



Introduction to Regulator and Relief Valve Sizing

Western Gas Measurement Short Course 2026

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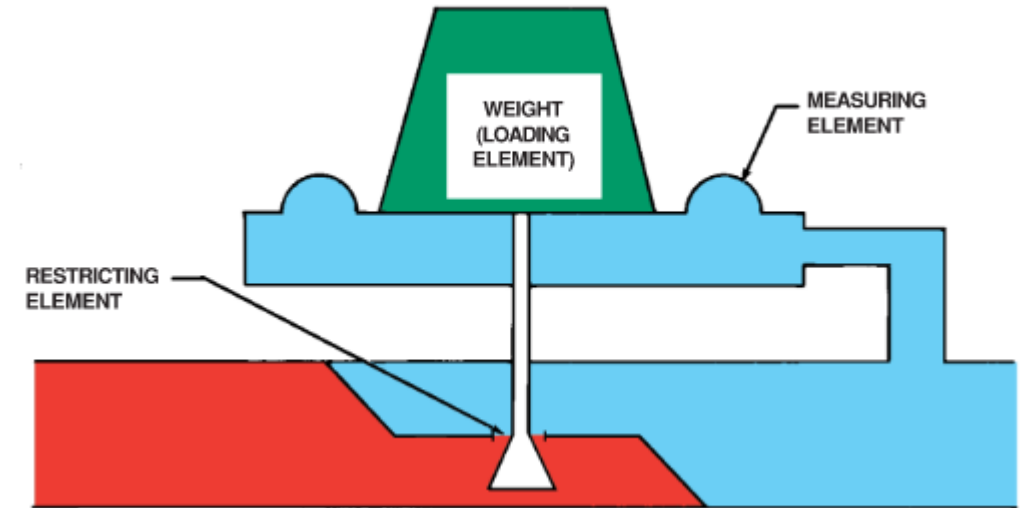
Regulator Basics

