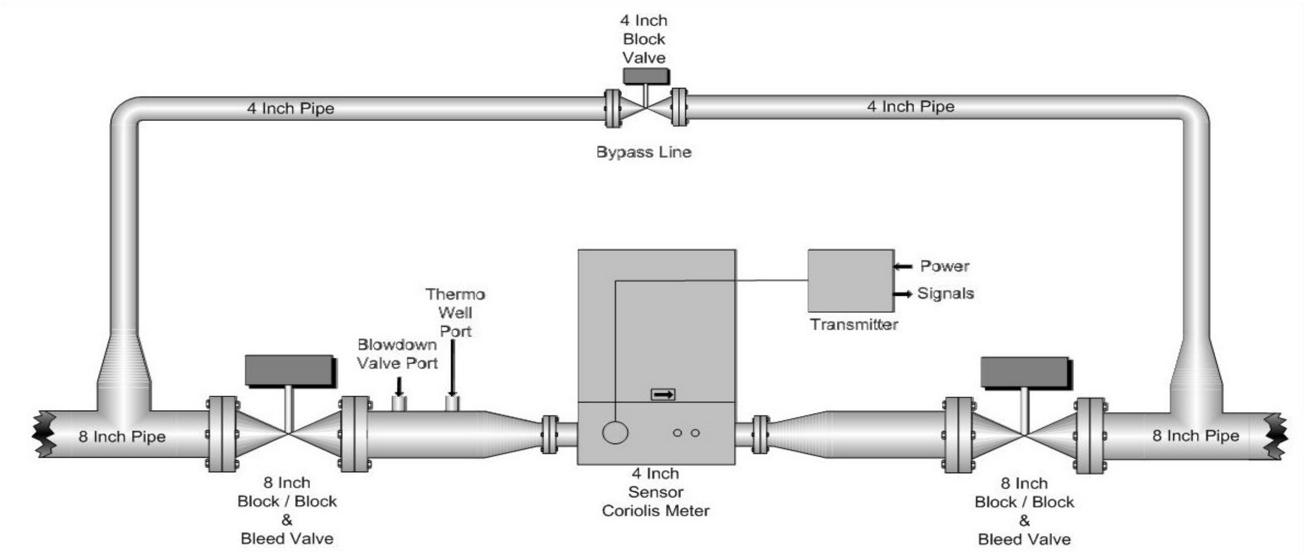
Coriolis Installation Best Practices

- No special upstream or downstream piping requirements
- Vertical line installations
  - Flow tubes in flag position
  - Flow direction down preferred for gas (especially wet gas)
  - Flow direction up preferred for liquid
- Horizontal line installations
  - Flow tubes up preferred for gas
  - Flow tubes down preferred for liquid



Coriolis Meter Installation – Piping Overall

- Upstream and downstream block valves
- Bypass to eliminate interruption of service
- Pressure port upstream of sensor (for dynamic F_p)
- Temperature port upstream of sensor (for temperature verification)
  - Avoid Joules Thompson effect



Station Design – Gas Chromatographs & Analyzers

Station Design - Analyze

- Purpose: Monitor the gas composition to ensure it's within the required specification

Metered Station

Gas Chromatographs

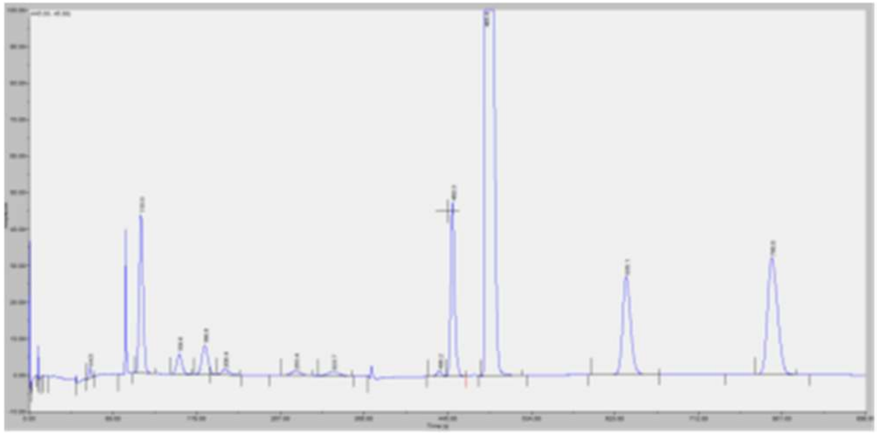
"What exactly is in this gas, and what is it worth"

Analyzers

"Is this gas safe and acceptable right now?"

