# REGULATOR & INDUSTRIAL METER STATION DESIGN

2024 Western Gas Measurement Short Course

Dominion Energy®

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## PRESENTATION OUTLINE

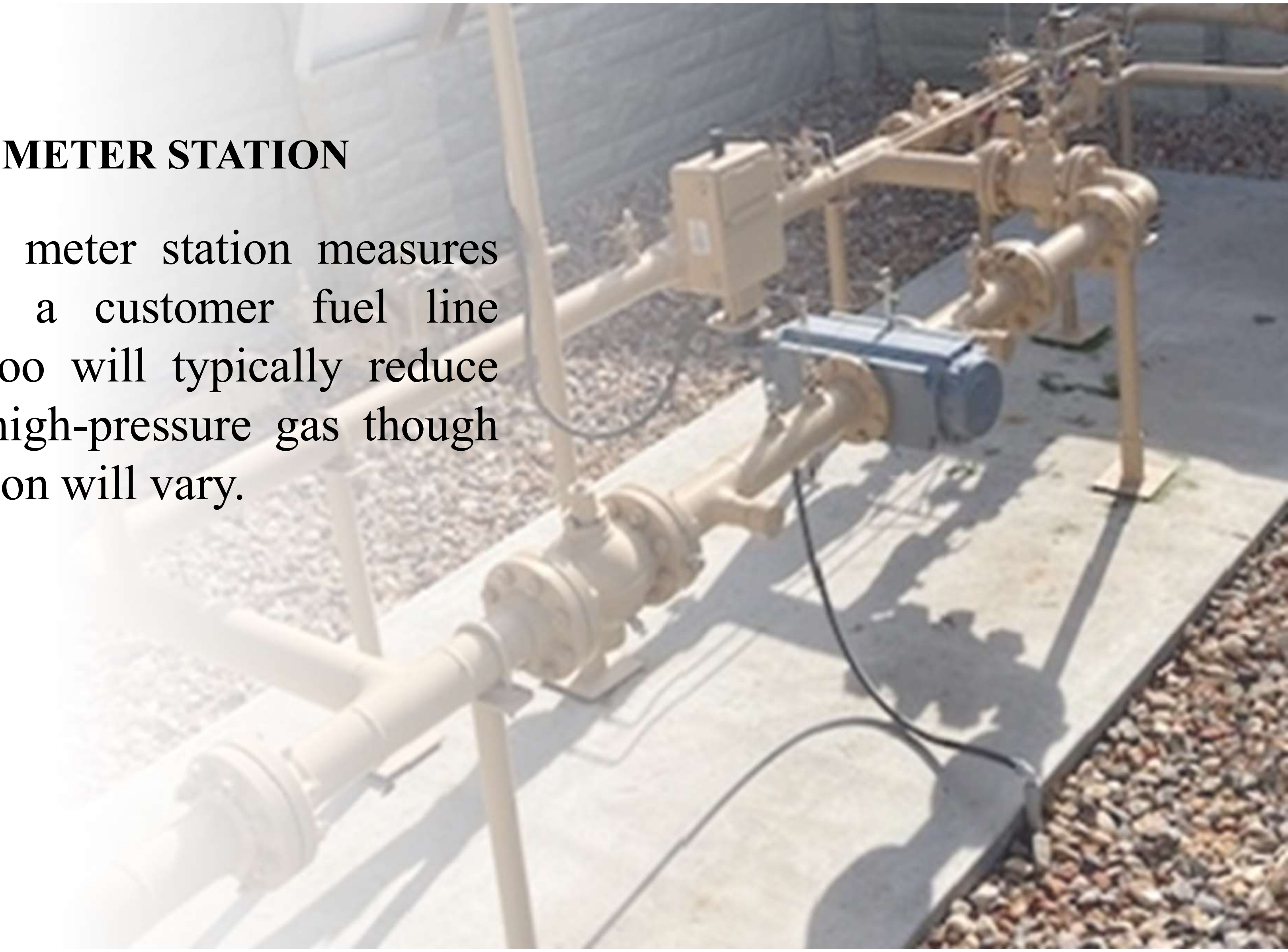
- Brief Introduction to Stations and Meter Sets
- Station / Meter set Design Factors
  - Location and Sizing
  - Pressure Regulation and OPP
  - Station Layout
  - Piping Design
  - Equipment Selection
- Intermission (5-minute break)

## REGULATOR STATIONS

A regulator station is a layout of pipe and equipment designed to reduce and control gas pressure from a high-pressure source to a distribution system.

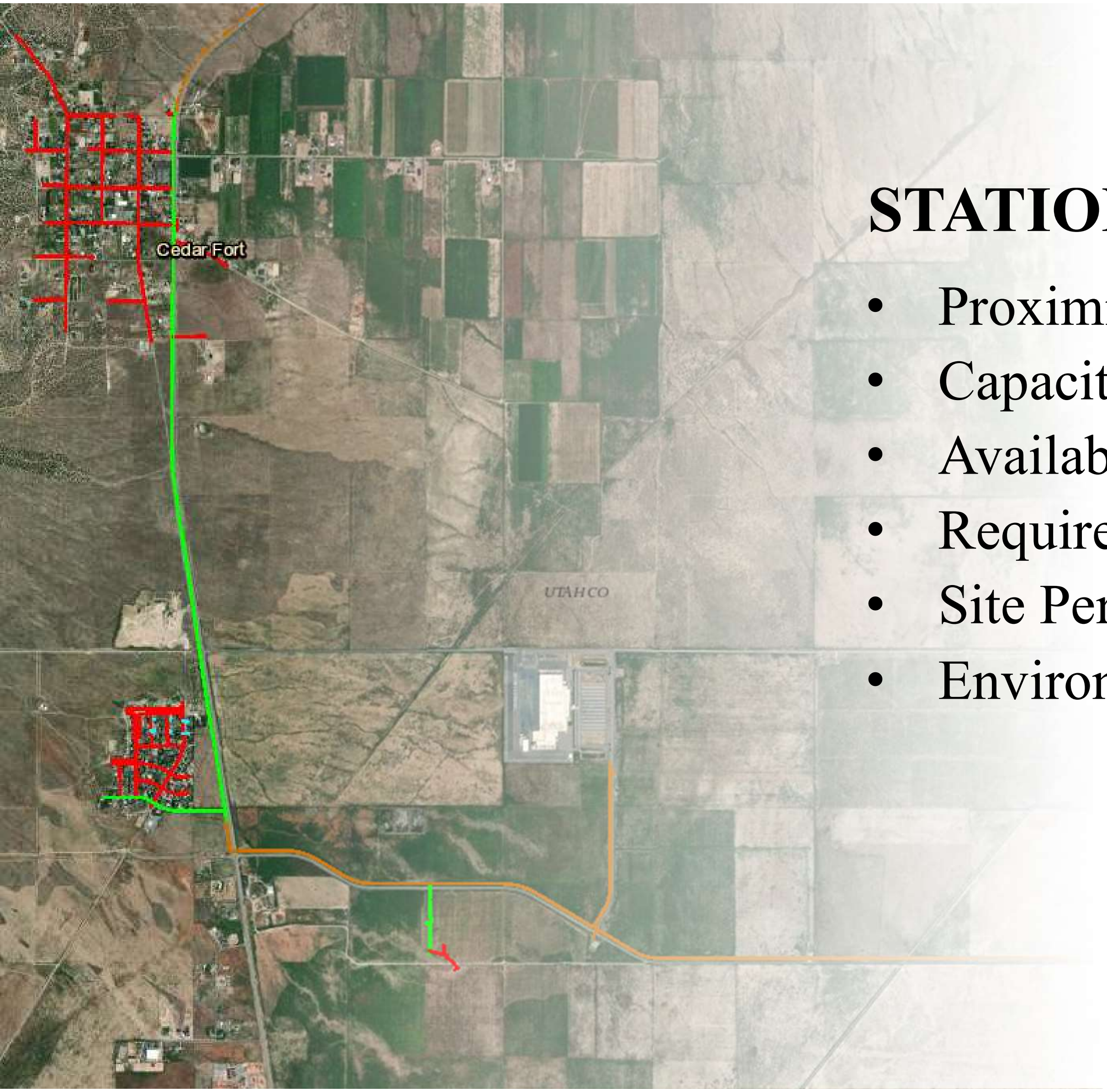
**INDUSTRIAL METER STATION**

An industrial meter station measures gas flow to a customer fuel line system. It too will typically reduce and control high-pressure gas though each application will vary.



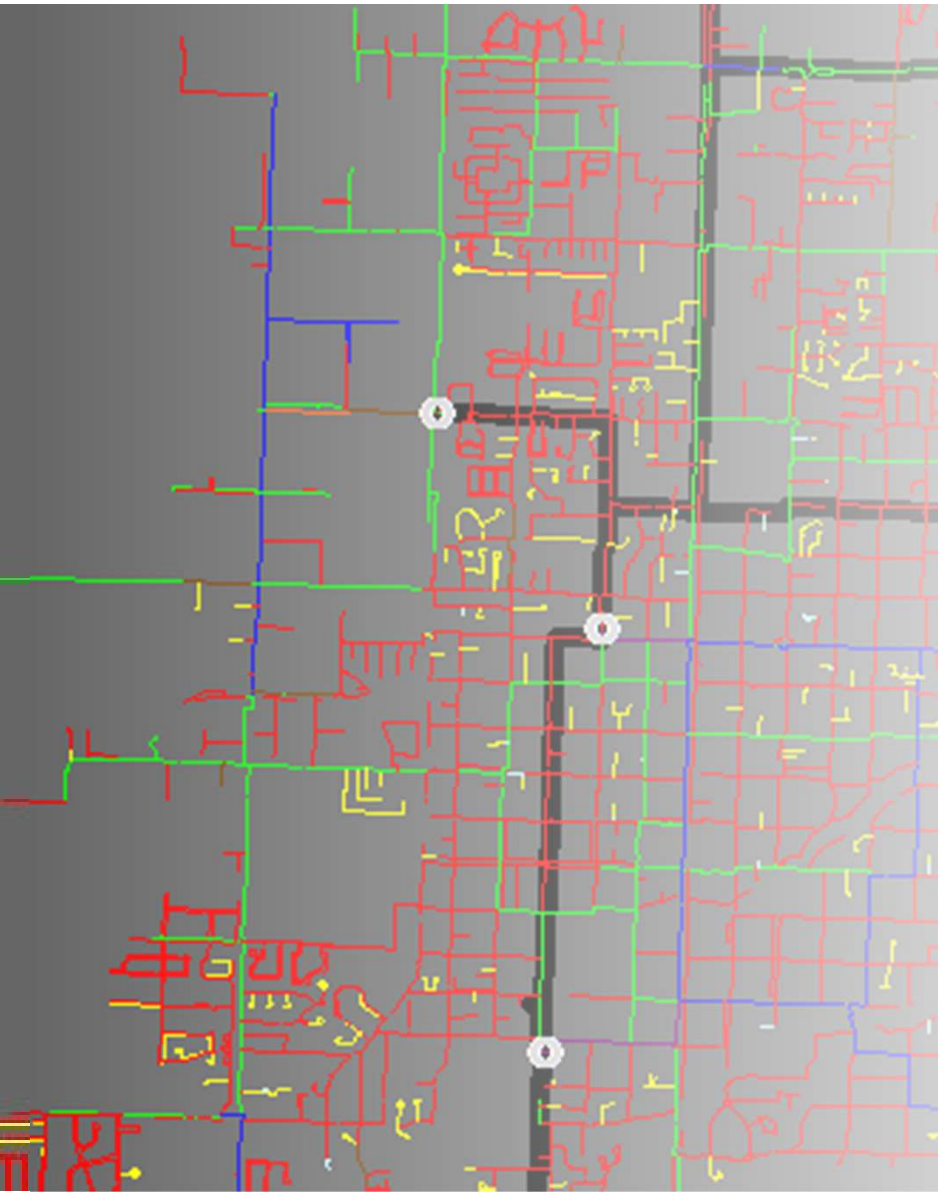
# DESIGN FACTORS

- Station Location and Sizing
- Pressure Regulation and OPP
- Station Layout
- Piping Design
- Equipment Selection




# STATION LOCATION

- Proximity to Load
- Capacity of Distribution Network
- Availability of High-Pressure Supply
- Required Lot Size and Land Availability
- Site Permitting and Conditional Use
- Environmental and Other Hazards

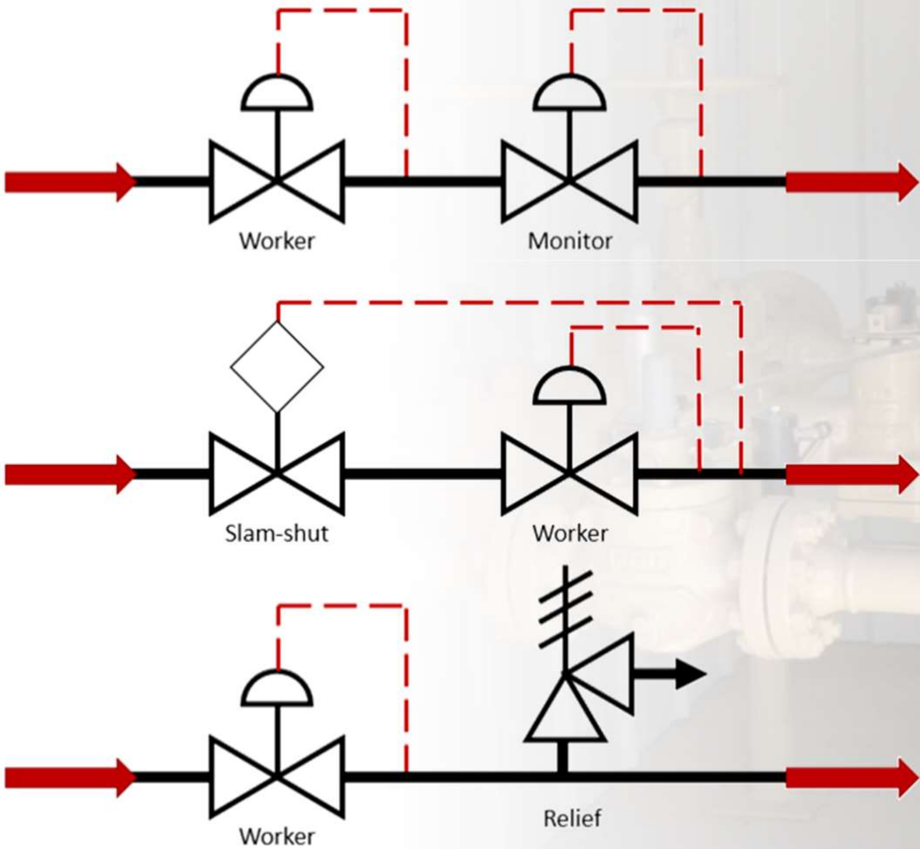


# STATION SIZING

- Utilize customer data and modeling
- Consider future growth for loads
- Will there be need for redundancy?