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

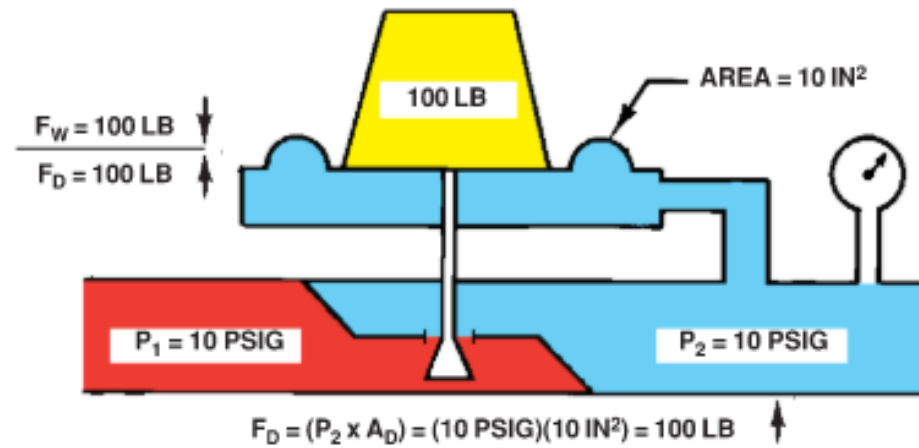
Basic Regulator Components

- Restricting Element
- Measuring Element
- Loading Element

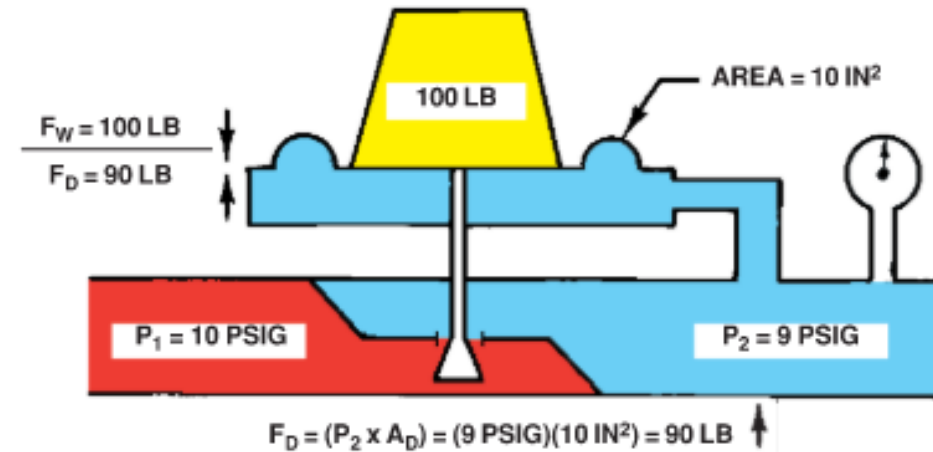


Regulator Operation (Direct-operated)

