Introduction to Regulator and Relief Valve Sizing

Western Gas Measurement Short Course 2026

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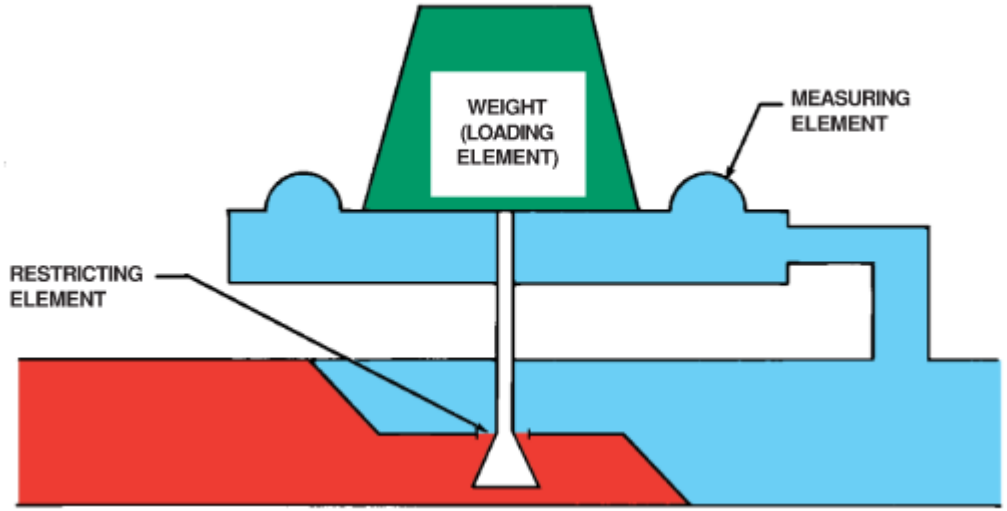
Regulator Basics

What is a Regulator?

- Natural gas regulators provide a means of control over the flow of gas supply to downstream processes or customers
- A regulator is used to maintain flow of gas at a constant downstream pressure (P_2)
- Pressure Reducing Regulators
- Direct-operated vs. Pilot-operated

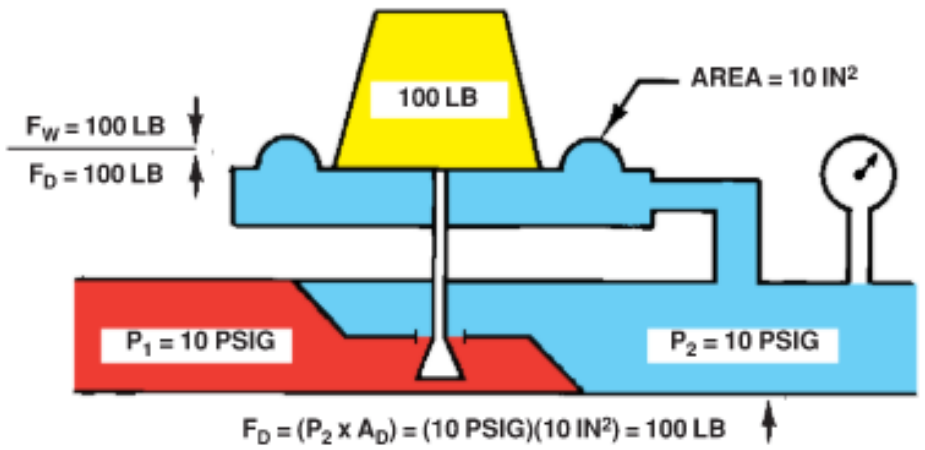
Basic Regulator Components

- Restricting Element
- Measuring Element
- Loading Element

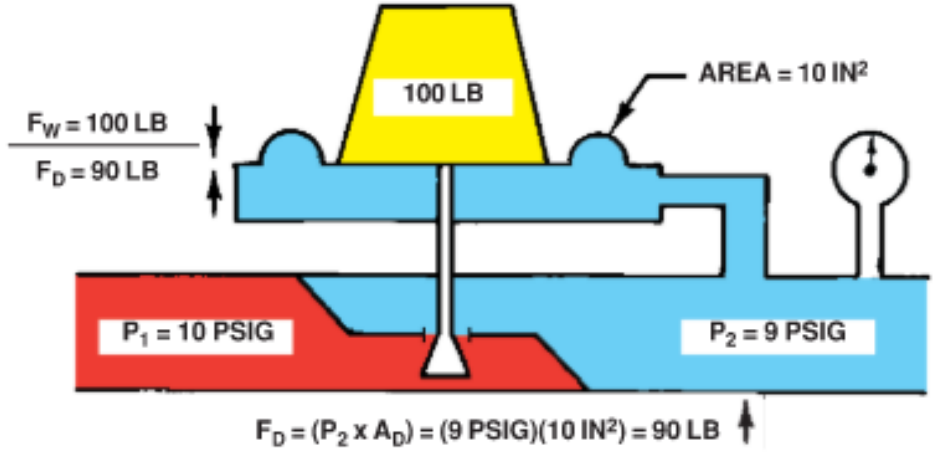


Regulator Operation (Direct-operated)