**Station size will be listed as a capacity rating and is usually reported in a standard flow rate (MSCFH or MMSCFD)**

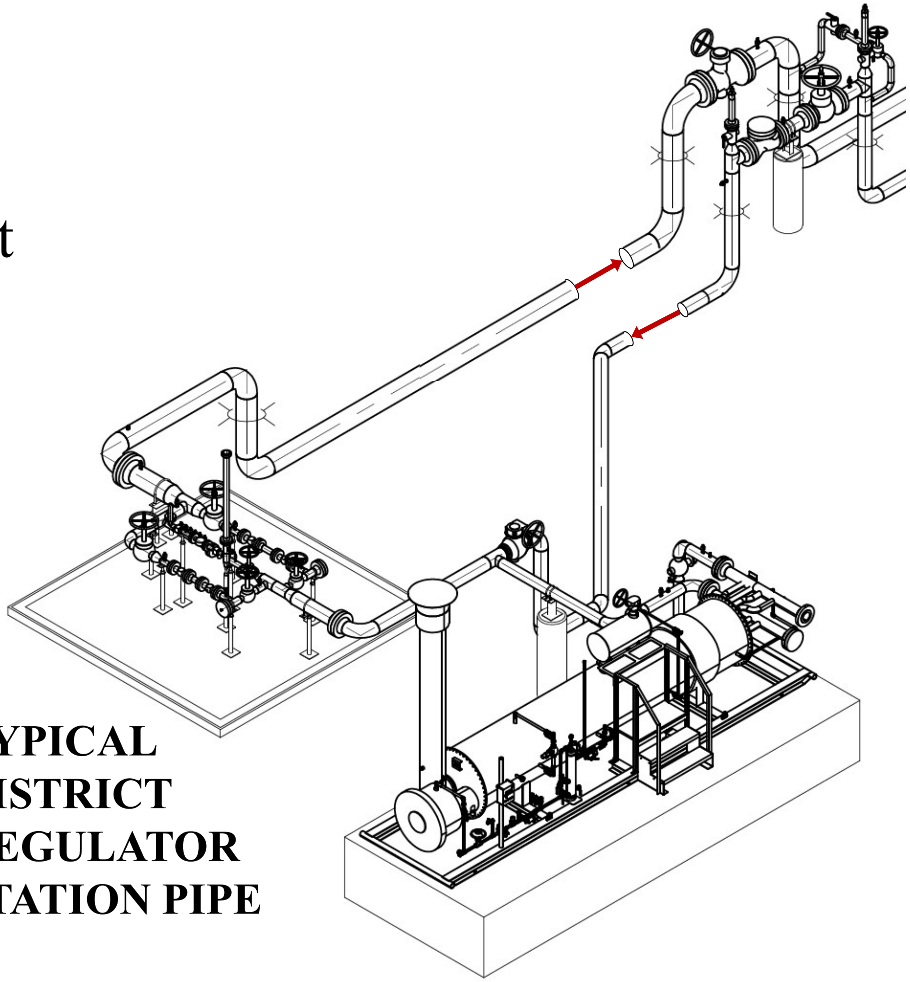
# PRESSURE REGULATION & OPP




Various operational parameters will impact this decision (inlet MAOP, minimum inlet pressure, remoteness of site, etc.

# STATION LAYOUT

- List the required processes
- Identify the required equipment
- Sequence the processes
- Identify Pressure, and Temper conditions at the inlet and outlet of each processes



TYPICAL
DISTRICT
REGULATOR
STATION PIPE

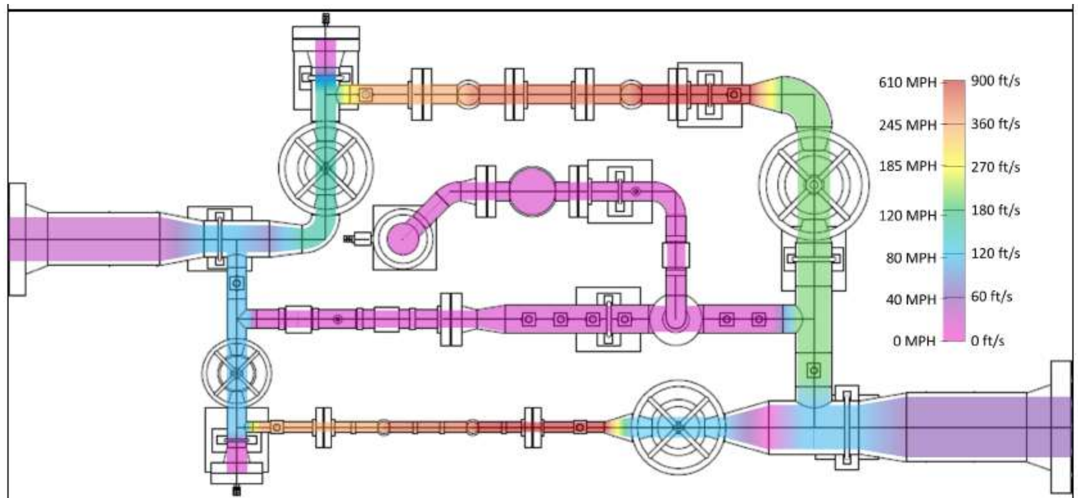
# PIPE DESIGN

Design pipe to conform to 49 CFR 192.103 through 192.115 also consider ensuring that the %SMYS at MAOP will be below 20% to facilitate compliance to 192.127.

Size pipe based upon maximum allowable flow velocity at conditions of maximum expected flow rate and minimum expected pressure. The maximum allowable flow velocity will change depending upon the application. The equation below can be used to **approximate** the flow velocity in a pipe.

$$V = \frac{Q_s T_a}{693 \times P_a D_i^2}$$

$V = Velocity\ (ft/s)$
$Q_s = Flow\ Rate\ (SCFH)$
$T_a = Absolute\ Temperature\ (°R)$
$P_a = Absolute\ Pressure\ (psia)$
$D_i = Internal\ Pipe\ Diameter\ (in)$



Anticipated Velocities During Normal Operation
Assumptions: 125 psig delivered to upstream regulator, full station flow with set pressure at 45 psig

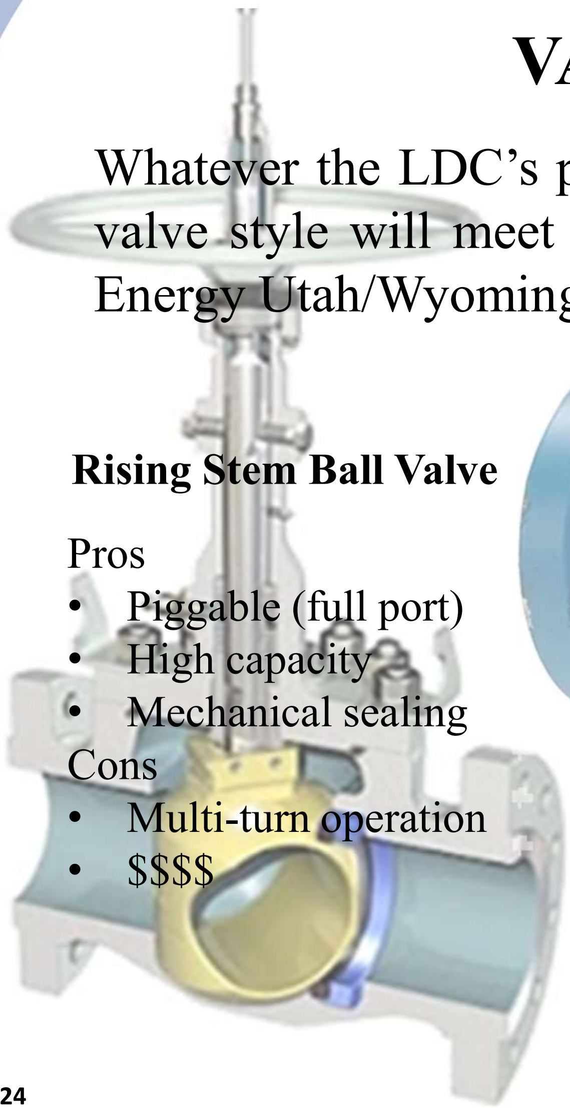
For long runs of pipe where the desire is to minimize pressure loss and noise a good rule of thumb is to keep the velocity around **70 to 120 ft/sec**.

For meter tubes, try to keep the velocity between the meter's maximum and minimum rating

For regulator or control valve runs where pressure drop of the pipe is unimportant higher velocities are likely unavoidable without a drastically oversized reg or valve.  Try to reduce velocities before elbows and valves to minimize wear on the equipment.

# VALVE SPECIFICATION

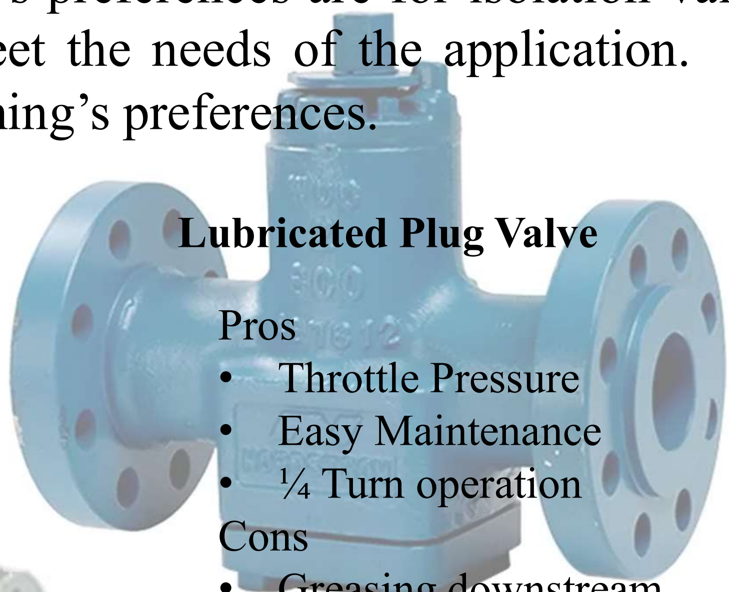
Whatever the LDC's preferences are for isolation valves, just be sure that the valve style will meet the needs of the application.  I will present Dominion Energy Utah/Wyoming's preferences.