Equilibrium

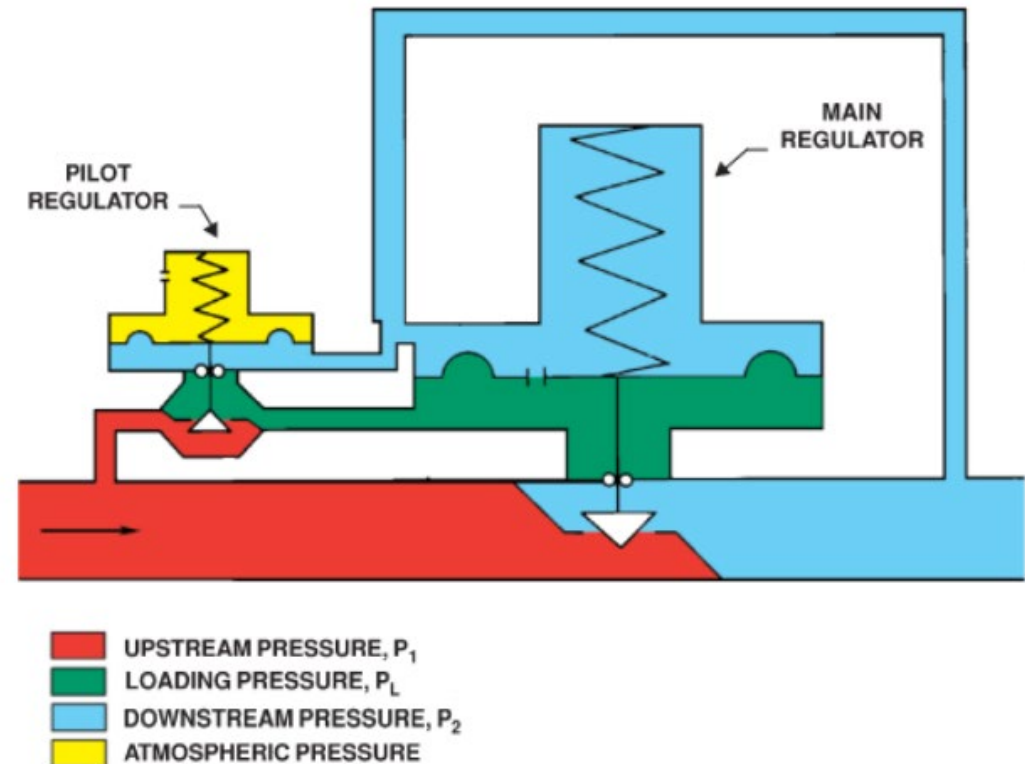


Increase in Downstream Demand

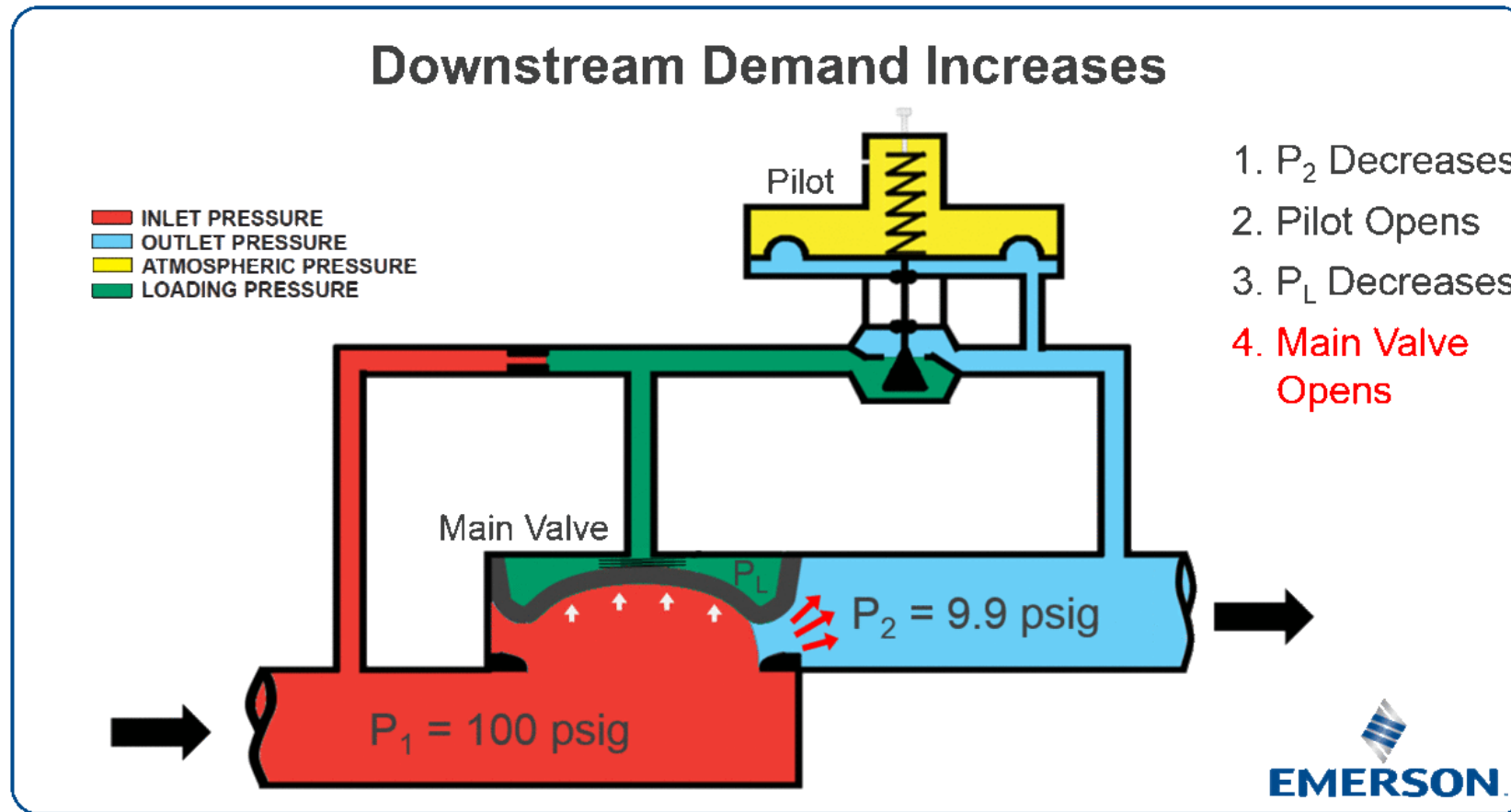


Pilot-Operated Regulators