Equilibrium

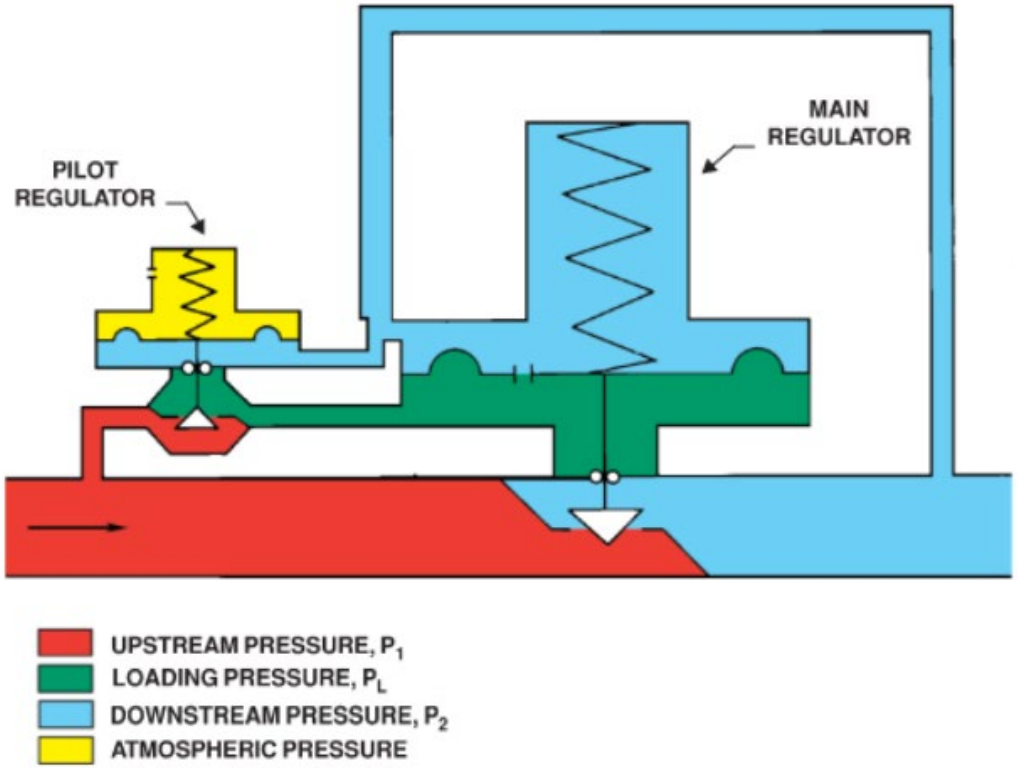


Increase in Downstream Demand

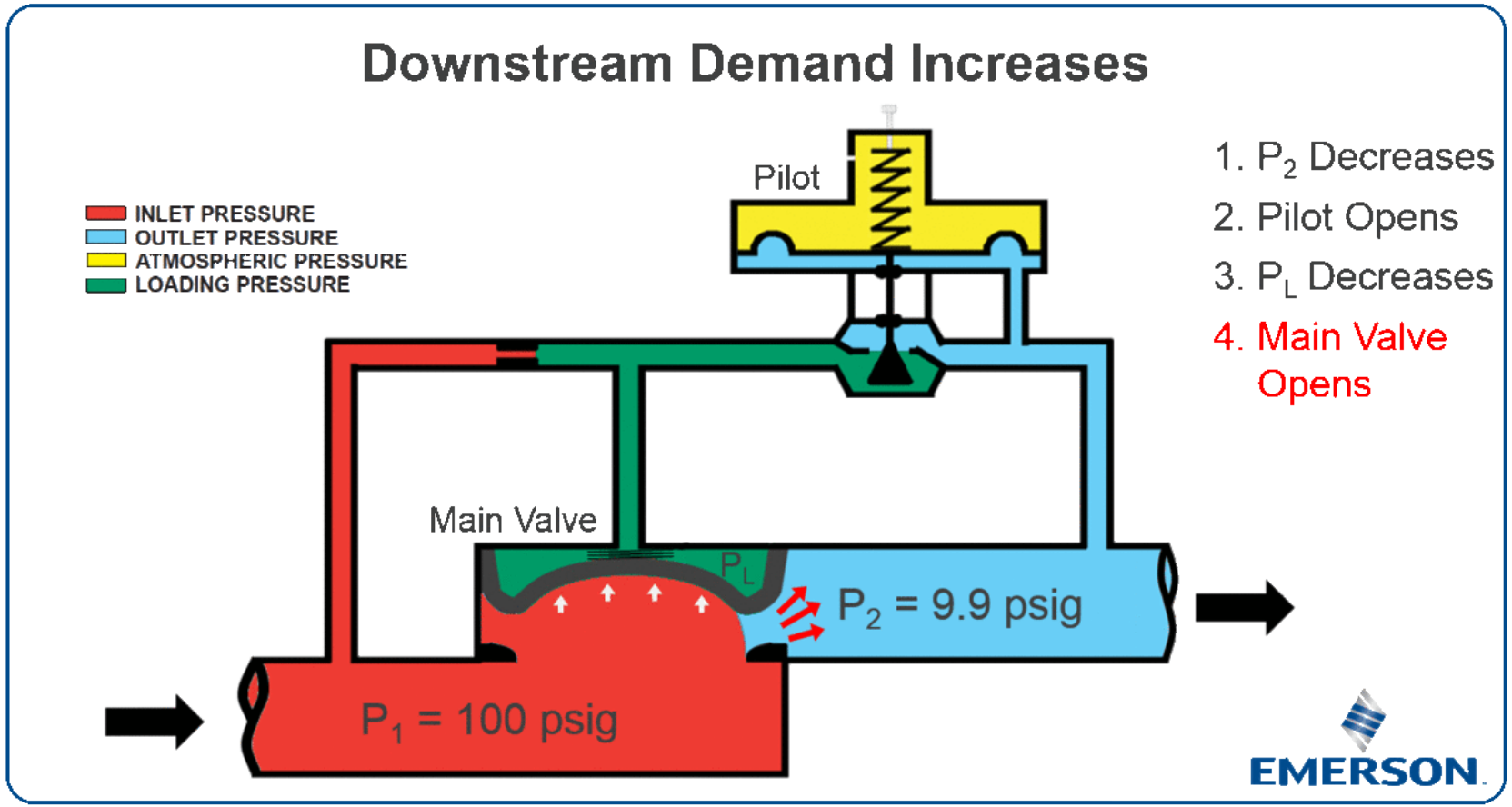


Pilot-Operated Regulators

- Improved accuracy, capacity, and sensitivity
- Two regulators connected together
- Senses P_2 and changes P_L
- Pilot Gain
- Pilot-loading vs. Pilot-unloading