Gas Chromatographs

- Gas Chromatographs (GCs) are used in natural gas custody transfer applications. They provide information on the gas quality and composition with components such as methane, ethane, and heavier hydrocarbons, water vapor, carbon dioxide, nitrogen and hydrogen sulfide.
- Normally located on large gas stations with dedicated buyer use.



Gas Chromatograph Best Practices

- Why use GC's?
  - Contractual requirements frequently define the energy content, relative density, and moisture content of the gas being sold. The sale of natural gas is performed on the basis of the heating value per unit volume of gas.

- Typically, it is the responsibility of the pipeline company to maintain this specification, but it is also beneficial for the supplying gas company to make measurements at the injection points to ensure a check of the pipeline GC and to divert off spec gas prior to injecting into the pipeline.

- GC's are typically used in conjunction with a volumetric flow meter to determine the BTU content per cubic meter of gas.

Station Design – Gas Heaters

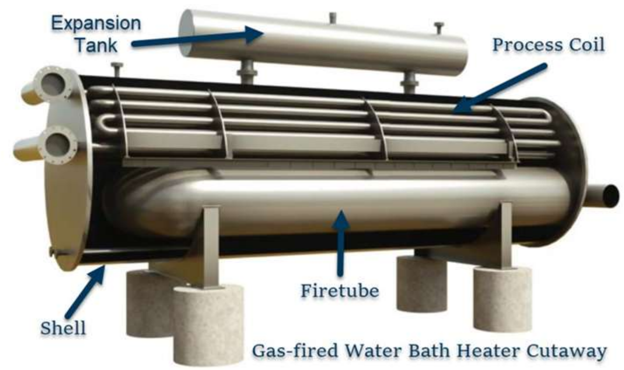
Station Design – Gas Heaters

- **<u>Purpose</u>**: prevent excessive temperature drop caused by pressure reduction, which can lead to freezing, hydrate formation, and measurement errors.
  - Joules-Thompson effect: reduction of 1°F for every 15 psi of pressure drop (≈1°C per 2 bar).

- Typical gas heater installation locations:
  - Upstream of pressure regulators
  - Upstream of meter runs
  - When regulation and metering are closely coupled
  - At city gate stations, pipeline interconnects, and producer receipts with large pressure drops

Station Design – Common Gas Heater Types

- Indirect Water Bath (Line) Heaters
  - Gas flows through a coil immersed in a heated water bath. Heat is transferred indirectly from the bath to the gas.
  - One of the most common types for metering and regulation stations
- Electric Gas Heaters
  - Electric elements heat the gas directly or via a heat exchanger.
- Catalytic (Flameless) Gas Heaters
  - Use catalytic oxidation of fuel gas to generate heat without an open flame.