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

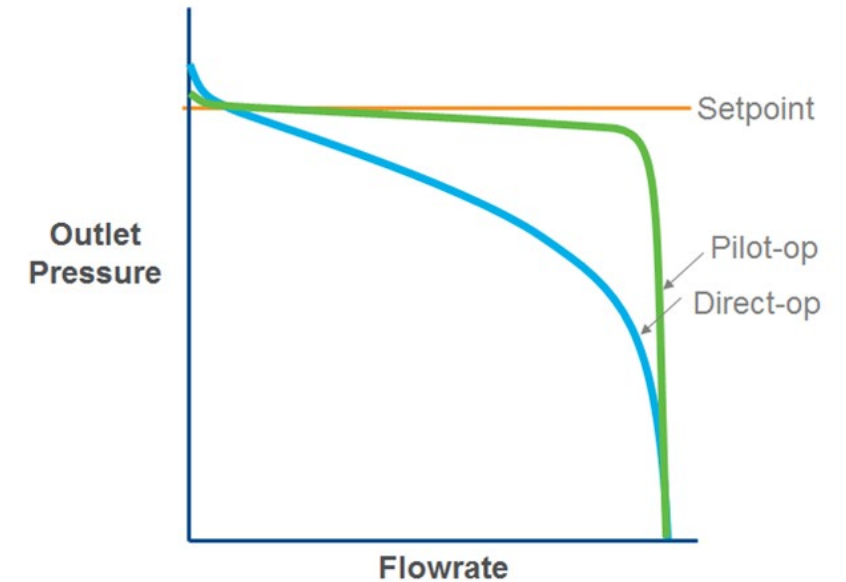
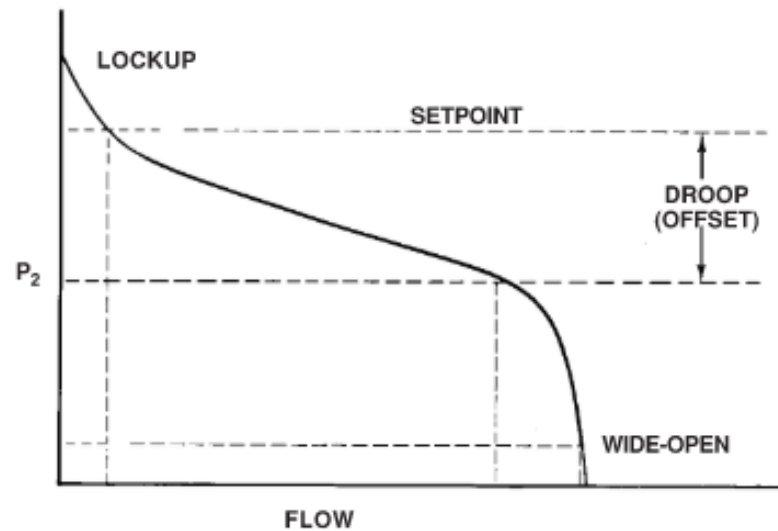