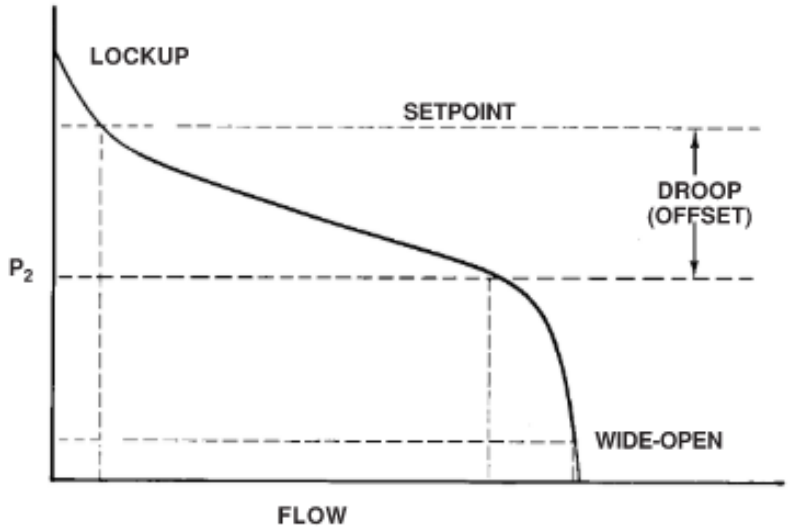


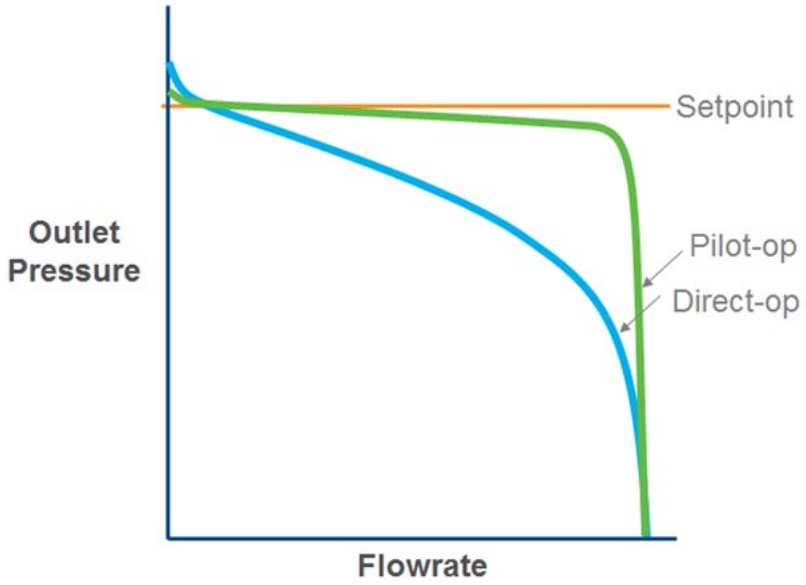
Pilot-unloading regulator



Regulator Performance and Terminology

- Setpoint
- Droop
- Accuracy
- Lock Up



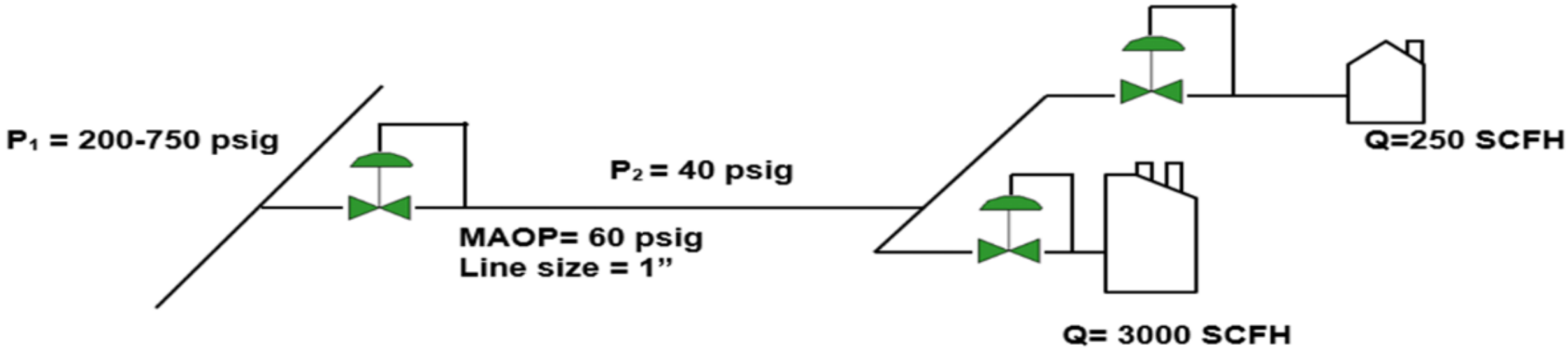


Selecting and Sizing

Regulators

Example Scenario

Below is a schematic for a pressure reduction application from a high-pressure line (P_1) to an intermediate pressure line (P_2) serving a local farm operation with a load for the farmhouse and some commercial dryers.



What information do we need?

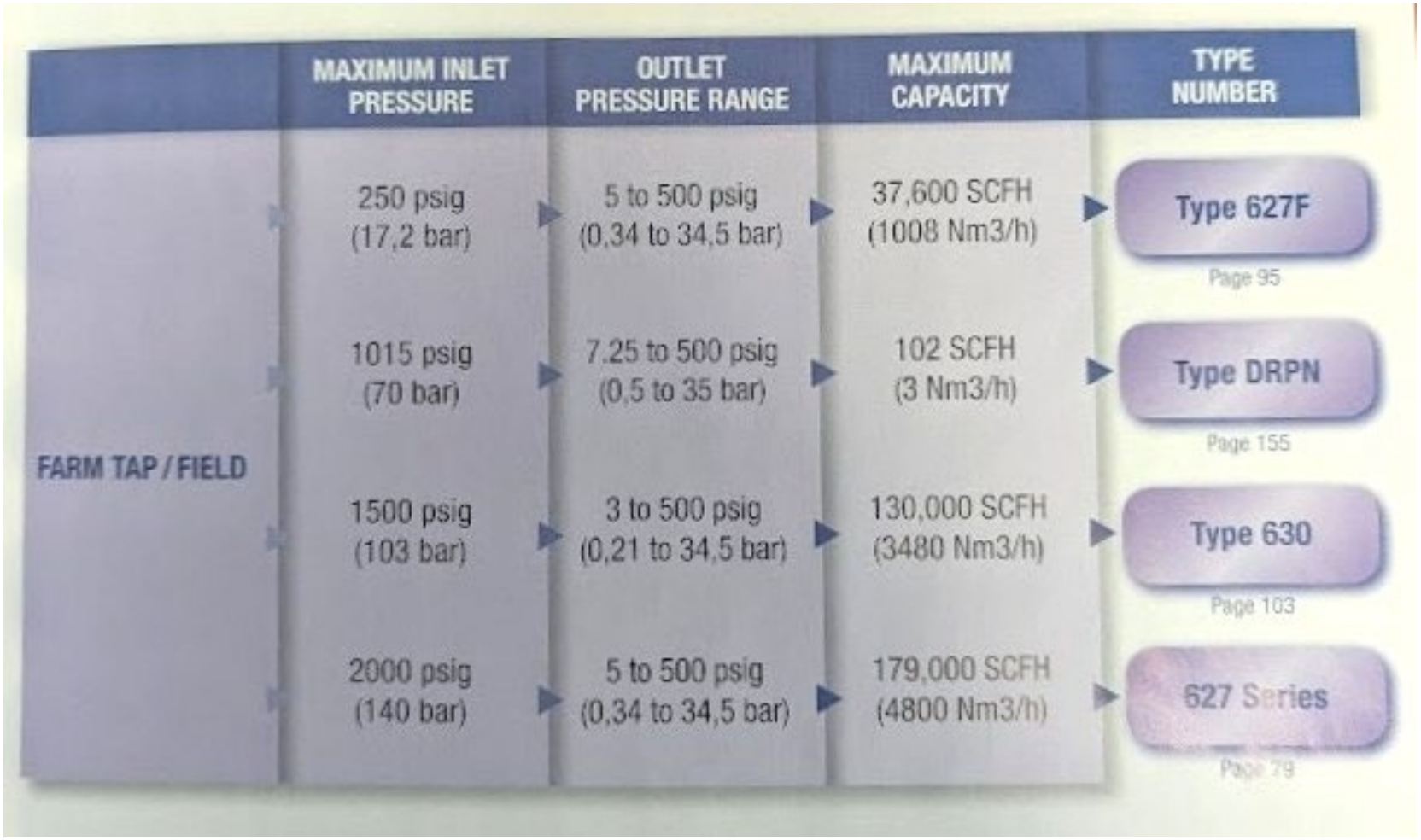
- P_1 = Inlet Pressure (min. and max.)
- P_2 = Regulator Setpoint
- Q = Flow Rate, scfh
- T = Temperature of Gas
- SG = Specific Gravity
- Line/Pipe Size
- Material Specifications
- Accuracy Requirements (Droop)

- P_1 = 200-750 psig
- P_2 = 40 psig
- Q = 3250 scfh
- T = 60 F
- SG = 0.6 for Natural Gas
- 1” Pipe