**Rising Stem Ball Valve**

Pros
- Piggable (full port)
- High capacity
- Mechanical sealing

Cons
- Multi-turn operation
- $$$$



**Lubricated Plug Valve**

Pros
- Throttle Pressure
- Easy Maintenance
- ¼ Turn operation

Cons
- Greasing downstream
- Non-piggable

**Trunnion Mounted Ball Valve**

Pros
- Piggable (full port)
- High capacity
- ¼ Turn operation

Cons-
- Damaged by Throttling
- Sealing issues

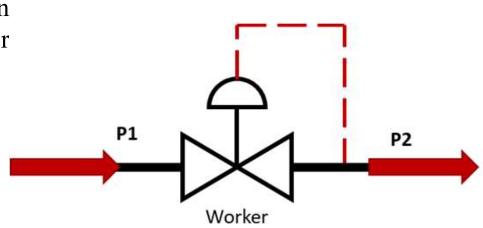
# REGULATOR SPECIFICATION

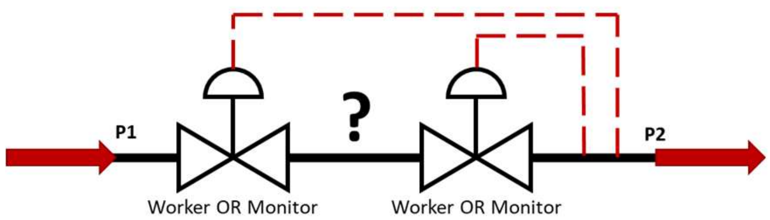
The amount of flow that a regulator can provide is dependent upon the pressures and temperatures both upstream and downstream of the regulator, the specific gravity of the fluid that is being passed through it, and the characteristics related to the flow path through the valve (Gas Sizing Coefficient Cg, and Valve Recovery Coefficient C1). Many styles of pilot operated regulators us the Universal Gas Sizing Equation to properly size a regulator for an application, though some do use the ISA standard equations (covered in the control valve section). Direct operated regulators will usually have capacity tables that can be referenced with the Cg/C1 values only being used for the Failure flow calculation.

$$Q_{SCFH} = \sqrt{\frac{520}{GT}} C_g P_1 \sin\left[\frac{3417}{C_1}\sqrt{\frac{\Delta P}{P_1}}\right]$$

Note that the terms within the brackets should never be greater than 90°

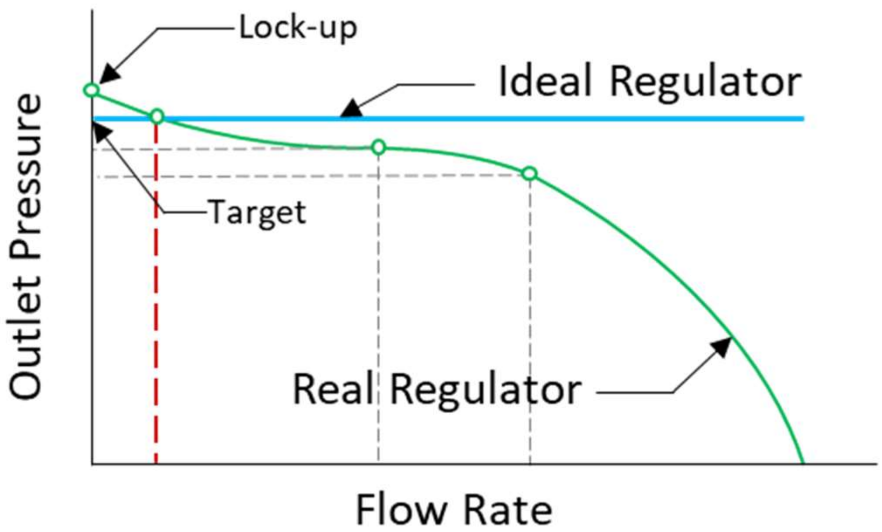
Where $Q$ = gas flow rate, scfh
$C_g$ = gas sizing coefficient
$P_1$ = valve inlet pressure, psia
$\Delta P$ = pressure drop across valve, psi
$C_1$ = valve recovery coefficient
$G$ = gas specific gravity (0.6)
$T$ = gas inlet temperature, °R



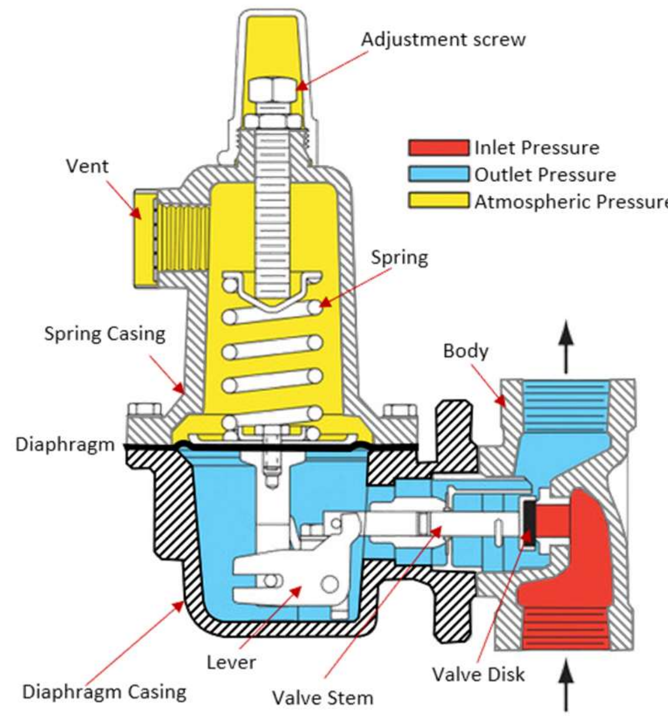



# REGULATOR SPECIFICATION

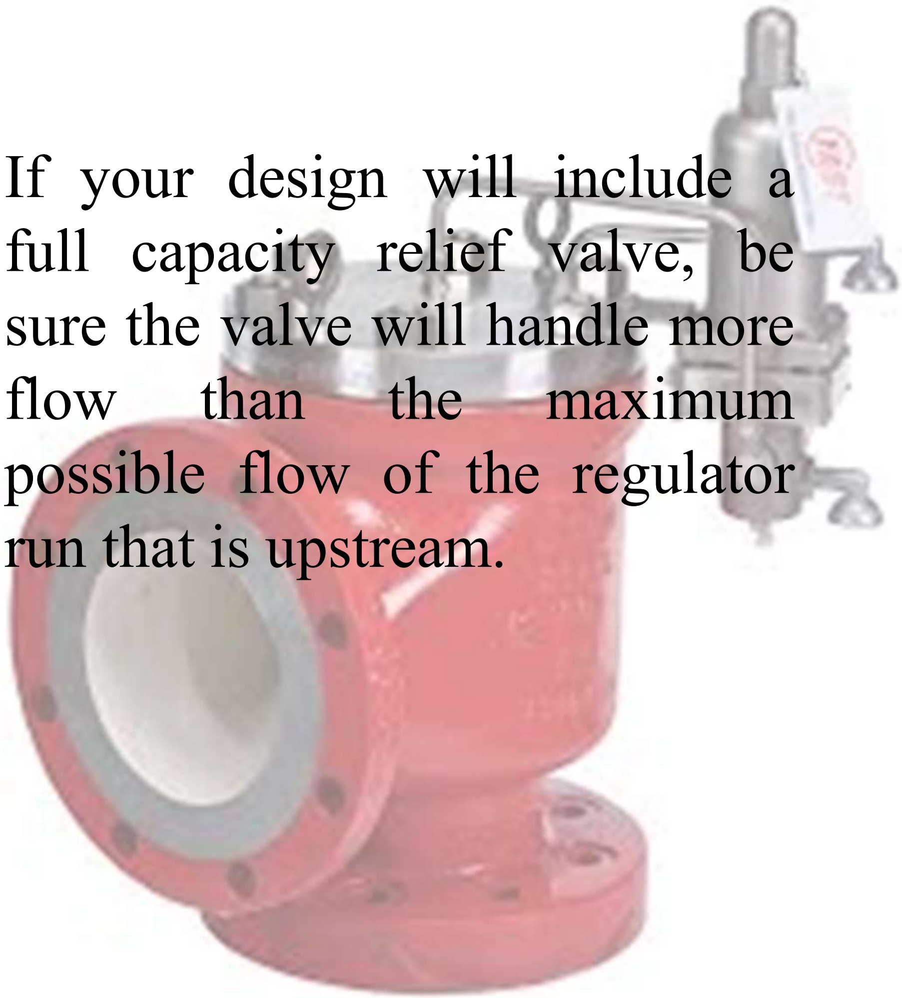
In addition to the sizing of the regulator, it is crucial to understand the nature of the demand downstream. If this is a system that has very little tolerance for variation in the delivery pressure, some regulators may not be appropriate for the application. Looking at the chart below we see that the delivered pressure could vary significantly as demand increases.



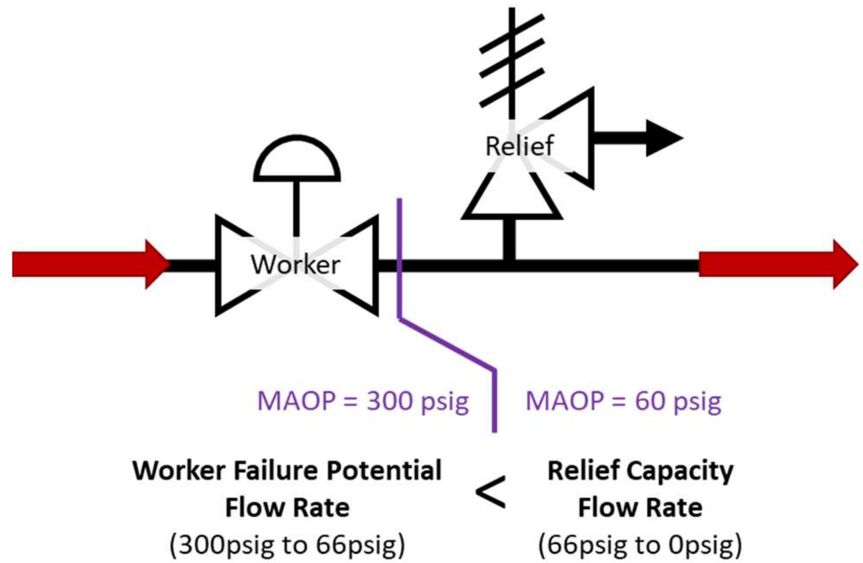

Be sure to understand the maximum allowable working pressure for all the components in a regulator. These may not always match the ANSI rating of the valve body and if you are not careful you could end up over pressuring your regulator.



# REGULATOR SPECIFICATION



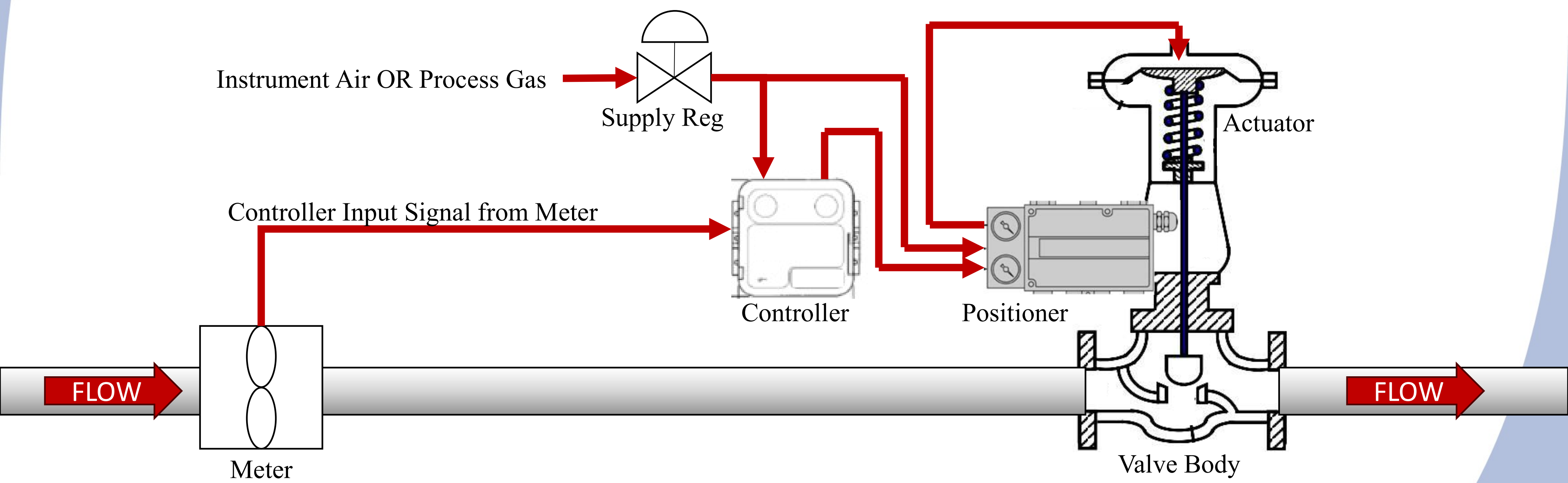
If your design will include a full capacity relief valve, be sure the valve will handle more flow than the maximum possible flow of the regulator run that is upstream.



# CONTROL VALVE SPECIFICATION

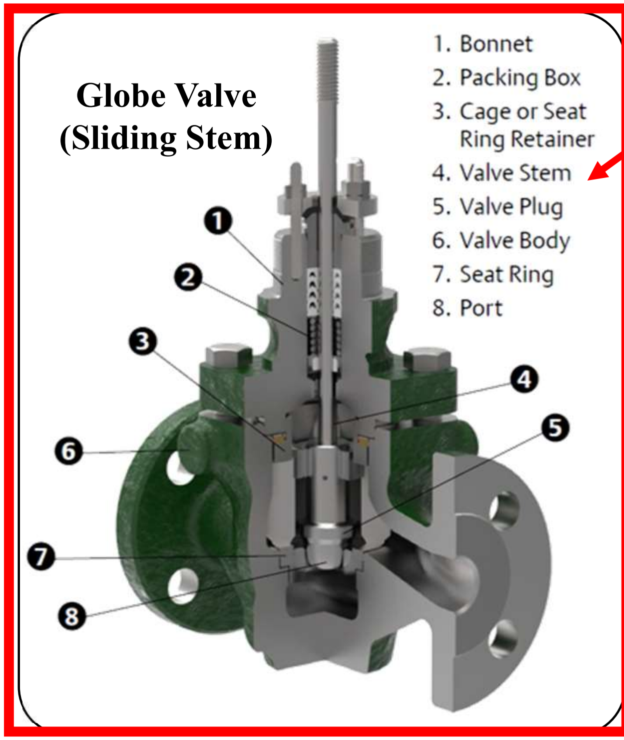
Some station designs require that the controlling parameter of a process be the flow rate rather than the pressure. In these cases, a typical pressure regulator will need to swapped for a control valve coupled with measurements from the flow meter.