Pilot-unloading regulator



Regulator Performance and Terminology

- Setpoint
- Droop
- Accuracy
- Lock Up

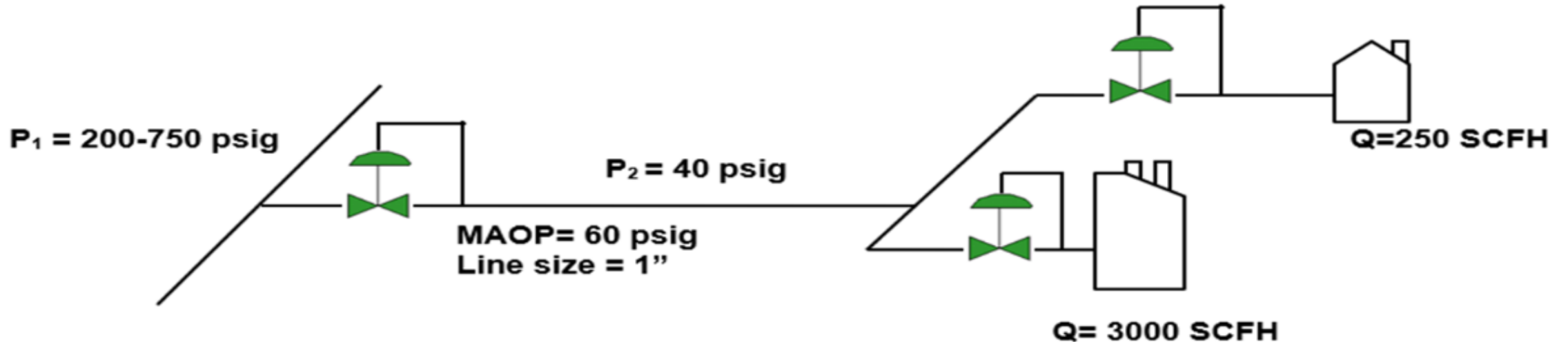


Selecting and Sizing

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

	MAXIMUM INLET PRESSURE	OUTLET PRESSURE RANGE	MAXIMUM CAPACITY	TYPE NUMBER
FARM TAP / FIELD	250 psig (17,2 bar)	5 to 500 psig (0,34 to 34,5 bar)	37,600 SCFH (1008 Nm3/h)	Type 627F Page 95
	1015 psig (70 bar)	7.25 to 500 psig (0,5 to 35 bar)	102 SCFH (3 Nm3/h)	Type DRPN Page 155
	1500 psig (103 bar)	3 to 500 psig (0,21 to 34,5 bar)	130,000 SCFH (3480 Nm3/h)	Type 630 Page 103
	2000 psig (140 bar)	5 to 500 psig (0,34 to 34,5 bar)	179,000 SCFH (4800 Nm3/h)	627 Series Page 79

Wizards / Online Tools

- GASCalc
- Fisher Regulator Toolkit
- Other Manufacturer website

Device MatchMaker Specifications...

Device Type: Regulator

Manufacturer: Any/All

Target Operating Data...

Flow Rate: 3250 Cfh

Minimum Inlet Pressure: 200.000 Psi

Maximum Inlet Pressure: 750.000 Psi

Set Pressure: 40.000 Psi

Outlet Velocity: 70 Feet/sec

Elevation: 0.000 ft

A Z Z A

List Matching Devices

List All Devices

Size/Type Code	Flow, Min	Flow, Max	Out Velocity	In P, Max	Set P, Min	Set P, Max
FC 627 3/4 3/8	3041.323	12165.293	65.475	1250.000	5.000	500.000
FC 627 1 3/16	1554.454	6217.817	40.400	2000.000	5.000	500.000
FC 627 1 1/4	2675.238	10700.952	40.400	1750.000	5.000	500.000
FC 627 3/4 3/8	1554.454	6217.817	40.400	2000.000	5.000	500.000

Base Conditions Clear Help Notes

Cancel Open Save Print Close

Flow Coefficients

Universal Sizing Equation

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

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

$\Delta P = 200 - 40 = 160$ 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

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

$$Q = 3132 \text{ scfh}$$

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 / Nm ³ /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
$\geq 60\text{psi}$	MAOP + 10% or 75% of the Specified Min Yield Strength (SMYS) which ever is less
$\geq 12\text{psi}$ and $< 60\text{psig}$	MAOP + 6psi
$< 12\text{psi}$	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