Options for Selecting

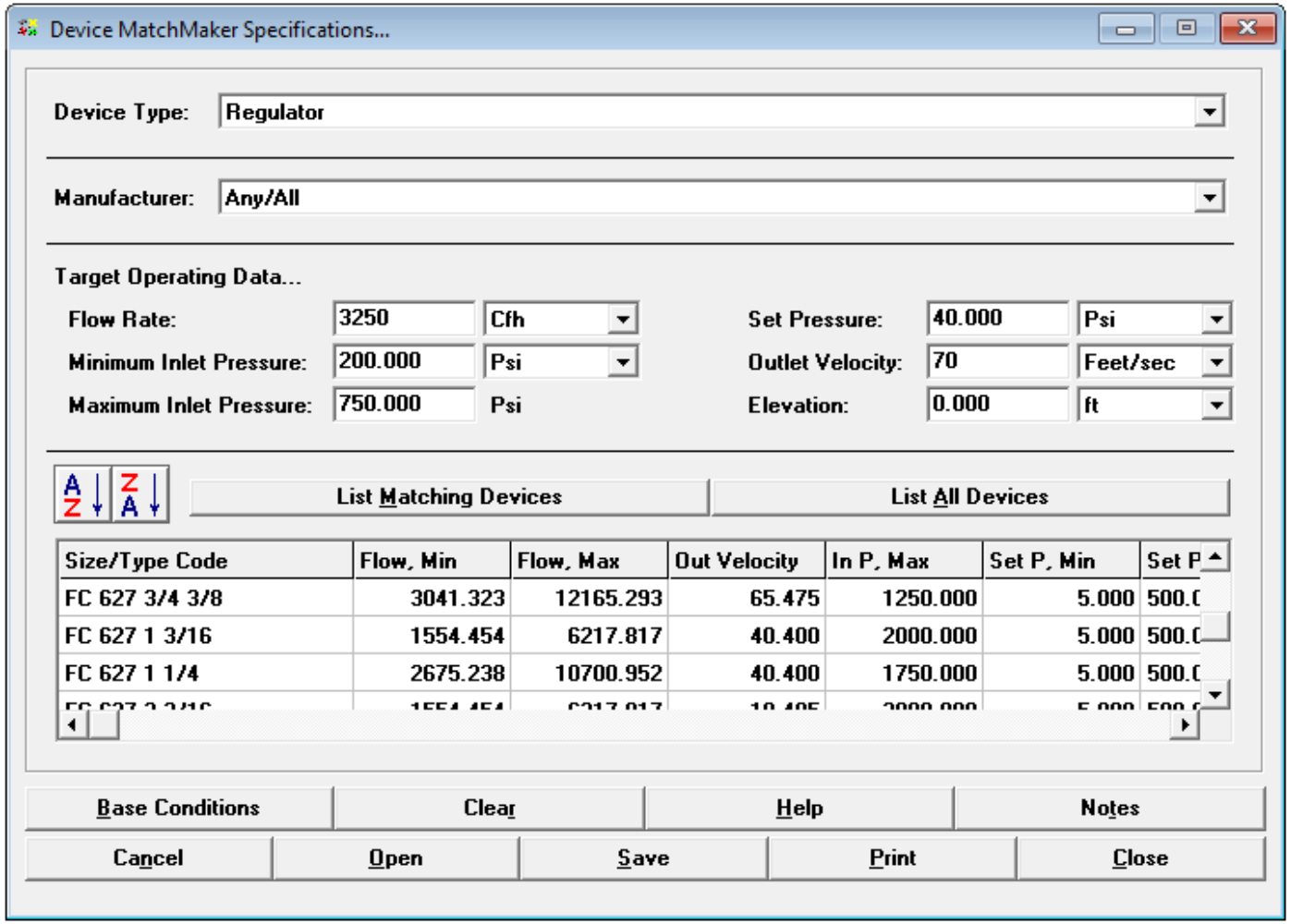
- Manufacturers' Quick Selection Guides
- Selection Wizards / Online Tools
- Manufacturers' Flow Coefficients
- Manufacturers' Published Capacity Tables

Quick Selection Guides



Wizards / Online Tools

- GASCalc
- Fisher Regulator Toolkit
- Other Manufacturer website



Flow Coefficients

Universal Sizing Equation

$$Q_{scfh} = \sqrt{\frac{520}{GT}}\, C_g P_1 \, SIN\left[\left(\frac{3417}{C_1}\right)\sqrt{\frac{\Delta P}{P_1}}\right] Deg.$$

Flow Coefficients

C_g = Gas Sizing Coeff

C_v = Liquid Sizing Coeff

$$C_1 = C_g/C_v$$

G = Specific Gravity = 0.6

T = Temp F = 60

P_1 = 200 psig

ΔP = 200-40 = 160 psig

Table 16. *Flow Coefficients*

ORIFICE SIZE, IN. / mm	NPS 3/4 / DN 20 BODY			NPS 1 / DN 25 BODY		
	Wide-Open C_g for External Relief Sizing	Wide-Open C_v for External Relief Sizing	C_1	Wide-Open C_g for External Relief Sizing	Wide-Open C_v for External Relief Sizing	C_1
3/32 / 2.4	6.9	0.24	29.2	6.9	0.24	28.5
1/8 / 3.2	12.5	0.43	29.1	12.5	0.43	29.4
3/16 / 4.8	29	1.01	28.6	29	0.93	31.2
1/4 / 6.4	50	1.63	30.6	50	1.71	29.3
3/8 / 9.5	108	2.99	36.1	108	3.42	31.6
1/2 / 13	190	4.87	39.0	190	5.29	35.9
9/16 / 14.3	----	----	----	211.6	5.6	37.8

$$Q = \sqrt{\frac{520}{0.6(520)}}\,(12.5)(200)\,\sin\left(\left(\frac{3417}{29.4}\right)\sqrt{\frac{160}{200}}\right)$$

$$Q = 3132\ scfh$$

Published Capacity Tables

Table 7. *Types 627, 627M, 627MR, 627BM, 627BMR, 627OSX and 627BMOSX Capacities for NPS 1 / DN 25 Body Size*[1][4]

OUTLET PRESSURE RANGE, SPRING PART NUMBER AND COLOR CODE	OUTLET PRESSURE SETTING[2], psig / barg	INLET PRESSURE, psig / barg	CAPACITIES IN SCFH / Nm³/h OF 0.6 SPECIFIC GRAVITY NATURAL GAS						
			Orifice Size, In. / mm						
			For All Types Except Types 627BM and 627BMR						For Types 627BM and 627BMR only
			3/32 / 2.4	1/8 / 3.2	3/16 / 4.8	1/4 / 6.4	3/8 / 9.5	1/2 / 13	9/16 / 14.3
15 to 40 psig / 1.0 to 2.8 barg 10B3077X012 Green	40 / 2.8	60 / 4.1	610 / 16.3	1090 / 29.2	2530 / 67.8	4510 / 121	9290 / 249	9420 / 252	14,400 / 386
		75 / 5.2	760 / 20.4	1370 / 36.7	3080 / 82.5	5640 / 151	10,800 / 289	16,500 / 442	18,800 / 504
		100 / 6.9	990 / 26.5	1790 / 48.0	4070 / 109	7310 / 196	14,700 / 394	21,900 / 587	26,000 / 697
		150 / 10.3	1420 / 38.1	2580 / 69.1	5850 / 157	10,500 / 281	20,500 / 549	34,500 / 925	40,500 / 1085
		200 / 13.8	1850 / 49.6	3370 / 90.3	7630 / 204	13,700 / 367	27,100 / 726	46,400 / 1244	48,100 / 1289
		300 / 20.7	2700 / 72.4	4910 / 132	11,200 / 300	20,100 / 539	40,100 / 1075	67,100 / 1798	63,400 / 1698
		500 / 34.5	4400 / 118	8090 / 217	18,300 / 490	32,900 / 882	63,900 / 1713		66,800 / 1790
		750 / 51.7	6600 / 177	12,000 / 322	27,200 / 729	39,400 / 1056			69,000 / 1849
		1000 / 69.0	8700 / 233	16,000 / 429	36,100 / 967				71,100 / 1905
		1250 / 86.2	11,000 / 295	19,000 / 509					71,500 / 1915
		1500 / 103	13,000 / 348	22,000 / 590					71,900 / 1926
		1750 / 121	15,000 / 402						
		2000 / 138	17,000 / 456						

Other Installation Considerations

- Inflow / Outflow Conditions (straight pipe requirements)
- External Sensing Lines
- Regulator Venting
- Oversizing

Overpressure Protection Basics

Federal Guidelines

- Regulators are designed to maintain downstream pressure over a range of possible flow rates. However, in the event of a regulator failure, the downstream system could be subject to pressure which it is not designed for. In order to prevent this, there are several forms of overpressure protection that should be installed

- Natural gas safety codes and state/federal regulations require overpressure protection whenever a pressure reducing station is installed with the downstream system having a lower MAOP (Maximum Allowable Operating Pressure) than the upstream system.

- PHMSA Part 192

Federal Guidelines Cont.