Station Design - Odorization

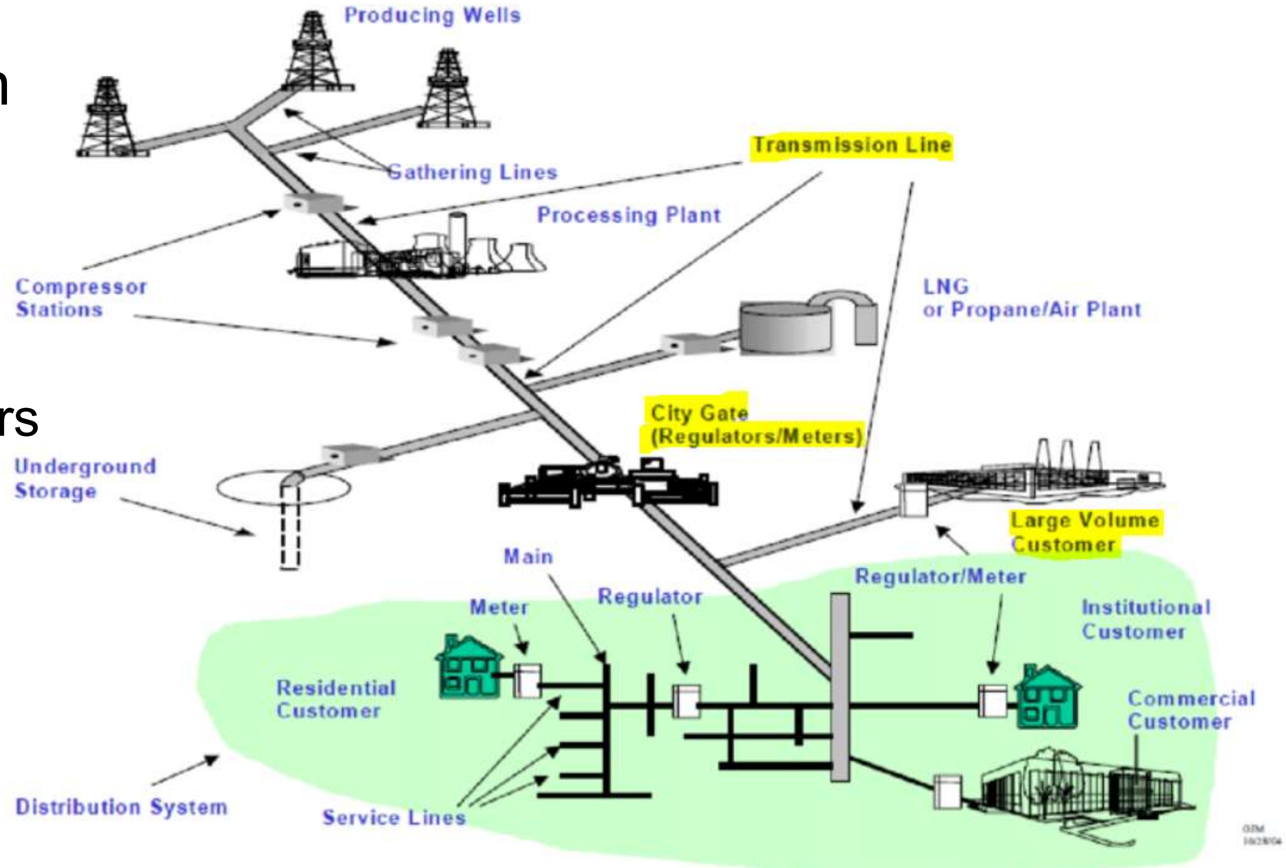
Why Odorize Natural gas?

- Public Safety! So we can detect a gas leak.
  - Natural gas is odorless (in its natural state)
  - Natural gas is extremely volatile

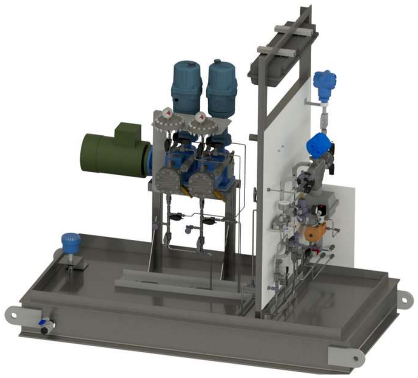
- We add mercaptan to Natural Gas to “odorize” it.
  - Mercaptan makes the gas smell like rotten eggs
  - Mercaptan is an organic sulfur-containing compound and at very small quantities, can be detected by most people

Market

- Typical points of injection
  - Directly into the Transmission lines
  - City Gate
  - Farm Taps
  - Large Volume Customers
  - Truck/Rail Loading

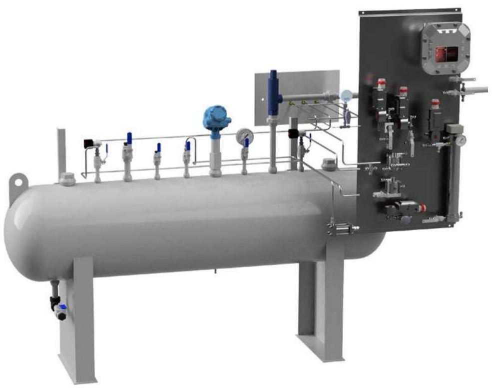


What makes a good Odorant Injection System?