In basic terms, a flow rate signal is delivered to a controller. The controller (which has been preprogrammed with a desired flow rate for the customer), compares the measurement with the setpoint and sends a signal to modulate position to the valve positioner. The valve positioner, by means of the actuator, will reposition the valve to either increase or decrease the opening based on what the controller required.



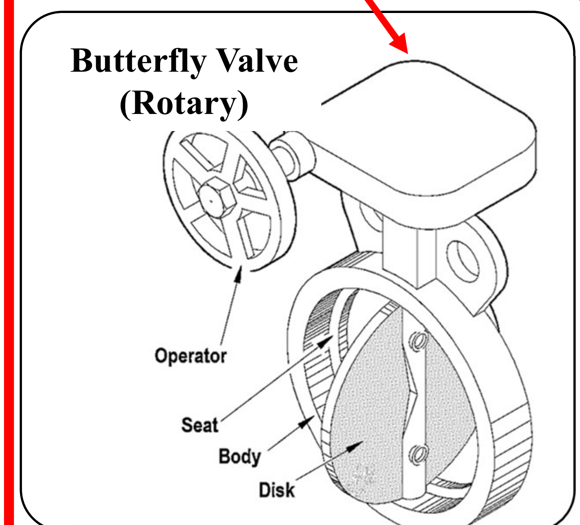
# CONTROL VALVE SPECIFICATION

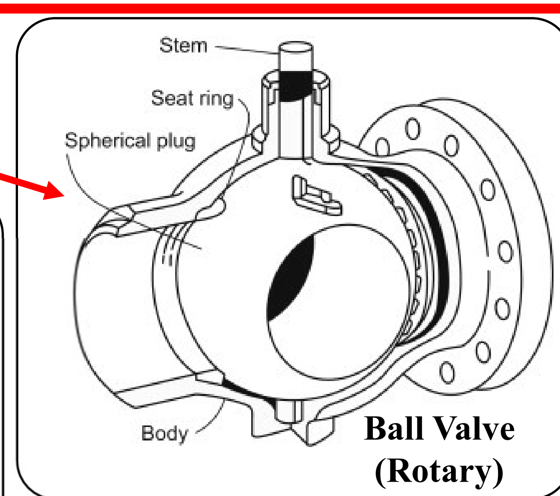
Control valves will generally be much more customizable than their regulator counterparts so careful attention is needed when making the specifications. The types of control valves can be divided into two groups, Sliding stem control valves and Rotary control valves. Sliding stem valves require an actuator to place an axial load on the valve stem to move it up and down for opening and closing. Rotary control valves require an actuator to place a torsional load on the shaft to rotate a plug or disk into place




Typically used for high pressure differential applications

Typically used for higher volume applications



# CONTROL VALVE SPECIFICATION

Sizing and rating of the valve will be completed by the vendor. It is essential that the process conditions be communicated effectively if the valve is to perform as desired. Typical process conditions the vendor will need include:

- Design Pressure & Temperature
- Inlet Pressure (Min, Normal, Max)
- Outlet Pressure (Min, Normal, Max)
- Volumetric Flow Rate (Min, Normal, Max)
- Operating Temperature Range
- Fluid Type with a Specific Gravity
- Inlet Pipe Size/Schedule
- Outlet Pipe Size/Schedule
- Connection Types
- Input Signal
- Desired Fail Mode
- Shutoff Class
- Shutoff Pressure
- Supply Pressure Available (type of supply gas)
- Generated Noise limits (~85 to 90 dBA)

Typically multiple Cv values will be calculated to ensure the proper operation throughout the expected range of flows and conditions.

The given information will allow the vendor to determine the required valve flow coefficient (Cv) for the application using standardized sizing equations (ISA).

- Minimum Cv (where valve is least open, smallest flow rate, and dP is highest)
- Normal Cv (Typical flows and pressures for various seasons)
- Maximum Cv (where valve is most open, largest flow rate, and dP is lowest)

These will usually be presented on the full flow curve for the selected valve as shown below:

$$C_v = \frac{q}{N_9 F_P P_1 Y}\sqrt{\frac{M T_1 Z_1}{x_{sizing}}}$$

$$x_{sizing} = x_{choked} \text{ or } x, \text{ (Whichever is smallest)} \qquad x = \frac{\Delta P}{P_1}$$

$$x_{choked} = F_\gamma \cdot x_{TP}$$

$$F_p = \left[1 + \frac{\sum K}{N_2}\left(\frac{C_v}{d^2}\right)^2\right]^{-1/2}$$

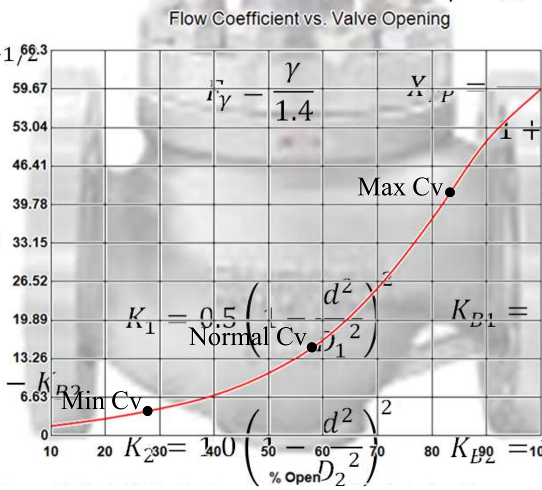
$$F_\gamma = \frac{\gamma}{1.4} \qquad x_{TP} = \frac{\frac{x_t}{F_P^2}}{1 + \frac{x_T (K_1 + K_{B1})}{N_5}\left(\frac{C_v}{d^2}\right)^2}$$

$$Y = 1 - \frac{x_{sizing}}{3 \cdot x_{choked}}$$

$$K_1 = 0.5\left(1 - \frac{d^2}{D_1^2}\right)^2 \qquad K_{B1} = 1 - \left(\frac{d}{D_1}\right)^2$$

$$\sum K = K_1 + K_2 + K_{B1} - K_{B2}$$

$$K_2 = 1.0\left(1 - \frac{d^2}{D_2^2}\right)^2 \qquad K_{B2} = 1 - \left(\frac{d}{D_2}\right)^2$$



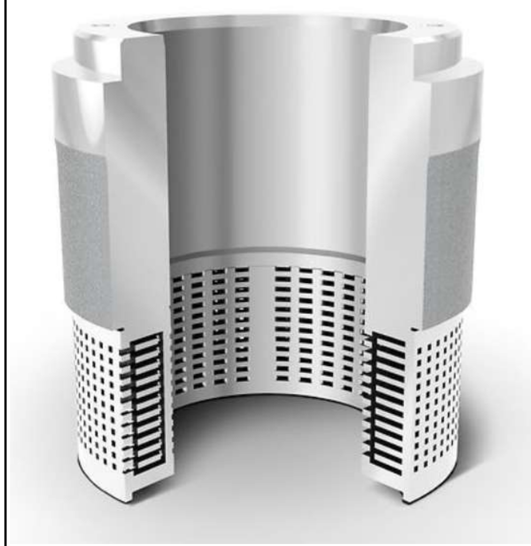
# CONTROL VALVE SPECIFICATION

Control valves like regulators, are likely to be the loudest piece of equipment, manufacturers do have a variety of noise attenuating trims that are exceptional at reducing the generated noise. The reduction in vibration can also help reduce wear and tear on other components of the station. These benefits come at the expense of the valve being much more susceptible to fouling and plugging due to the small holes used within noise reducing trims.

Typical Equal-Percentage Cage


Whisper 1 Trim (about -18 dBA)

WhisperFlo Trim (about -40 dBA)



# CONTROL VALVE SPECIFICATION

Control valves should typically be avoided in situations that require full isolation because control valves are inherently “leaky” and will have published allowable leak rates depending on the shut-off class of the valve.

| Leakage Class Designation | Maximum Leakage Allowable |
|---|---|
| I | --- |
| II | 0.5% of rated capacity |
| III | 0.1% of rated capacity |
| IV | 0.01% of rated capacity |
| V | 0.0005ml per minute of water per inch of orifice diameter per psi differential |
| VI | Not to exceed amounts shown in following table based on port diameter. |

| Nominal Port Diameter | | Bubbles per Minute[1] | |
|---|---|---|---|
| In | mm | ml per Minute | Bubbles per Minute |
| 1 | 25 | 0.15 | 1 |
| 1-1/2 | 38 | 0.30 | 2 |
| 2 | 51 | 0.45 | 3 |
| 2-1/2 | 64 | 0.60 | 4 |
| 3 | 76 | 0.90 | 6 |
| 4 | 102 | 1.70 | 11 |
| 6 | 152 | 4.00 | 27 |
| 8 | 203 | 6.75 | 45 |

*1. Bubbles per minute as tabulated are a suggested alternative based on a suitably calibrated measuring device, in this case a 1/4 inch (6.3 mm) O.D. x 0.032 inch (0.8 mm) wall tube submerged in water to a depth of from 1/8 to 1/4 inch (3 to 6 mm). The tube end shall be cut square and smooth with no chamfers or burrs, and the tube axis shall be perpendicular to the surface of the water. Other apparatus may be constructed and the number of bubbles per minute may differ from those shown as long as they correctly indicate the flow in ml per minute.*

Have a good understanding of the operation of the actuator that is coupled with the control valve as this will help with setting up the control loop. These will also play a role in the failure mode of the valve. See the two actuators below.

Direct-Acting

Reverse-Acting

# LET'S TAKE A BREATHER

# METER SPECIFICATION

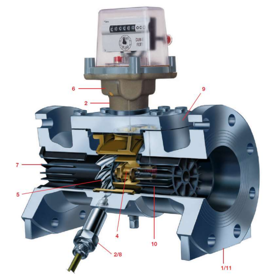
The nature of the customer load will largely determine what meter type should be used for the application.

## Positive Displacement Meters

Diaphragm Meter

Rotary Meter

## Velocity Type Meters



Turbine Meter

Ultrasonic Meter

## Differential Pressure Meters

Orifice Meter

Venturi Meter

## Mass Flow Meters

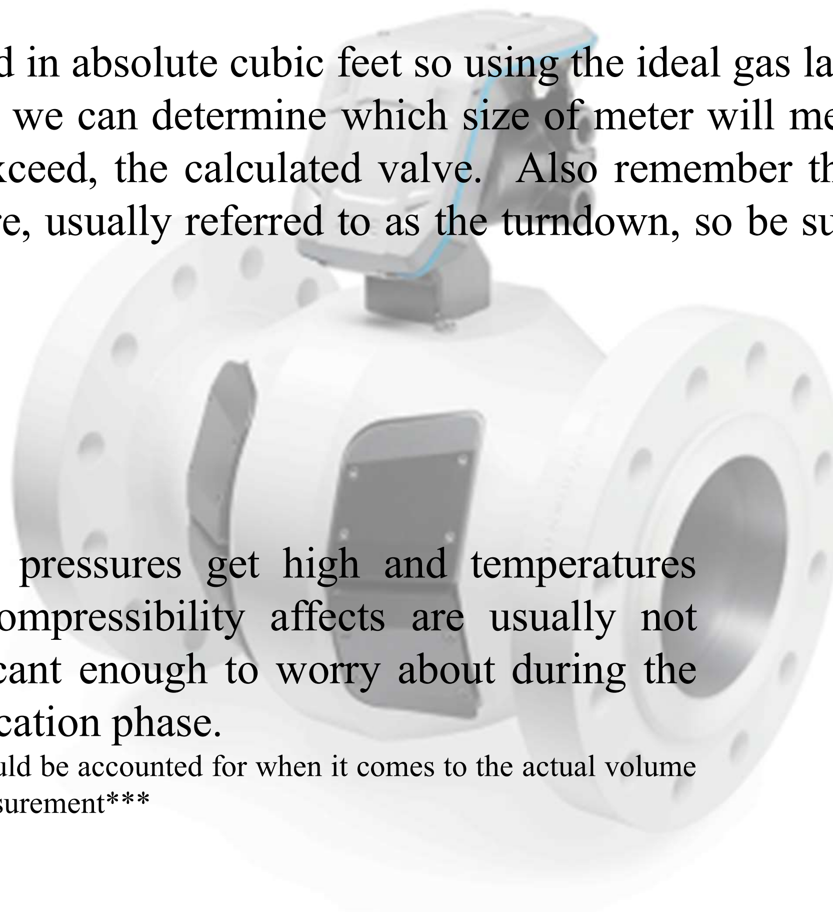
Coriolis Meter

Thermal Mass Meter

# METER SPECIFICATION

Most gas meters (but not all) will have their rating reported in absolute cubic feet so using the ideal gas law, if we know our expected peak flow rate for the customer, we can determine which size of meter will meet the requirements. The rating of the meter will need to exceed, the calculated valve. Also remember that each meter will have a lower limit to which it can measure, usually referred to as the turndown, so be sure that lower volume measurement won't be problematic.

$$V_{actual} = \frac{V_{std}}{\left(\frac{P_{actual}}{P_{std}}\right)\left(\frac{T_{std}}{T_{actual}}\right)\left(\frac{Z_{std}}{Z_{actual}}\right)}$$



Unless pressures get high and temperatures low, compressibility affects are usually not significant enough to worry about during the specification phase.