MAOP	Allowable Overpressure
≥ 60psi	MAOP + 10% or 75% of the Specified Min Yield Strength (SMYS) which ever is less
≥ 12psi and < 60psig	MAOP + 6psi
< 12psi	MAOP + 50%
Low Pressure	Prevent unsafe operation of any appliance

Types of Overpressure Protection

- **Relief Valves**
- Monitors
- Series Regulation
- Shutoff

Relief Valves Basics

- A relief valve is a device the vents gas to the atmosphere to maintain downstream pressure at or below the MAOP
- Operate under similar principles as regulators

Advantages

- Not subject to line blockage
- No effect of regulator capacity
- Produce sound and smell as alarm

Disadvantages

- Vent gas to atmosphere
- Careful sizing considerations

Types of Relief Valves

- Pop type
- Direct-operated
- Pilot-operated
- Internal Relief (IRV)

H200 Series Pop Type

Type 289 Direct-Operated

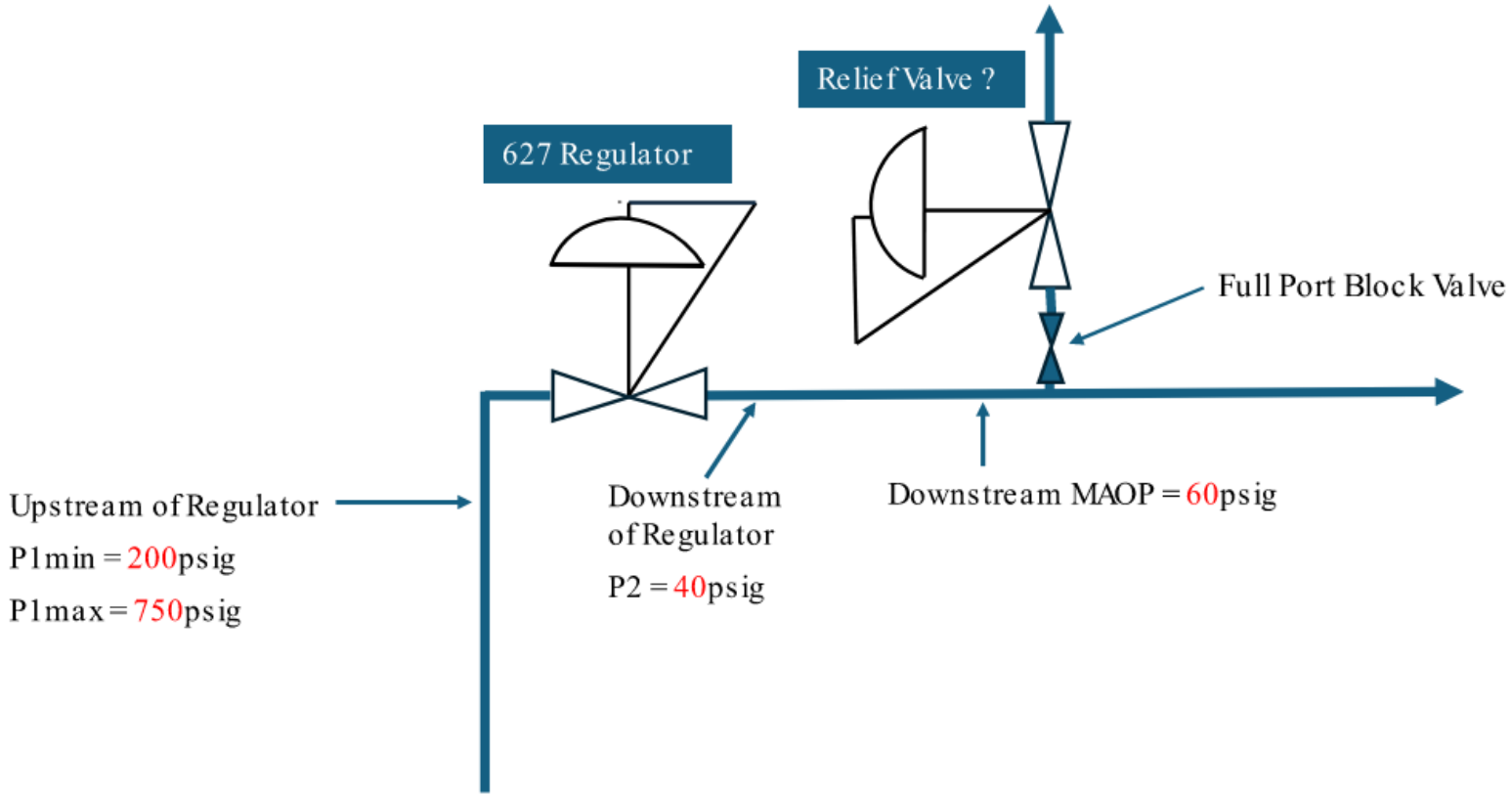
Type 289P-6358 Pilot-Operated

Type 627 with Internal Relief

Selecting and Sizing

Relief Valves

Example Scenario



What information do we need?

- P_1 = Inlet Pressure (max.)
- Q_{max} = Regulator wide-open capacity
- MAOP (Max Allowable Operating Pressure)

In order to protect against the worst-case scenario, we will assume the regulator has failed wide-open at the maximum inlet pressure.

Calculating Regulator Failure Flow

- Need C_1 (29.4) or C_g (12.5) for given regulator
- P_1 = 750 psig, P_2 = 40 psig

❑ **Non-Critical (Sub Sonic) flow** $\frac{P_{1,abs}}{P_{2,abs}} \leq 1.814$

Use Equation: $Q = \frac{\sqrt{1}}{SG} \times P_{inlet} \times sin\left[\left(\frac{3417}{C_1}\right) \times \sqrt{\frac{P_{inlet} - P_{outlet}}{P_{inlet}}}\right] \text{deg}$

❑ **Critical (Sonic) Flow** $\frac{P_{1,abs}}{P_{2,abs}} \geq 1.814$

Use Equation: $Q = 1.291 \times C_g \times P_{inlet\,(max),abs}$

Rule of thumb: If the $P_{2,abs}$ pressure is less than ½ of the $P_{1,abs}$ pressure you can use the Critical (Sonic) flow equation.

Q = 1.291 x 12.5 x (750+14.7)

= 12.3 MCFH

What information do we need?