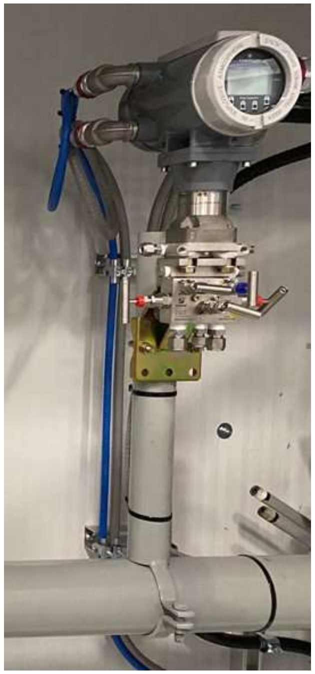
- Tight Odorant Control
  - Under odorize and the mixture is not in compliance with the laws regarding transportation
  - Over odorize and the utilities company will receive nuisance calls
    - The only way to remove excessive odorant from a pipeline is to burn the gas off

- Application Specific
  - Most systems are not a “one type fits all” and need to be customized to fit
  - Some common types are:
    - Absorption or Sweep
    - Pump
    - Solenoid injection



Station Design – RTUs and Telemetry

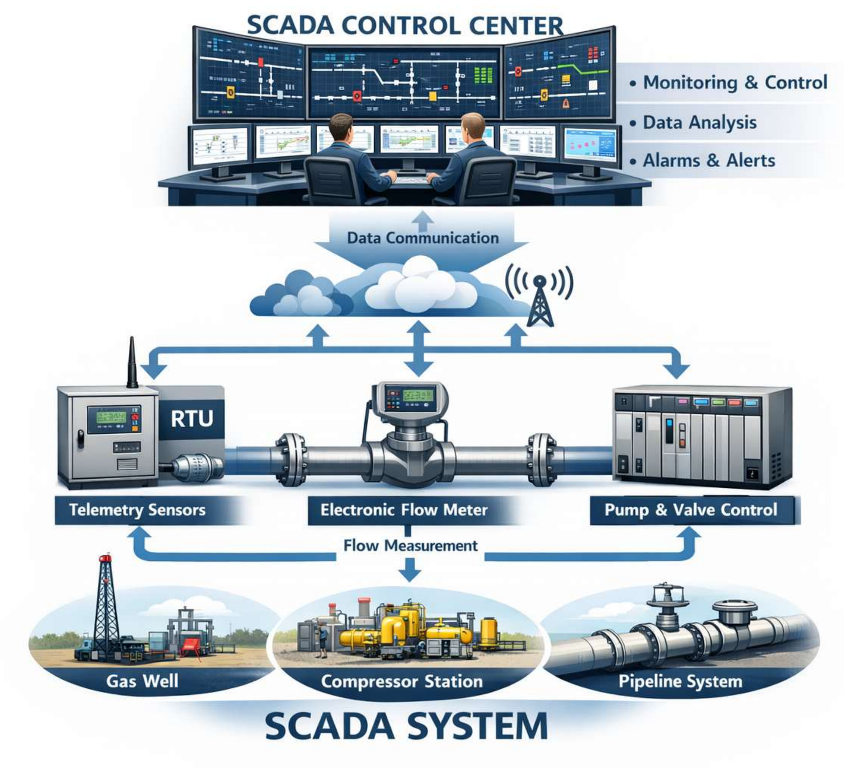
Station Design - Remote Terminal Unit (RTU)



- RTU also referred to as a flow computer
- Two parts needed
  - FT-xxx Measurement Transmitter
  - FQ-xxx RTU/FC Electronics
  - May be separate or integral
- Control capabilities
  - Valve switching
  - PID, ESD
- Datalogging and historian capability

Station Design - Telemetry

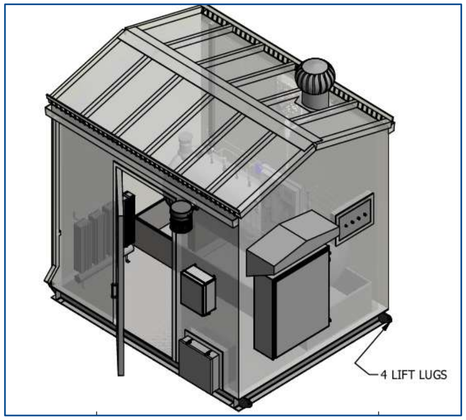
- Telemetry is the data communication layer that moves information from field devices (sensors, RTUs, flow computers) back to the Supervisory Control and Data Acquisition (SCADA) host systems.
- Why?
  - Real-time visibility into remote assets
  - Improved safety - detection of abnormal pressure or flow
  - Operational efficiency - fewer site visits
  - Sends information to gas control



Station Design – Buildings & Available Power

Station Design - Building Considerations & Available Power

- Building required for the station?
- Ventilation
- Accessibility/Space
- Land Rights
- Location
- Safety
- Regulator Compliance
- Reliable power source(s) available



Example

Station Design - Bringing it all together!

Thank You!

Questions?

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Join the conversation…

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