***It should be accounted for when it comes to the actual volume flow measurement***

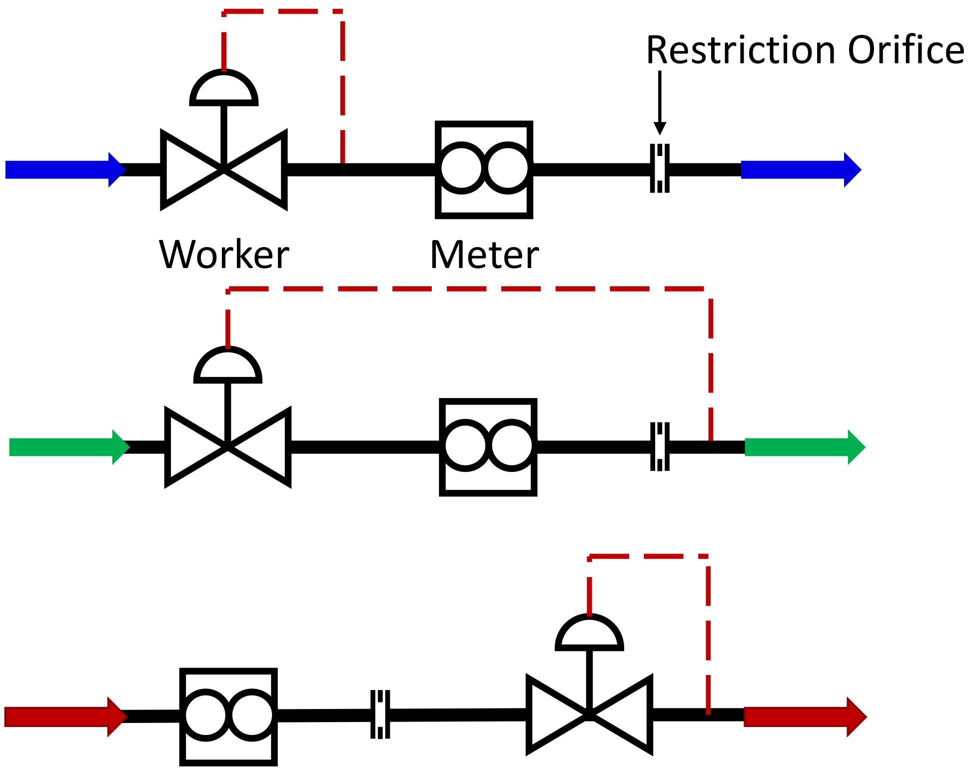
# METER SPECIFICATION

## (Increasing Meter Rangeability with pressure management)

Pressure at the meter ~ setpoint, delivery pressure downstream will be flow dependent

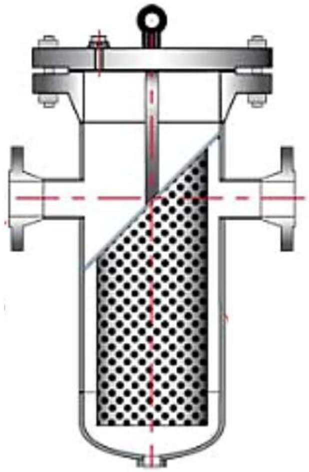
Pressure downstream ~ setpoint, pressure at the meter will be flow dependent

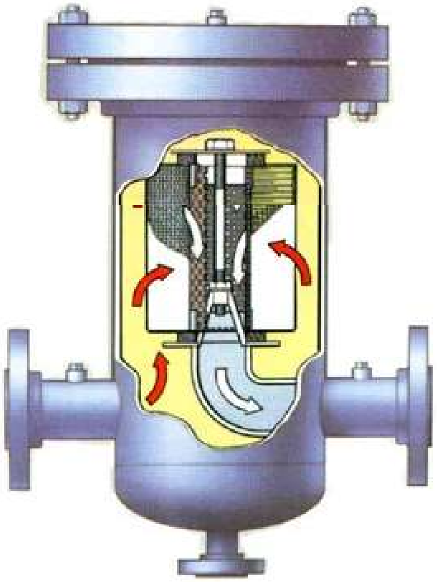
Pressure at the meter upstream dependent, delivery pressure downstream ~ setpoint

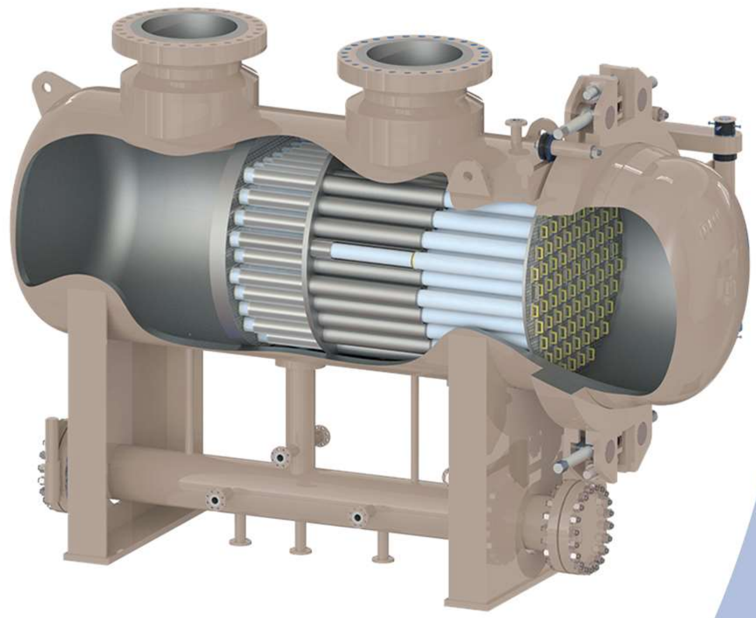


# FILTRATION

Filtration specification can vary widely depending on the expected amount of fouling, the type of particulates, and the size of the particles, liquid or solid that need to be filtered out. In all cases, essentially the filtering surface area is being calculated based on an allowable differential pressure across the element, the strained particle size and the percentage that can be allowed through with an expected amount of clogging.





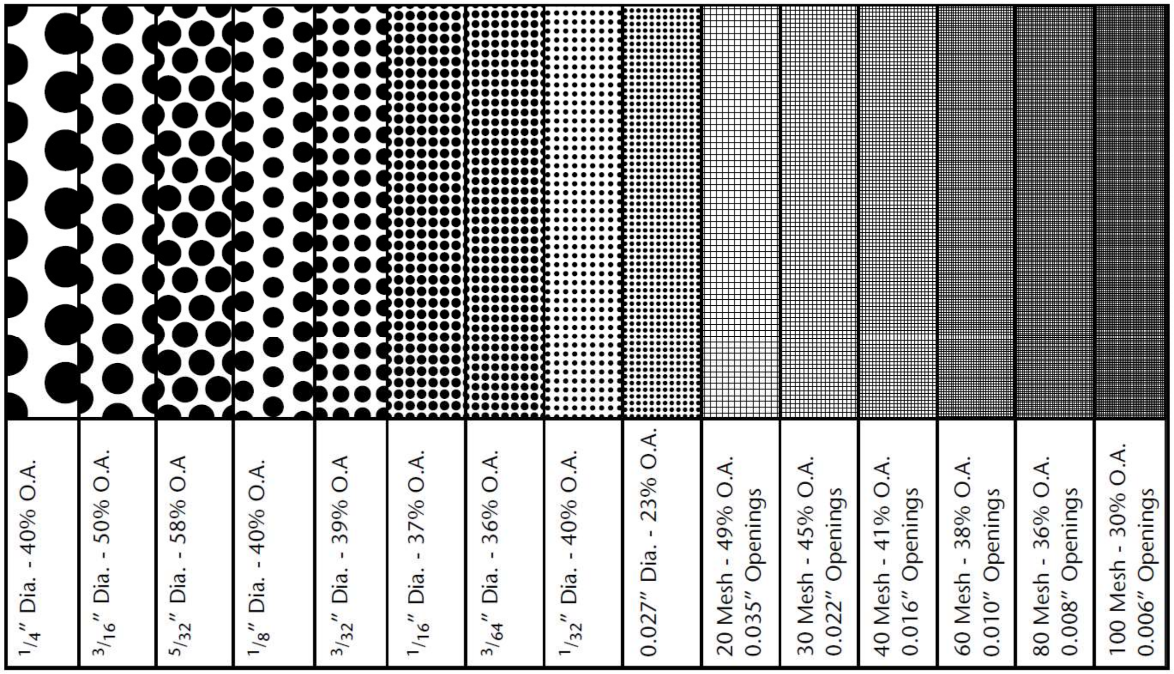


# STRAINER SPECIFICATION

For gas streams that are expected to contain very little particulates, a strainer may be specified to catch what remains or provide protection for station equipment.

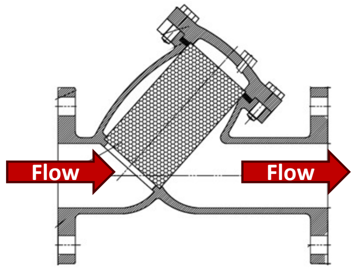
Start your specification with identifying the largest allowable particle size. Anything above this size would need to be captured by the strainer. This will determine the mesh size needed.

For higher pressure streams, a perforated plate with larger holes will be used to provide rigidity to the strainer and will be lined with the finer mesh to capture the particulates. This way the potential for bursting the basket is minimized.



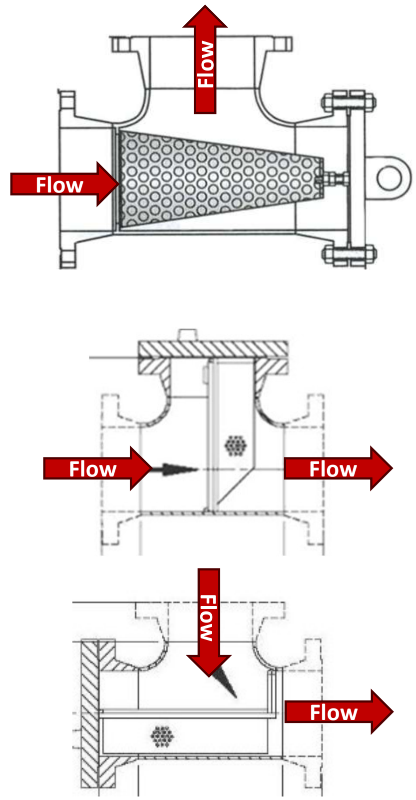

The open area (area which allows flow through the mesh) is usually indicated with each mesh size. If this percentage is small, the amount of debris that can pass through will be small as well, but the mesh will have a higher chance of becoming clogged.