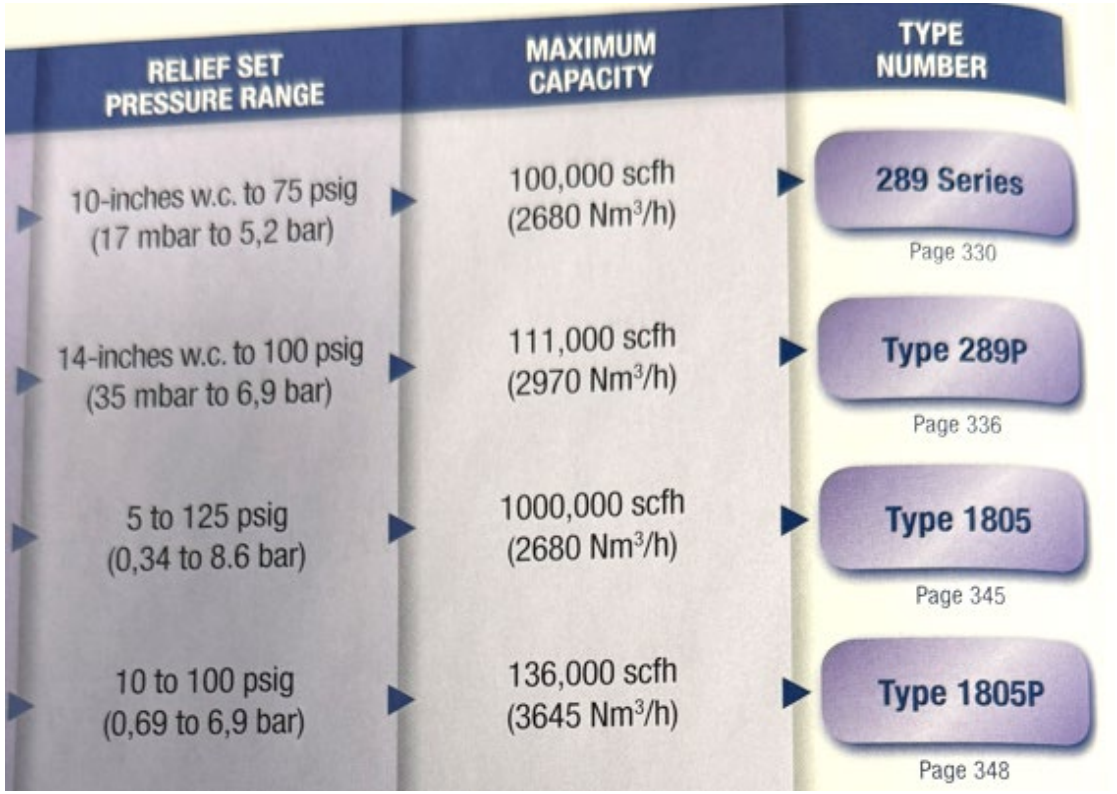
- P_1 = Inlet Pressure (max.)
- Q_{max} = Regulator wide-open capacity
- MAOP (Max Allowable Operating Pressure)

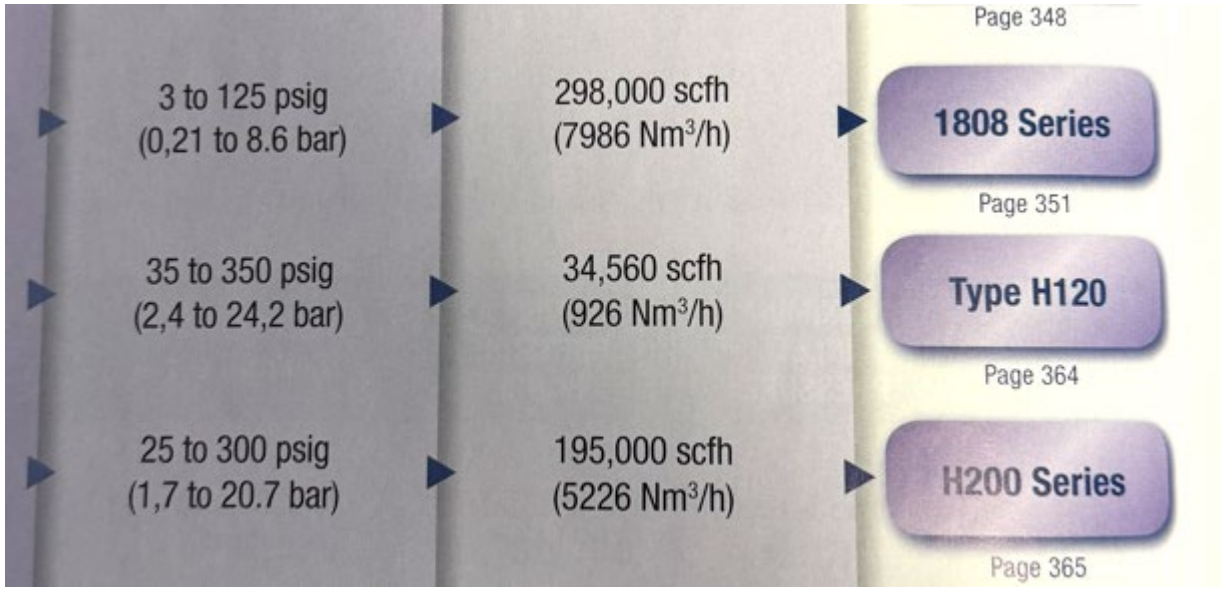
- P_1 = 750 psig
- Q_{max} = 12.3 MCFH
- MAOP = 60 psig

Options for Selecting

- Manufacturers' Quick Selection Guides
- Selection Wizards / Online Tools
- Manufacturers' Flow Coefficients
- Manufacturers' Published Capacity Tables / Charts