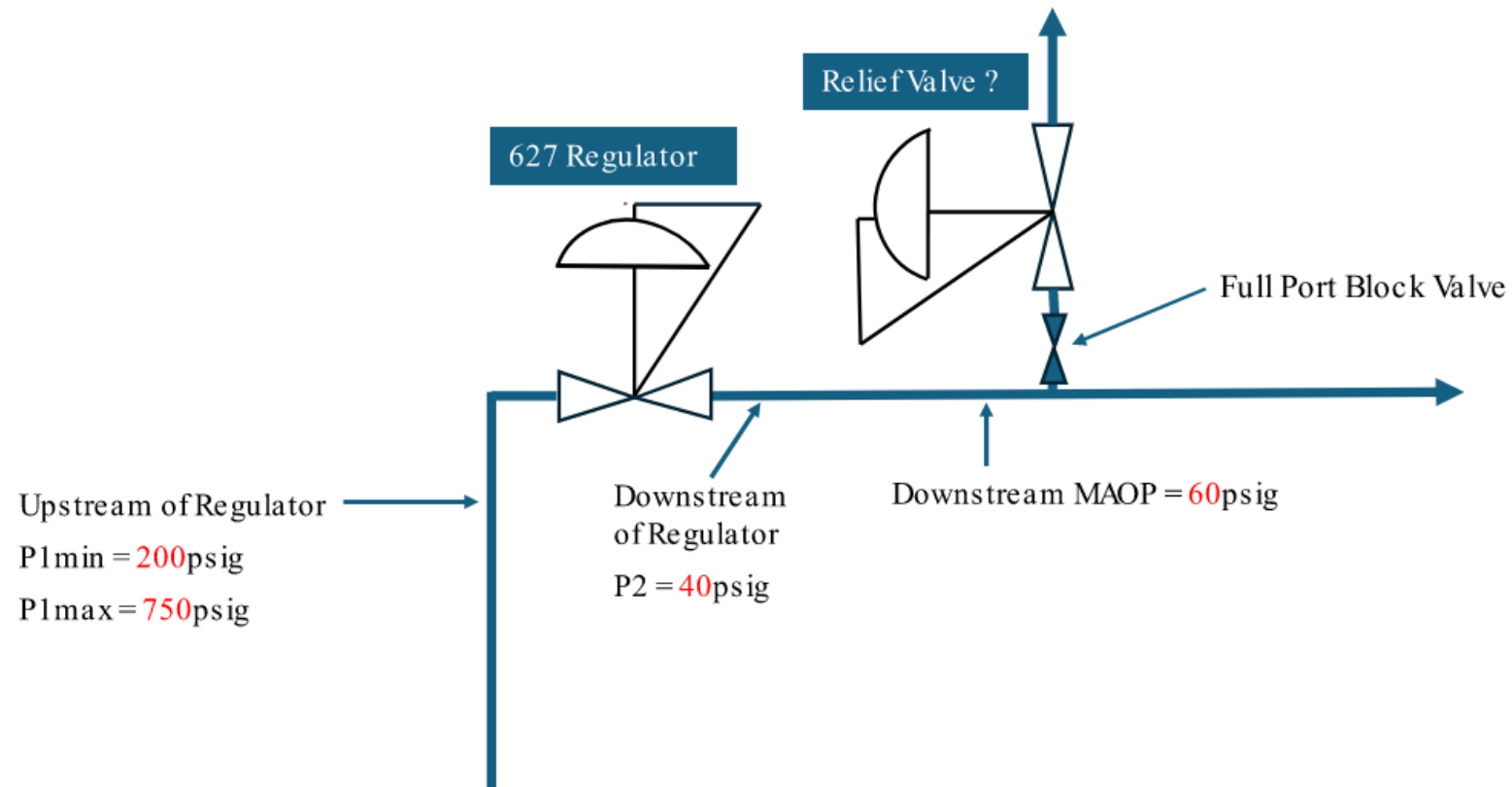


Type 627 with Internal Relief

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** $\frac{P_{1,abs}}{P_{2,abs}} \geq 1.814$

$$Q = 1.291 \times 12.5 \times (750 + 14.7)$$

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

$$= 12.3 \text{ MCFH}$$

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

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

RELIEF SET PRESSURE RANGE	MAXIMUM CAPACITY	TYPE NUMBER
10-inches w.c. to 75 psig (17 mbar to 5,2 bar)	100,000 scfh (2680 Nm ³ /h)	289 Series Page 330
14-inches w.c. to 100 psig (35 mbar to 6,9 bar)	111,000 scfh (2970 Nm ³ /h)	Type 289P Page 336
5 to 125 psig (0,34 to 8.6 bar)	1000,000 scfh (2680 Nm ³ /h)	Type 1805 Page 345
10 to 100 psig (0,69 to 6,9 bar)	136,000 scfh (3645 Nm ³ /h)	Type 1805P Page 348