# STRAINER SPECIFICATION
## STRAINER TYPES

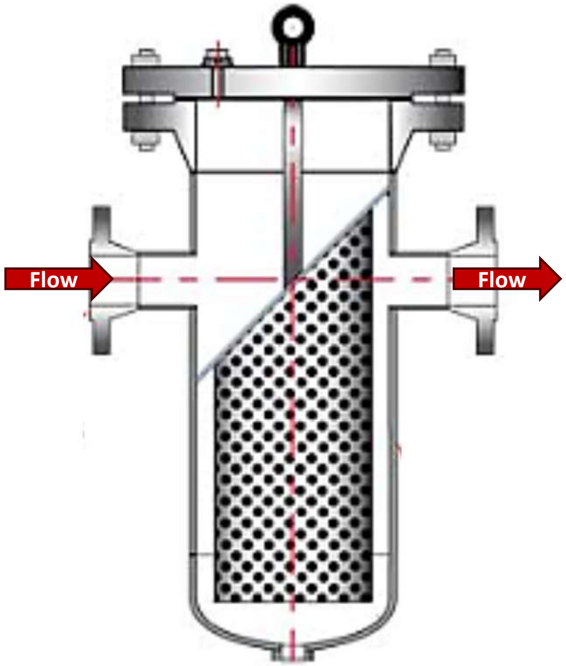



Y Strainer

Conical Strainer

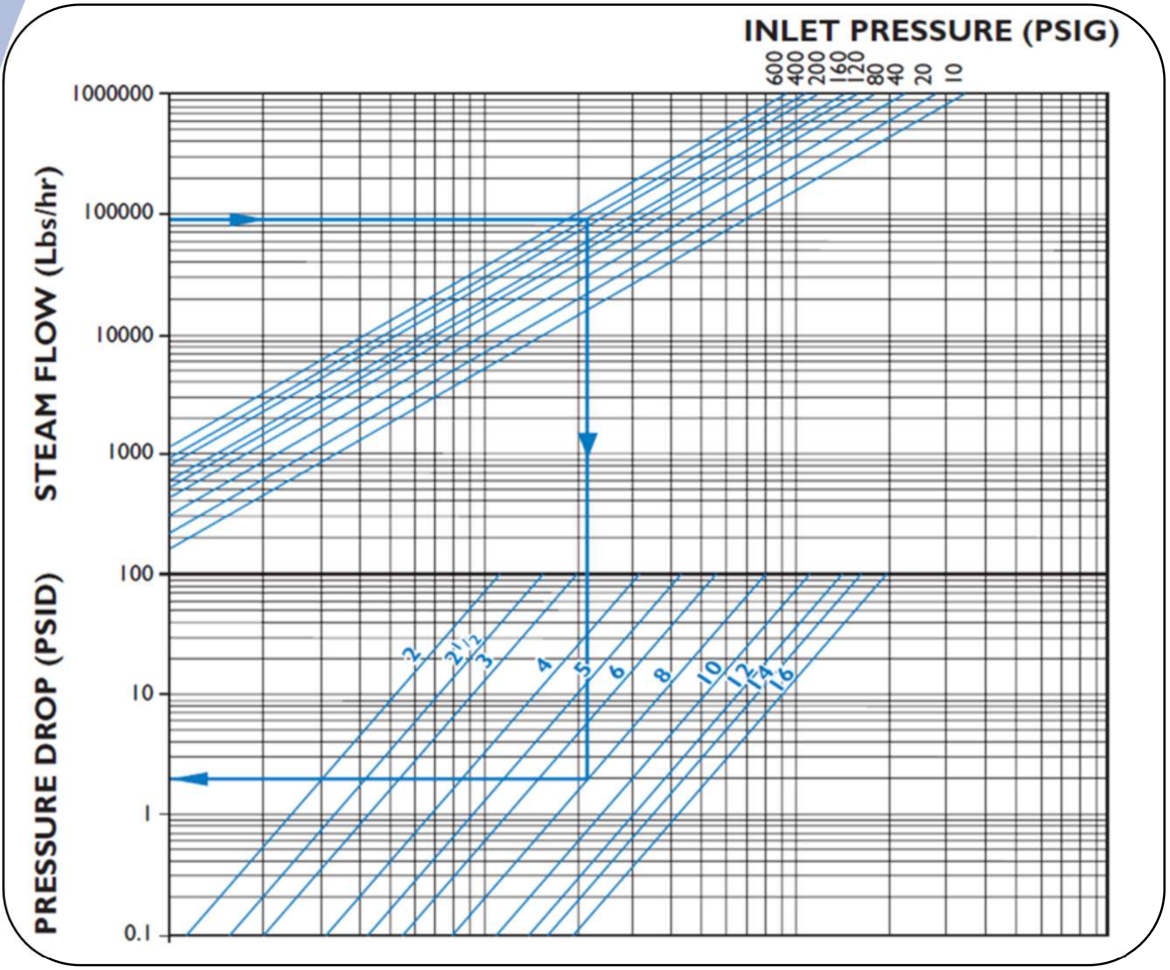



Tee Strainers




Basket Strainer

# STRAINER SPECIFICATION




With a strainer type selected and the mesh size known, sizing the unit can begin. Manufacturers typically provide capacity charts for strainers with standard screens. We can use these to determine the expected pressure loss during our minimum inlet pressure and maximum flow rate.

The chart at the right shows flow for saturated steam through a y-strainer with a standard screen. This can be used for air or gas flow by converting your standard flow rate to an equivalent steam flow rate with the below equation.

$$Qs = 0.138Qg\sqrt{(460+t)\ s.g.}$$

**where;** DP/P2<1

Qs = Equivalent Steam Flow, lbs./hr.

Qg = Air or gas flow, SCFM.

t = Temperature, °F.

s.g. = Specific gravity (s.g. = 1 for air.)

DP = Pressure Drop, psid

P2 = Outlet Pressure

# STRAINER SPECIFICATION

Correct the pressure drop calculated to account for any difference that our screen might have with the open area of the standard screen used to develop the chart. This is done by multiplying the pressure drop read from the chart on the previous slide by the factor in the table that corresponds with the % Open area of your selected mesh.

| % Screen Material Open Area | | | | | | | |
|---|---|---|---|---|---|---|---|
| Perforated Plate | | | | | Mesh Lined | | |
| **60%** | **50%** | **40%** | **30%** | **20%** | **50%** | **40%** | **30%** |
| 0.65 | 0.8 | 1 | 1.4 | 2.15 | 1.05 | 1.05 | 1.2 |

Next, we calculate the ratio of free screen area to pipe area to see how prone to clogging our unit will be. This is done with the equation below.

$$R = \frac{Ag \times OA}{100Ap}$$

where;

R = Ratio Free Area to Pipe Area

Ag = Gross screen area, sq. in.

OA = Open area of screen media, %

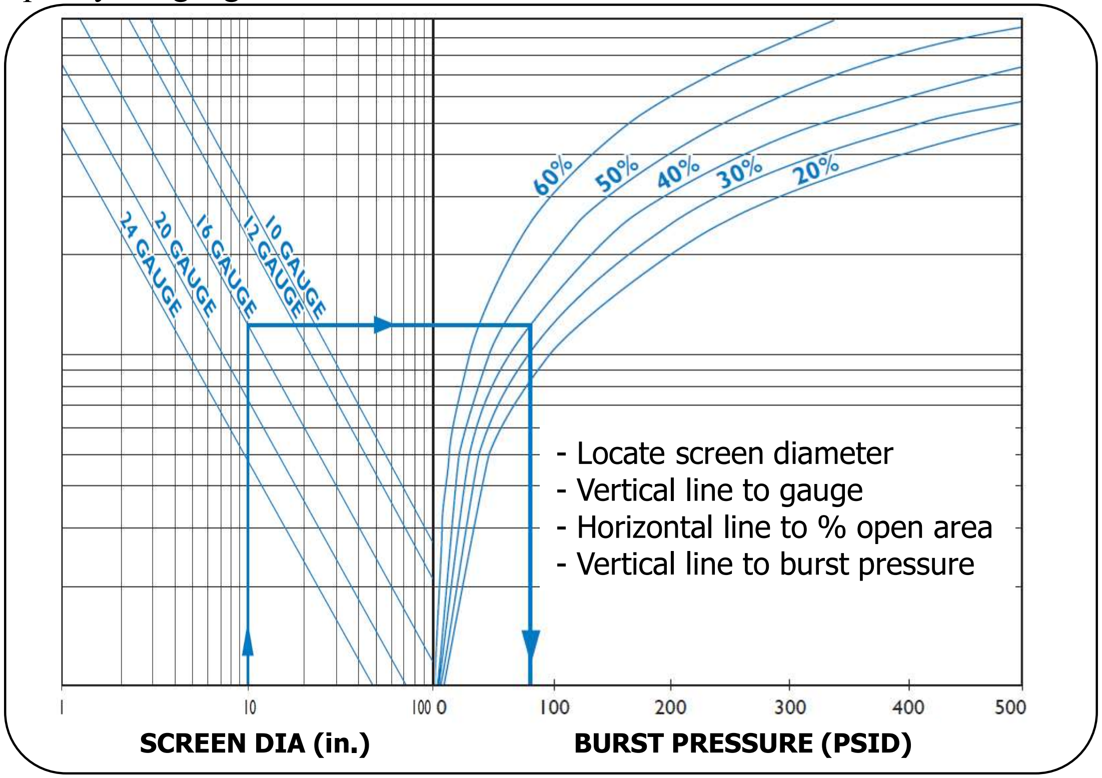
Ap = Nominal area of pipe fitting, sq. in.

Multiplying the corrected pressure drop by the factor that corresponds most closely to the calculated ratio will give the expected pressure drop when the strainer is at the indicated clogged percentage.

| | Ratio of Free Screen Area to Pipe Area | | | | | | |
|---|---|---|---|---|---|---|---|
| **% Clogged** | **10:1** | **8:1** | **6:1** | **4:1** | **3:1** | **2:1** | **1:1** |
| **10%** | - | - | - | - | - | - | 3.15 |
| **20%** | - | - | - | - | - | 1.15 | 3.9 |
| **30%** | - | - | - | - | - | 1.4 | 5 |
| **40%** | - | - | - | - | - | 1.8 | 6.65 |
| **50%** | - | - | - | - | 1.25 | 2.5 | 9.45 |
| **60%** | - | - | - | 1.15 | 1.8 | 3.7 | 14.5 |
| **70%** | - | - | - | 1.75 | 2.95 | 6.4 | 26 |
| **80%** | - | 1.1 | 1.75 | 3.6 | 6.25 | 14 | 58 |
| **90%** | 2.3 | 3.45 | 6 | 13.5 | 24 | 55 | - |

# STRAINER SPECIFICATION

With a properly sizes strainer it is important to also ensure that the expected differential pressure won't cause the screen to burst. Some vendors will provide a chart read for this as well to easily specify the gauge of steel needed for the basket.




As with most pieces of equipment a more detailed sizing is likely available from the vendor of the equipment. Here are some details you could provide the vendor to facilitate the specification.

1. Fluid to be strained
2. Flow Rate
3. Density of Fluid
4. Viscosity of Fluid
5. Fluid working pressure
    1. Expected Min and Max
6. Fluid working temperature
    1. Expected Min and Max
7. Connection Type & Size
8. Size of solids to be strained out
9. Maximum allowable dP

# HEATER SPECIFICATION

A more rigorous process for sizing a heater intended for process gas heating will more than likely be performed by the vendor of the heater unit as these are typically designed for specific applications. The design engineer should provide the vendor with operational parameters related to gas pressure, temperature, and composition at the anticipated extremes for the flow rate to ensure that pressure ratings and sizes will be appropriate for the application.

Presented below is a simple equation to get an idea for the size of heater that may be required. Remember that not all heat that a burner produces will to into the process fluid so oversize the heater to account for this. Typical heater efficiencies range between 50% to 80%

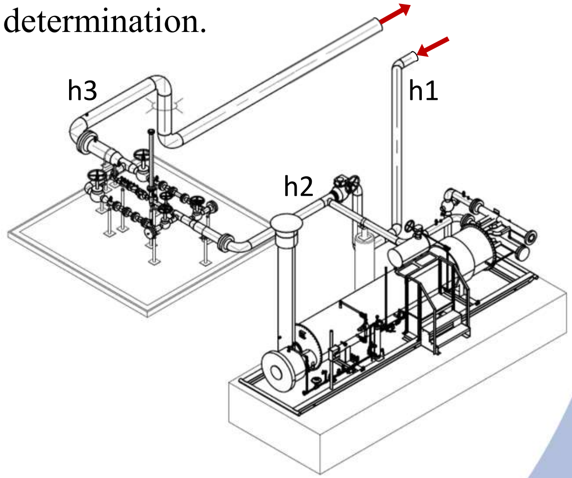
$$Q = V \times \rho(h_2 - h_1)$$

$Q = Heat\ Required\ (BTU/hr)$
$V = Maximum\ Volume\ Flow\ Rate\ (SCFH)$
$(h_2 - h_1) = Enthalpy\ Difference\ (BTU/lbm)$
$\rho = Standard\ Gas\ Density\ (lbm/ft^3)$

For a 0.60 specific gravity gas the standard gas density is approximately 0.046 lbm/ft3 and enthalpy values are tabulated on the following slide.

Temperature and pressure conditions for **h1** should be approximated by the engineer based upon site conditions.

Conditions downstream of the heater (**h2**) won't readily be known but, downstream of the regulators the engineer should know what delivery pressure is going to be and what the minimum allowable temperature will be. Knowing those value and understanding that throttling through a regulator is nearly isenthalpic, **h2 ≈ h3** (downstream of station) and the table can be used for the enthalpy determination.