Quick Selection Guide





Wizards / Online Tools

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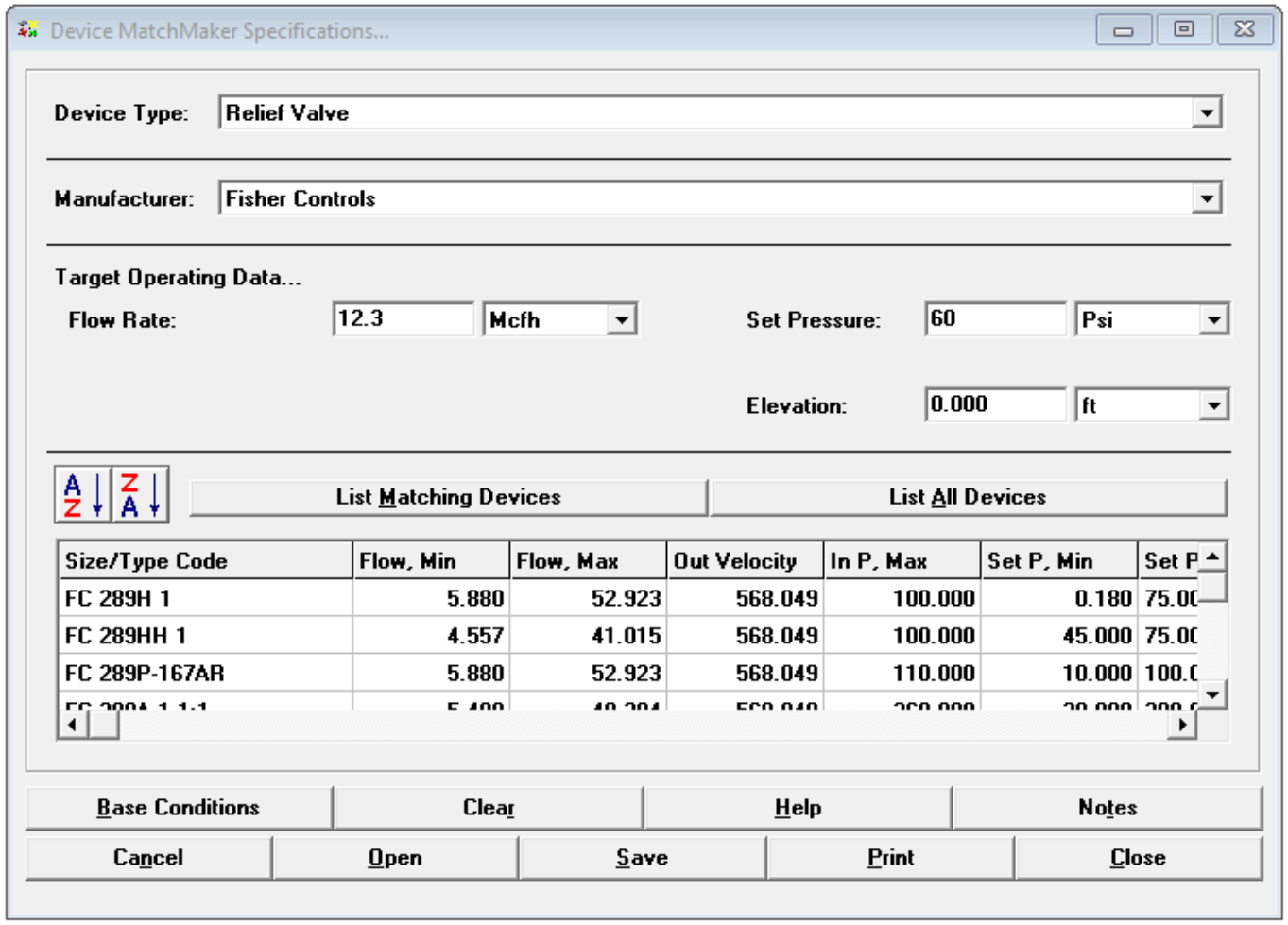
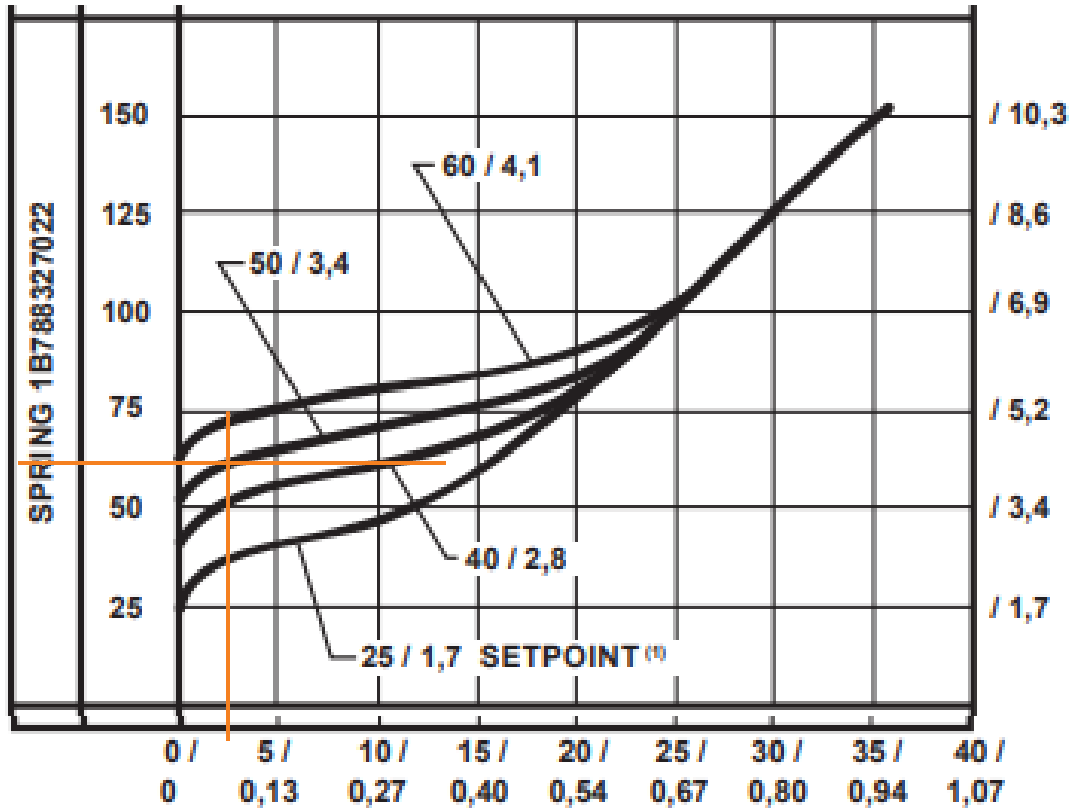


Capacity Chart – 1805

- 1805-2, 1” NPT
- Required flow = 12.3 MCFH
- Set point = 50 psig
- MAOP = 60 psig

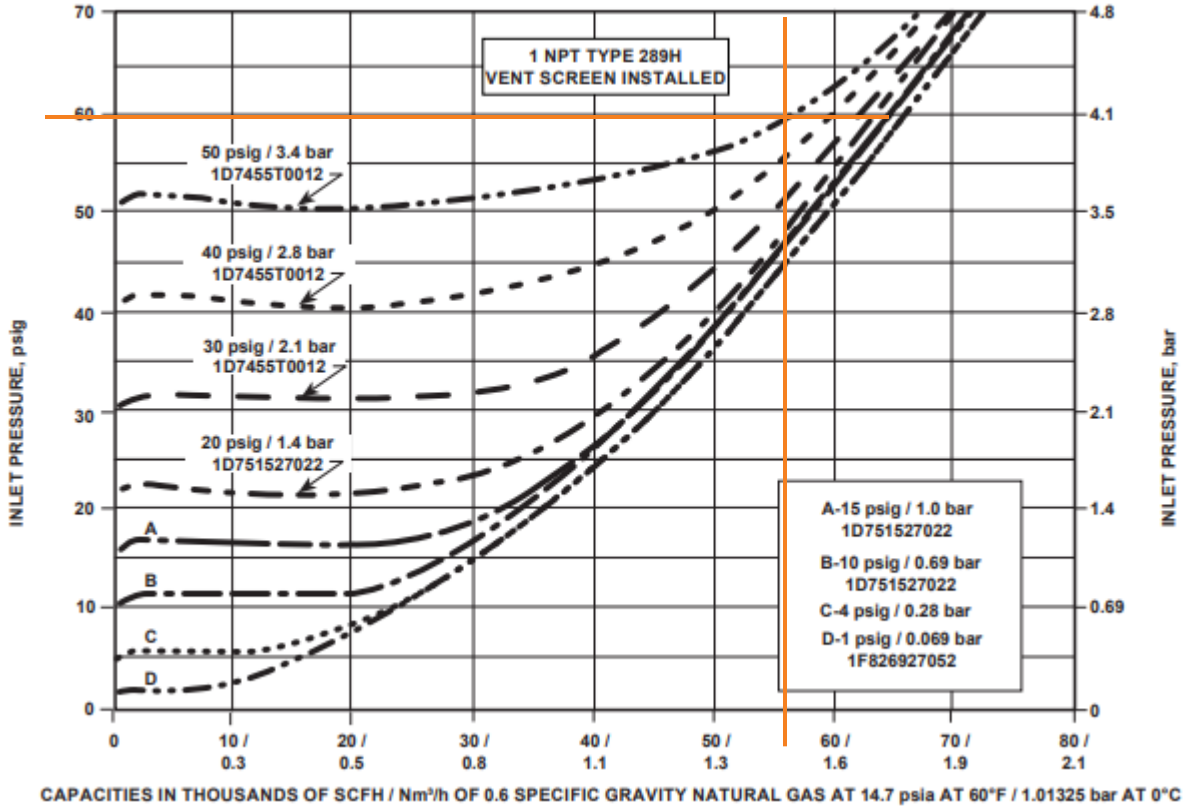
BODY SIZE	RELIEF PRESSURE RANGE		SPRING PART NUMBER
	psig	bar	
3/4 or 1 NPT	5 to 35 10 to 60 20 to 125	0.34 to 2.4 0.69 to 4.1 1.4 to 8.6	1B986027212 1B788327022 1B788427022
1-1/2 or 2 NPT	5 to 20 10 to 50 35 to 125	0.34 to 1.4 0.69 to 3.5 2.4 to 8.6	1D892327022 1D665927022 1E543627142



- Relief Capacity = approx. 2.5 MCFH
- Not enough capacity

Capacity Chart – 289H

- 289H, 1” NPT
- Required flow = 12.3 MCFH
- Set point = 50 psig
- MAOP = 60 psig