3 to 125 psig (0,21 to 8.6 bar)	298,000 scfh (7986 Nm ³ /h)	1808 Series Page 348
35 to 350 psig (2,4 to 24,2 bar)	34,560 scfh (926 Nm ³ /h)	Type H120 Page 351
25 to 300 psig (1,7 to 20.7 bar)	195,000 scfh (5226 Nm ³ /h)	H200 Series Page 364
		Page 365

Wizards / Online Tools

- GASCalc
- Fisher Regulator Toolkit
- Other Manufacturer website

Device MatchMaker Specifications...

Device Type:

Manufacturer:

Target Operating Data...

Flow Rate:

Set Pressure:

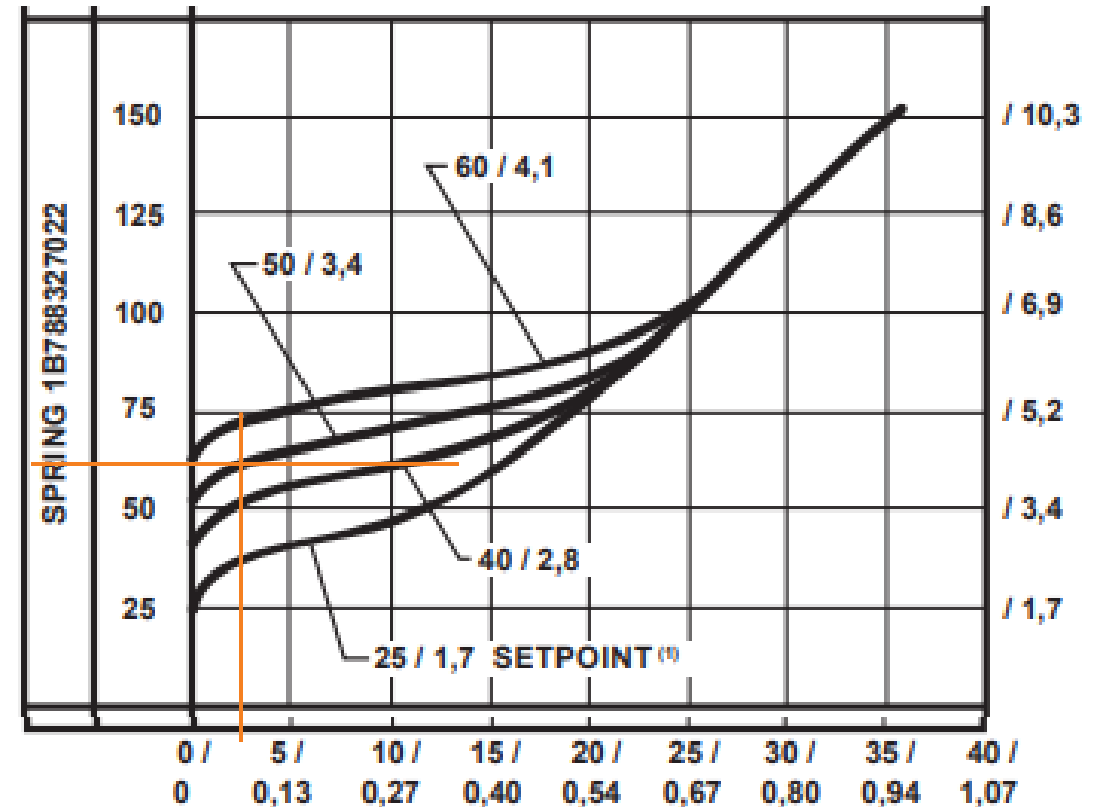
Elevation:

Size/Type Code	Flow, Min	Flow, Max	Out Velocity	In P, Max	Set P, Min	Set P, Max
FC 289H 1	5.880	52.923	568.049	100.000	0.180	75.000
FC 289HH 1	4.557	41.015	568.049	100.000	45.000	75.000
FC 289P-167AR	5.880	52.923	568.049	110.000	10.000	100.000
FC 289A 1 1-1	5.400	40.000	568.049	100.000	20.000	100.000