# HEATER SPECIFICATION

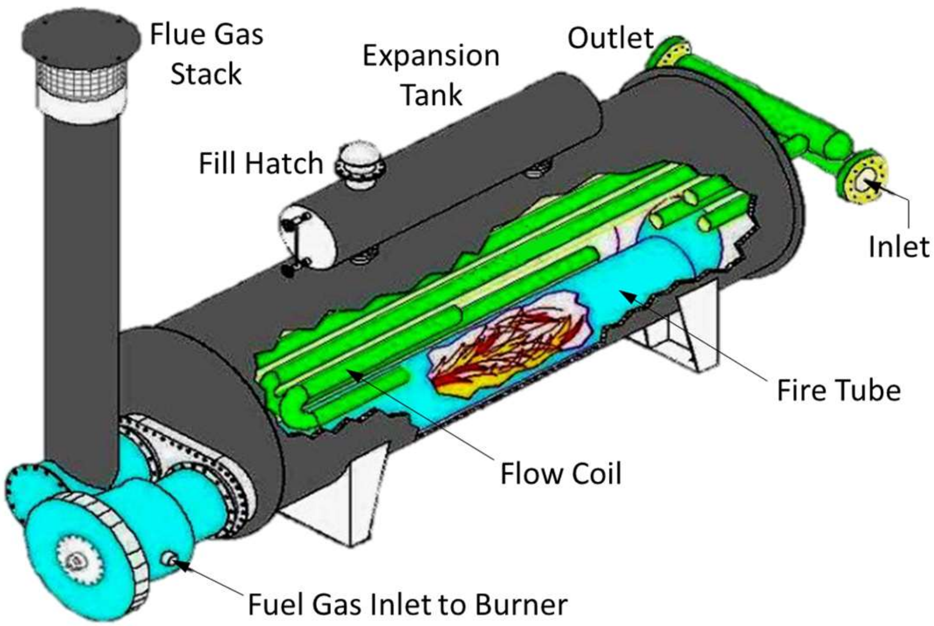
Dominion Energy

| 0.60 SPECIFIC GRAVITY NATRUAL GAS ENTHALPY (BTU/lbm) | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TEMPERATURE | PRESSURE [PSIA] | | | | | | | | | | | |
| [°F] | 1 | 12.5 | 57.5 | 72.5 | 137.5 | 366.5 | 482.5 | 732.5 | 1012.5 | 2012.5 | 5012.5 | 10012.5 |
| -200 | -2021.48 | -2040.72 | -2063.71 | -2073.62 | -2224.25 | -2223.88 | -2223.66 | -2223.16 | -2222.53 | -2219.85 | -2209.58 | -2189.38 |
| -150 | -1998.24 | -1999.14 | -2014.18 | -2017.68 | -2031.54 | -2176.49 | -2177.15 | -2178.19 | -2178.89 | -2179.27 | -2172.89 | -2155.04 |
| -100 | -1974.76 | -1975.49 | -1978.43 | -1979.43 | -1984.05 | -2013.63 | -2029.78 | -2106.95 | -2122.37 | -2133.95 | -2135.01 | -2120.42 |
| -80 | -1965.26 | -1965.94 | -1968.65 | -1969.57 | -1973.67 | -1992.71 | -2005.06 | -2036.95 | -2087.40 | -2113.88 | -2119.49 | -2106.45 |
| -60 | -1955.69 | -1956.32 | -1958.83 | -1959.68 | -1963.44 | -1978.05 | -1986.51 | -2008.67 | -2043.47 | -2092.57 | -2103.78 | -2092.41 |
| -40 | -1946.03 | -1946.62 | -1948.95 | -1949.74 | -1953.21 | -1966.37 | -1973.71 | -1991.58 | -2015.55 | -2070.31 | -2087.89 | -2078.30 |
| -20 | -1936.29 | -1936.84 | -1939.01 | -1939.74 | -1942.95 | -1954.93 | -1961.44 | -1976.64 | -1995.54 | -2047.90 | -2071.86 | -2064.12 |
| 0 | -1926.44 | -1926.95 | -1928.98 | -1929.66 | -1932.65 | -1943.63 | -1949.49 | -1962.80 | -1978.67 | -2026.36 | -2055.74 | -2049.86 |
| 20 | -1916.48 | -1916.96 | -1918.86 | -1919.50 | -1922.28 | -1932.41 | -1937.74 | -1949.62 | -1963.41 | -2006.25 | -2039.58 | -2035.53 |
| 32 | -1910.45 | -1910.91 | -1912.74 | -1913.35 | -1916.03 | -1925.70 | -1930.75 | -1941.92 | -1954.73 | -1994.90 | -2029.88 | -2026.91 |
| 60 | -1896.20 | -1896.63 | -1898.30 | -1898.86 | -1901.30 | -1910.04 | -1914.54 | -1924.35 | -1935.37 | -1970.23 | -2007.31 | -2006.68 |
| 100 | -1875.40 | -1875.78 | -1877.27 | -1877.77 | -1879.92 | -1887.56 | -1891.44 | -1899.78 | -1908.99 | -1938.11 | -1975.36 | -1977.59 |
| 200 | -1820.80 | -1821.09 | -1822.22 | -1822.60 | -1824.22 | -1829.89 | -1832.72 | -1838.69 | -1845.13 | -1865.38 | -1897.51 | -1903.87 |
| 300 | -1759.68 | -1759.91 | -1760.83 | -1761.13 | -1762.44 | -1766.97 | -1769.21 | -1773.94 | -1779.01 | -1794.91 | -1821.22 | -1827.48 |
| 400 | -1698.56 | -1698.74 | -1699.43 | -1699.66 | -1700.65 | -1704.04 | -1705.71 | -1709.19 | -1712.90 | -1724.44 | -1744.93 | -1751.10 |
| 500 | -1625.25 | -1625.40 | -1625.97 | -1626.16 | -1626.98 | -1629.80 | -1631.18 | -1634.06 | -1637.13 | -1646.63 | -1663.36 | -1667.63 |
| 600 | -1551.93 | -1552.05 | -1552.51 | -1552.66 | -1553.32 | -1555.56 | -1556.66 | -1558.94 | -1561.35 | -1568.81 | -1581.79 | -1584.16 |
| 700 | -1478.62 | -1478.71 | -1479.05 | -1479.16 | -1479.65 | -1481.32 | -1482.13 | -1483.81 | -1485.58 | -1490.99 | -1500.22 | -1500.69 |

*Figure 21: Enthalpy of 0.60 SG natural gas. The cells marked in yellow represent conditions where the gas is likely to exist with multiple phases (liquid & gas).*

# HEATER SPECIFICATION

Indirect Fired Bath Heaters should typically conform to API 12K. Using these requirements, we can get an approximation for Fire tube diameter and length that our heater will require.




Per API 12K, firetube heat density should never exceed 15,000 BTU/hr/in$^2$ thus rearranging the below equation and using our calculated heater rating from the previous steps we can get the cross-sectional area of the firetube and thus the diameter of pipe.

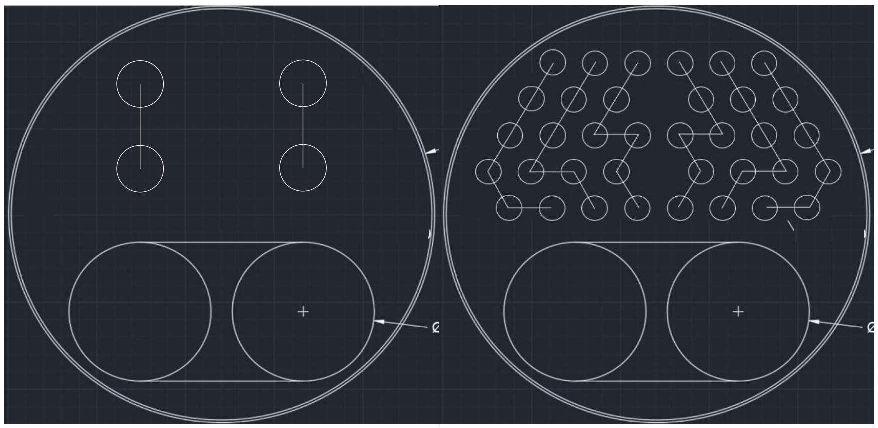
$$\text{Heat Density} = \frac{\text{Firetube Rating (BTU/hr)}}{(\text{Cross Sectional Area, in.}^2)\ (\text{Efficiency})}$$

Also, per API 12K, firetube average heat flux should range between 10,000 and 12,000 BTU/hr/ft2 for glycol/water bath heaters so using another equation we can calculate the overall square footage of firetube surface area needed. This value in conjunction with the diameter calculated above will indicate an overall length of pipe (remember that it's a U-tube though).

$$\text{Average Heat Flux} = \frac{\text{Firetube Rating (BTU/hr)}}{\text{ft}^2 \text{ of Firetube Surface}}$$

# HEATER SPECIFICATION

Typically, with an indirect fired bath heater, the fire tube will not have any issue with heating the bath and the limiting heat transfer element will be between the bath fluid and the process coil. Below shows how even a heater with sufficient capacity can fail to perform as desired.



Using the equations on this slide in conjunction with the graph will give you the required heat transfer area for the application. Select an appropriate size for a single coil and make sure to use multiple paths if needed, then do multiple passes to achieve the area needed. This coil and the firetube calculated on the previous slide should give you an indication of the heater length and diameter.

$$A_S = \frac{Q}{U_0 \times T_{lm}} \qquad T_{lm} = \frac{\Delta T_{in} - \Delta T_{out}}{\ln\left(\Delta T_{in} \div \Delta T_{out}\right)}$$