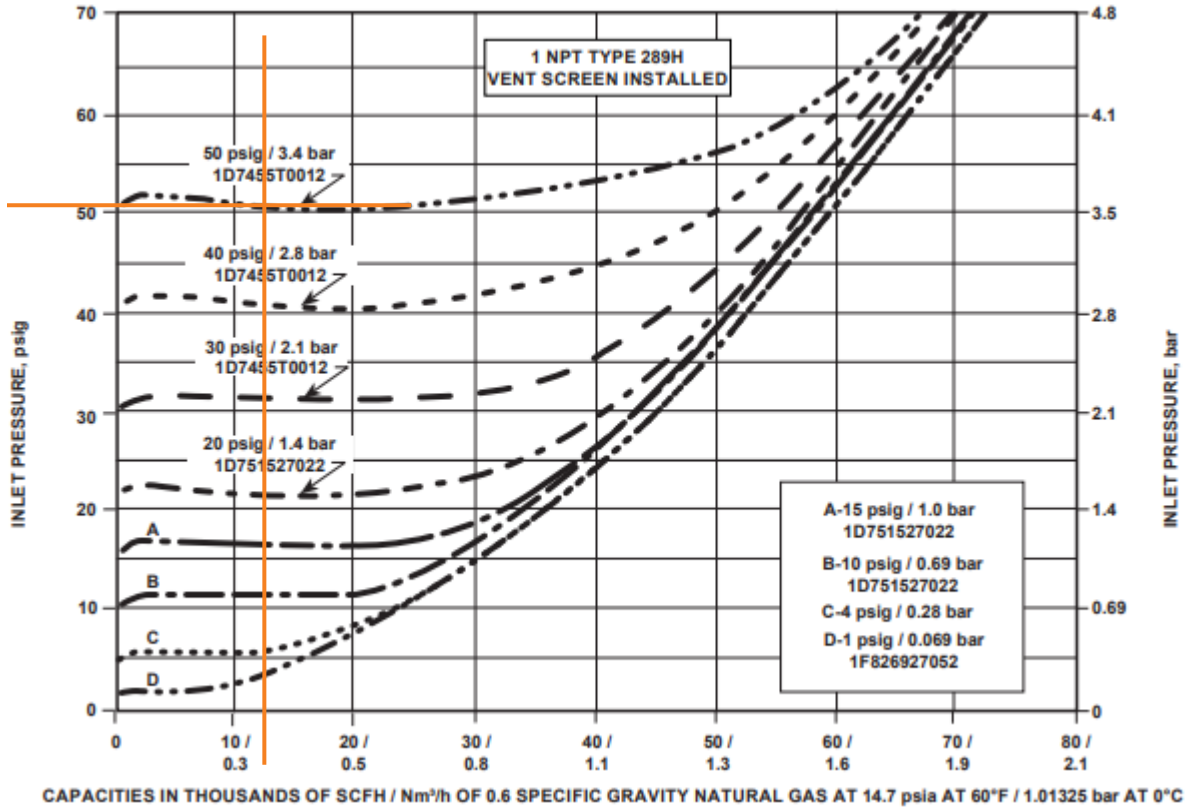


- Relief Capacity = approx. 56 MCFH
- Enough Capacity

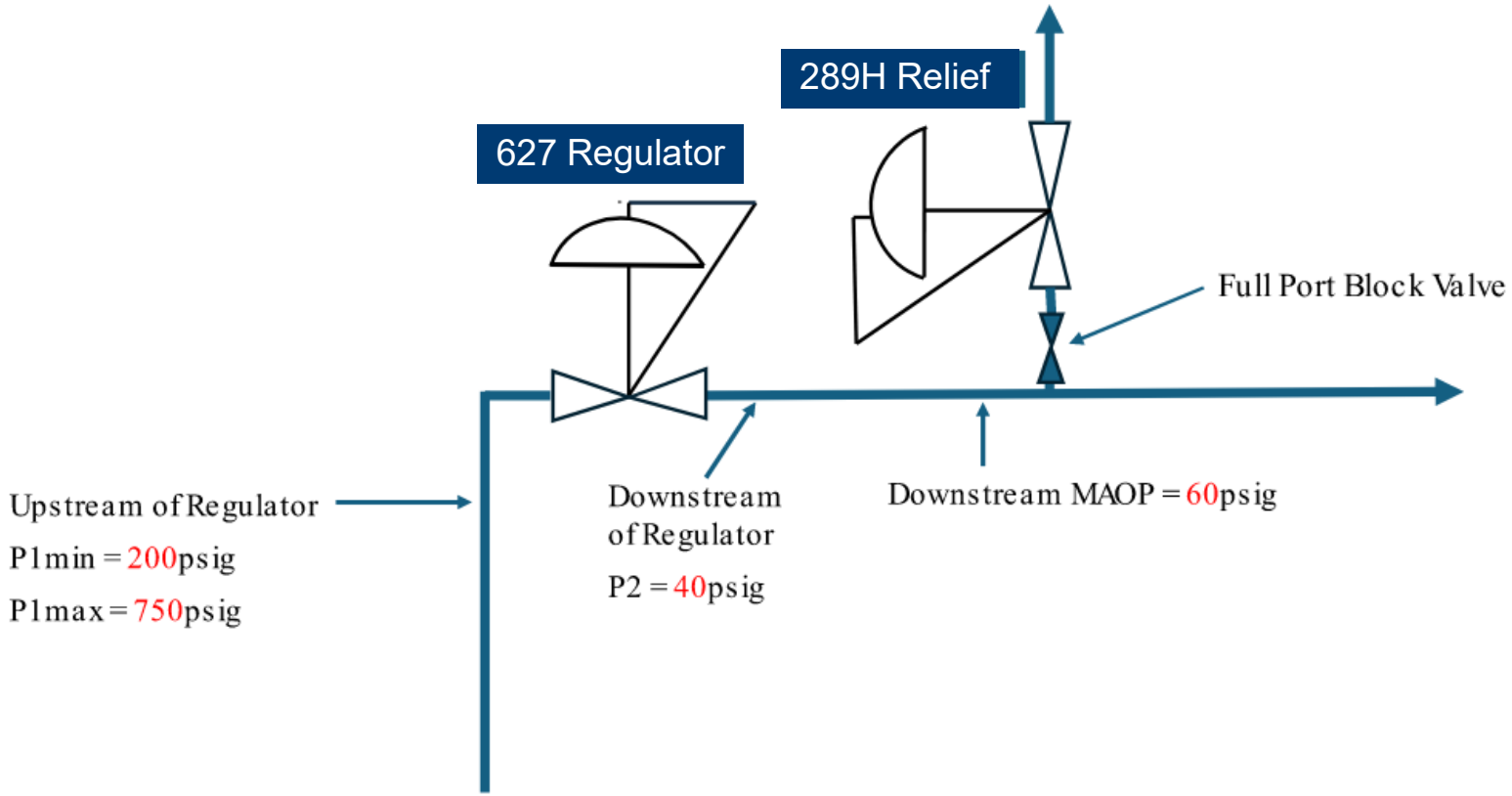
Check Downstream Pressure

Table 1. *Maximum Allowable Relief (Inlet) Pressure*

AVAILABLE CONFIGURATION	BODY SIZE, NPT	SPRING PART NUMBER	MAXIMUM ALLOWABLE RELIEF (INLET) PRESSURE[1]	
			psig	bar
Type 289A	1/4	0Z056327022 1B268227022	45	3.1
Type 289H	1	1F826927052 1D892327022 1D751527022 1D7455T0012	100	6.9
	2	1B536527052 1B536627052 1B536827062 1B536927052	25	1.7
Type 289HH	1	1D7455T0012	100	6.9



Final Design



Q&A

Thank you!