$A_s = Total\ Heat\ Transfer\ Area\ (ft^2)$

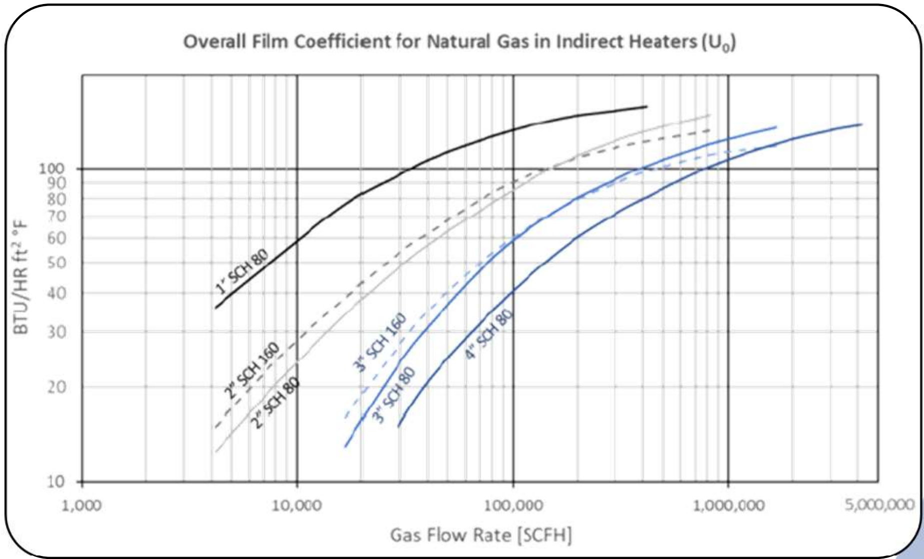
$Q = Heat\ Required\ (BTU/hr)$

$U_0 = Heat\ Transfer\ Coeff.\ (BTU/hr \times ft^2 \times °F)$

$T_{lm} = Log\ Mean\ Temperature\ Difference\ (°F)$

$\Delta T_{in} = Bath\ Temp - Inlet\ Gas\ Temp, (°F)$

$\Delta T_{out} = Bath\ Temp - Outlet\ Gas\ Temp, (°F)$

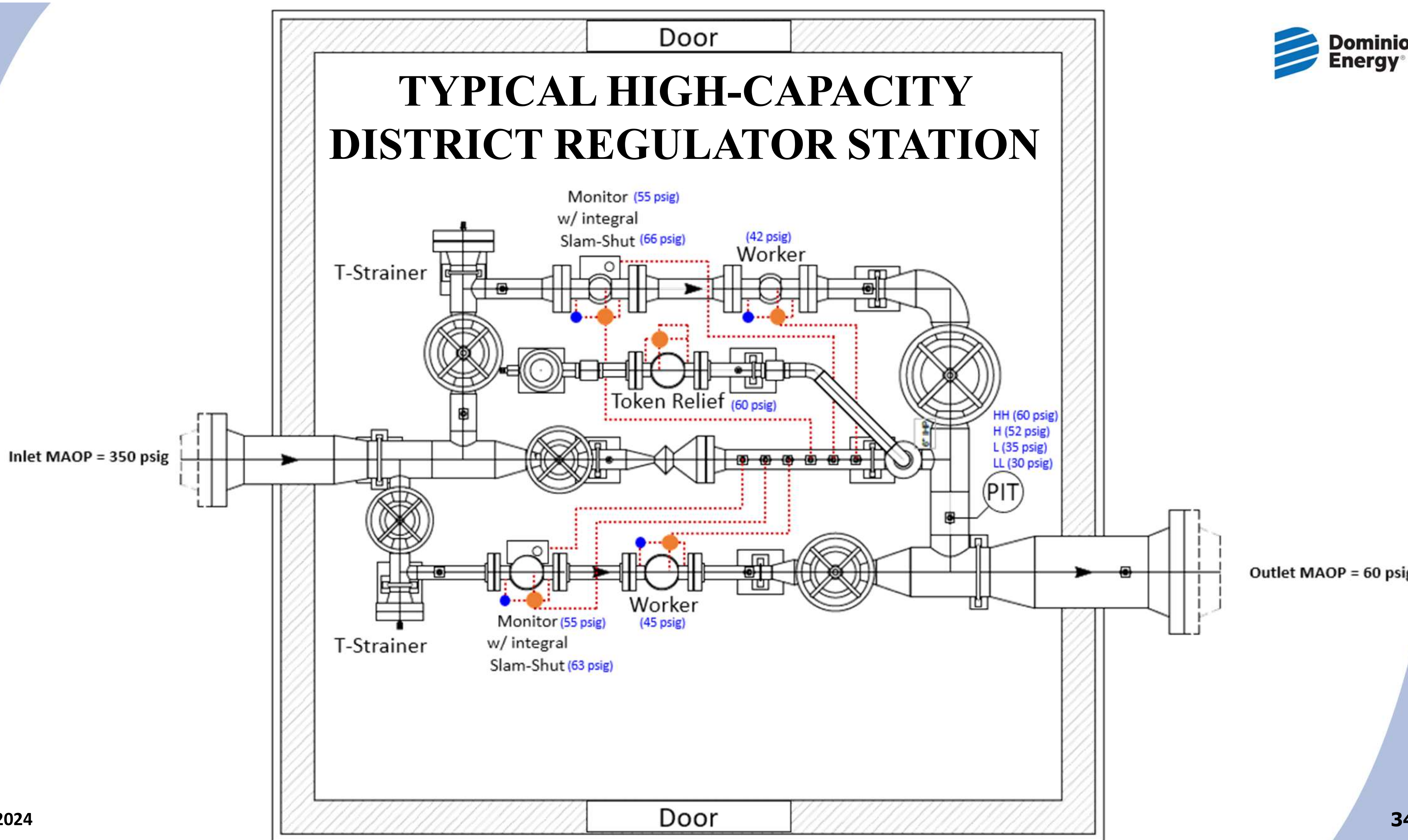


# OMITTED SPECIFICATIONS

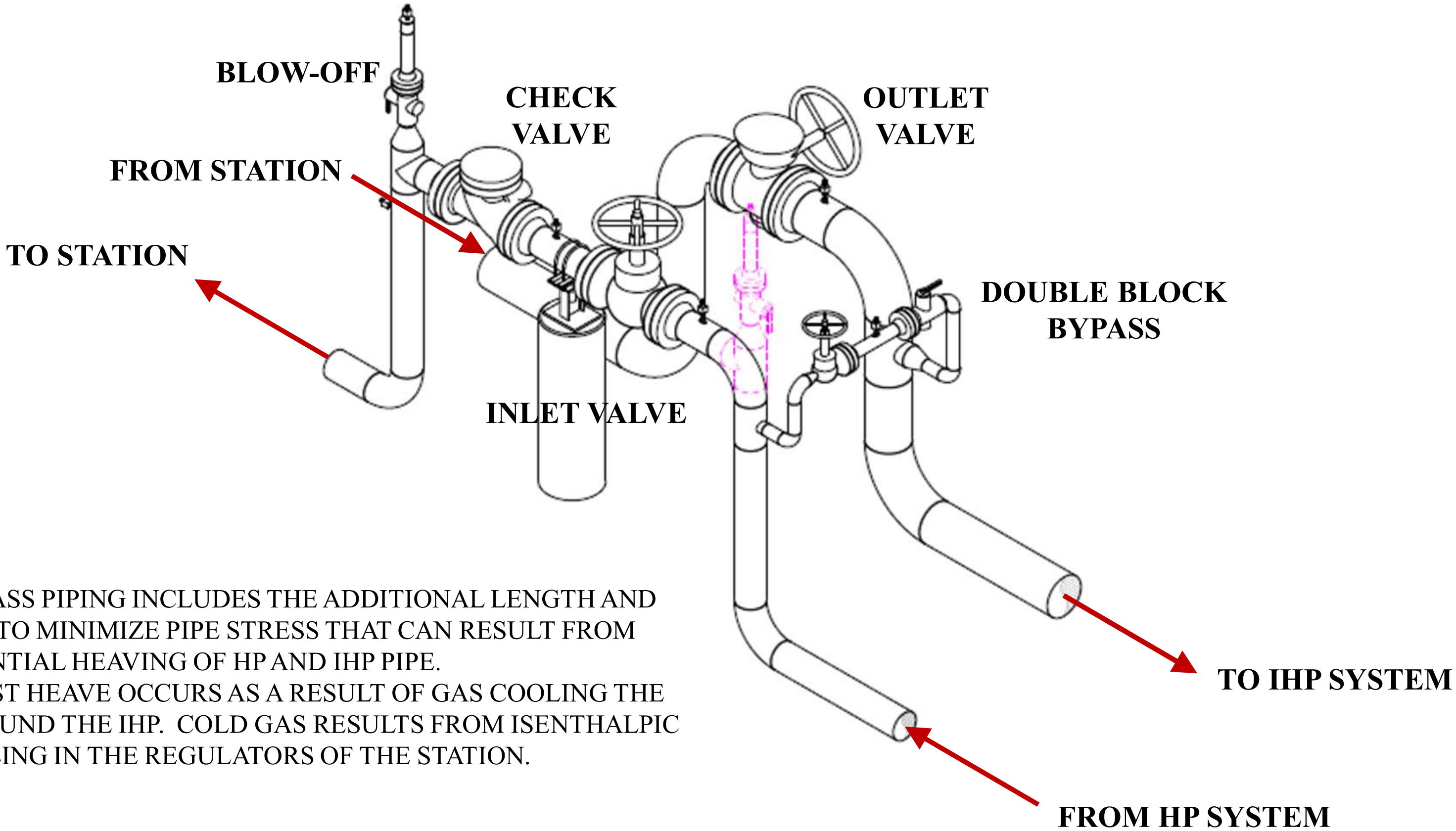
Dominion Energy

- Odorizers
- Buildings and Enclosures
- Sensors and Transmitters
- RTUs and PLCs
- Communication Equipment
- Temperature and Pressure correctors

# TYPICAL HIGH-CAPACITY DISTRICT REGULATOR STATION



# TYPICAL DISTRICT REGULATOR STATION EMERGENCY VALVES (BYPASS ASSEMBLY)

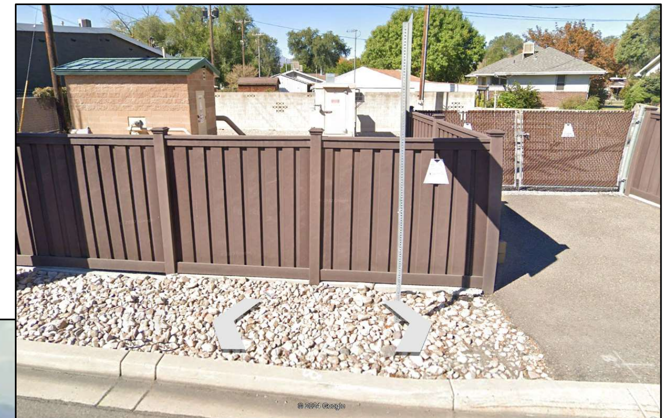



THE BYPASS PIPING INCLUDES THE ADDITIONAL LENGTH AND ELBOWS TO MINIMIZE PIPE STRESS THAT CAN RESULT FROM DIFFERENTIAL HEAVING OF HP AND IHP PIPE.
THE FROST HEAVE OCCURS AS A RESULT OF GAS COOLING THE SOIL AROUND THE IHP. COLD GAS RESULTS FROM ISENTHALPIC THROTTLING IN THE REGULATORS OF THE STATION.

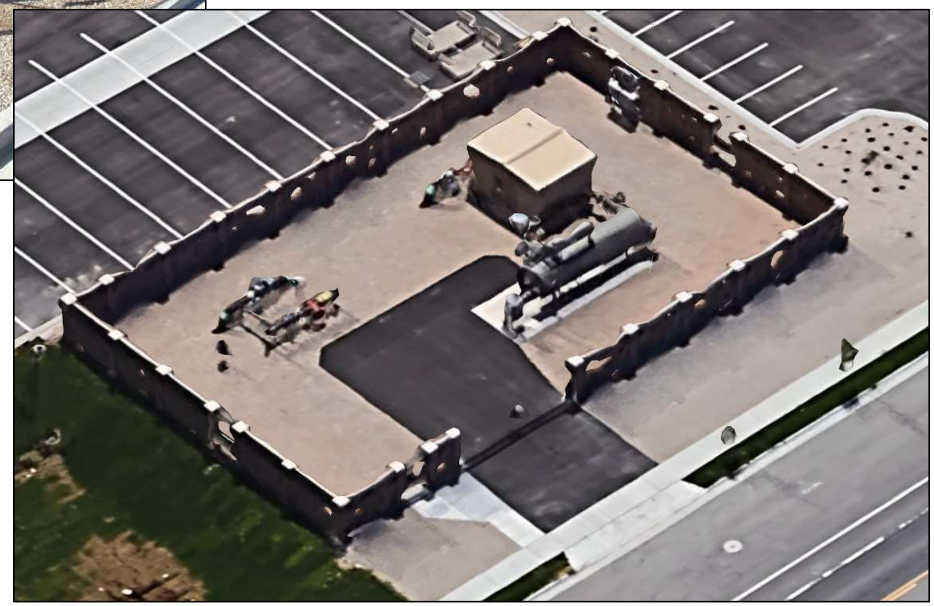
# OLD STATION EXPERIENCING FROST HEAVE OF BYPASS

Dominion Energy

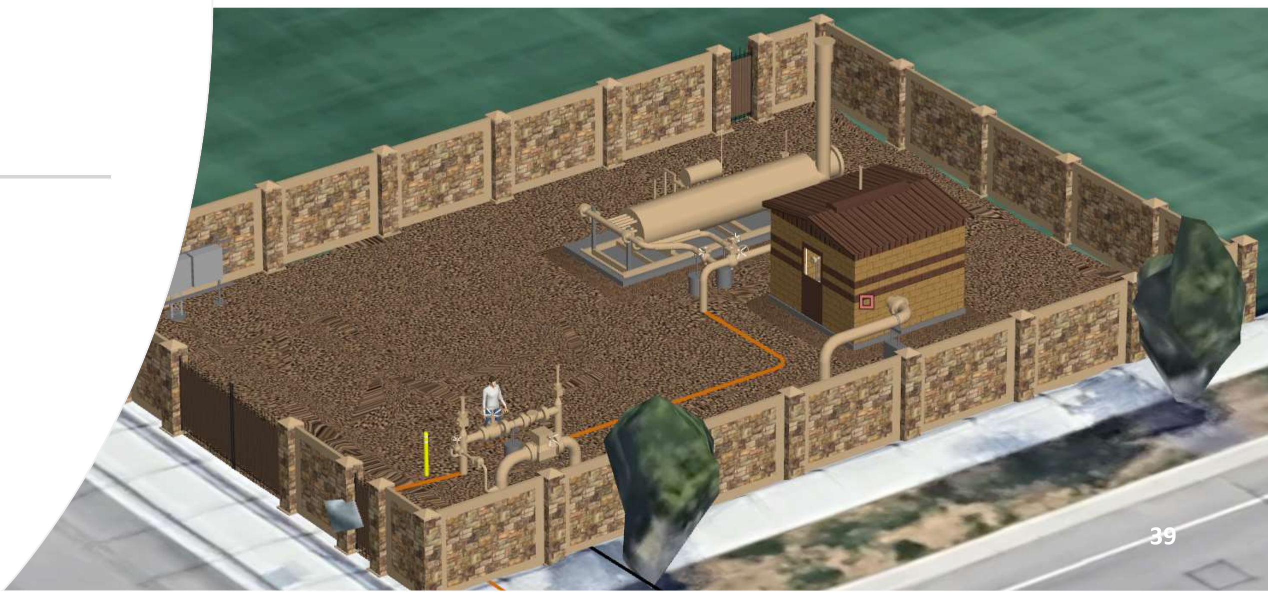
# EXISTING STATION PHOTOS



# EXISTING STATION PHOTOS



# SAME PROPOSED SITE WITH A DIFFERENT ASTHETIC

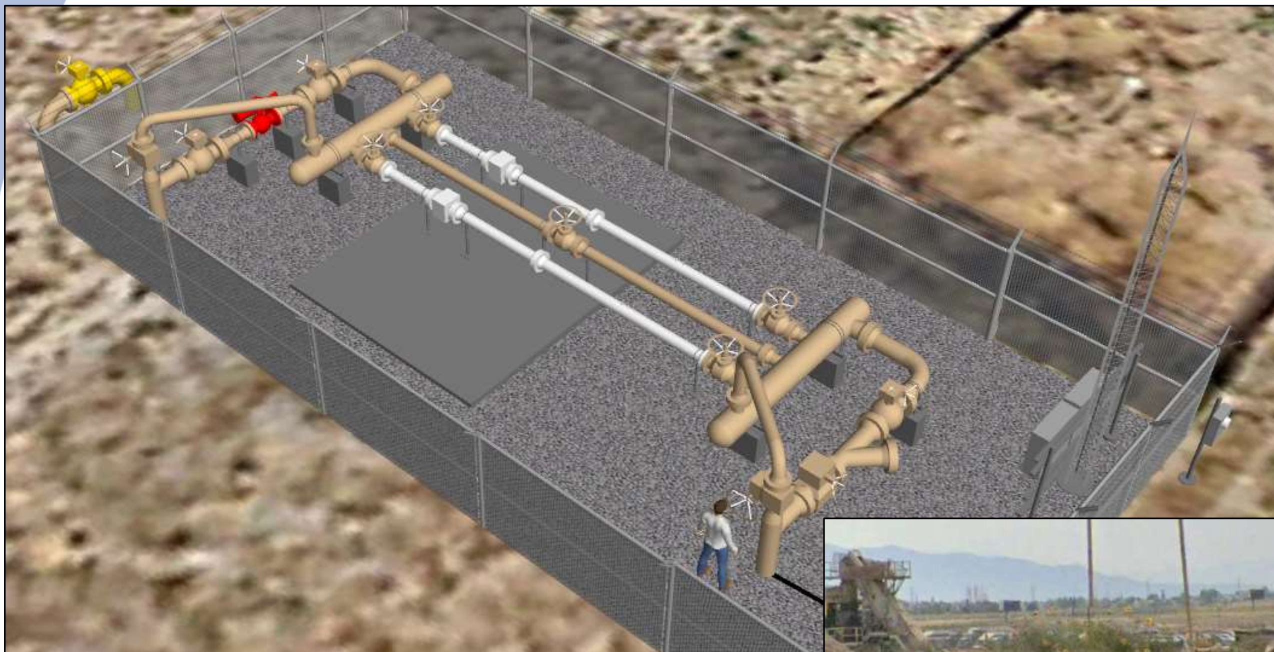
# INDUSTRIAL METER-SET PHOTOS

Dominion Energy

**TOP LEFT PHOTO WAS A METER SET THAT HAD TO BE RELOCATED DUE TO THE WIDENED ROAD. THE RIGHT PHOTO IS THE METER SET THAT REPLACED IT.**

# INDUSTRIAL METER-SET PHOTOS

Dominion Energy



# THANK YOU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