Capacity Chart – 1805

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

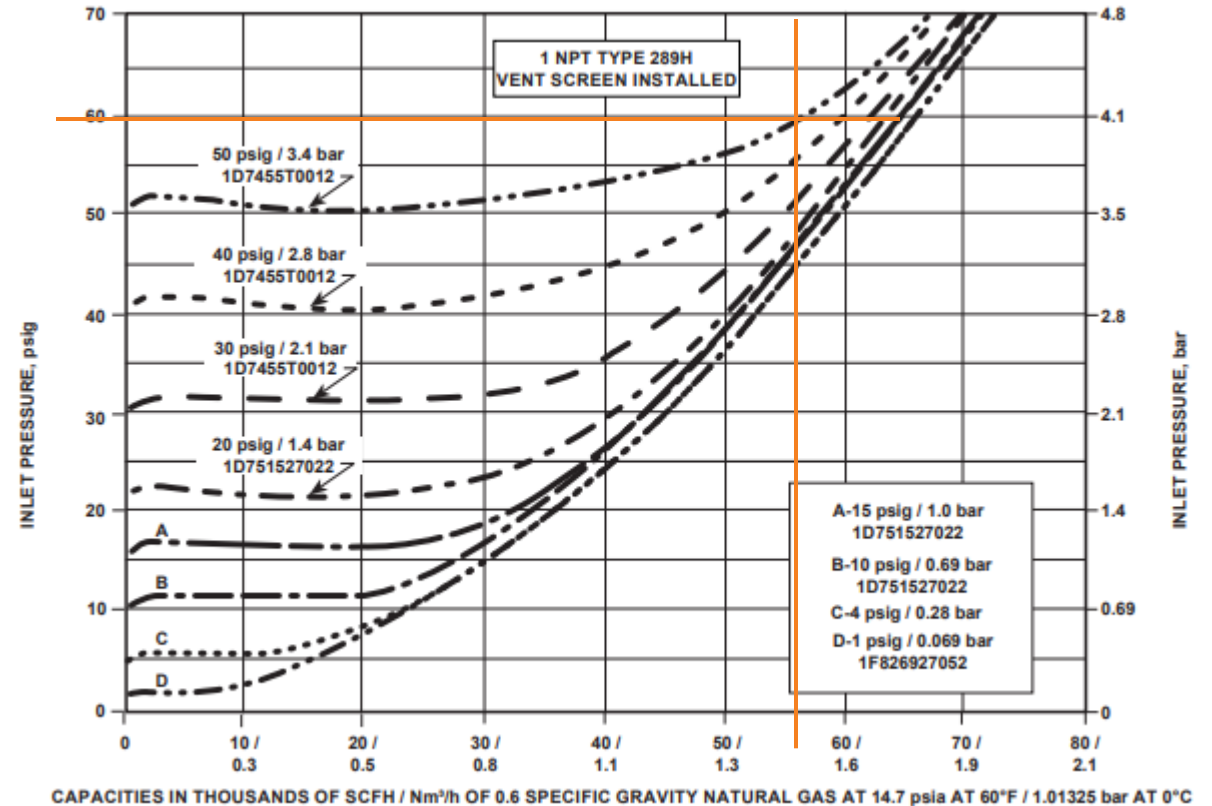
BODY SIZE	RELIEF PRESSURE RANGE		SPRING PART NUMBER
	psig	bar	
3/4 or 1 NPT	5 to 35	0.34 to 2.4	1B986027212
	10 to 60	0.69 to 4.1	1B788327022
	20 to 125	1.4 to 8.6	1B788427022
1-1/2 or 2 NPT	5 to 20	0.34 to 1.4	1D892327022
	10 to 50	0.69 to 3.5	1D665927022
	35 to 125	2.4 to 8.6	1E543627142



- 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



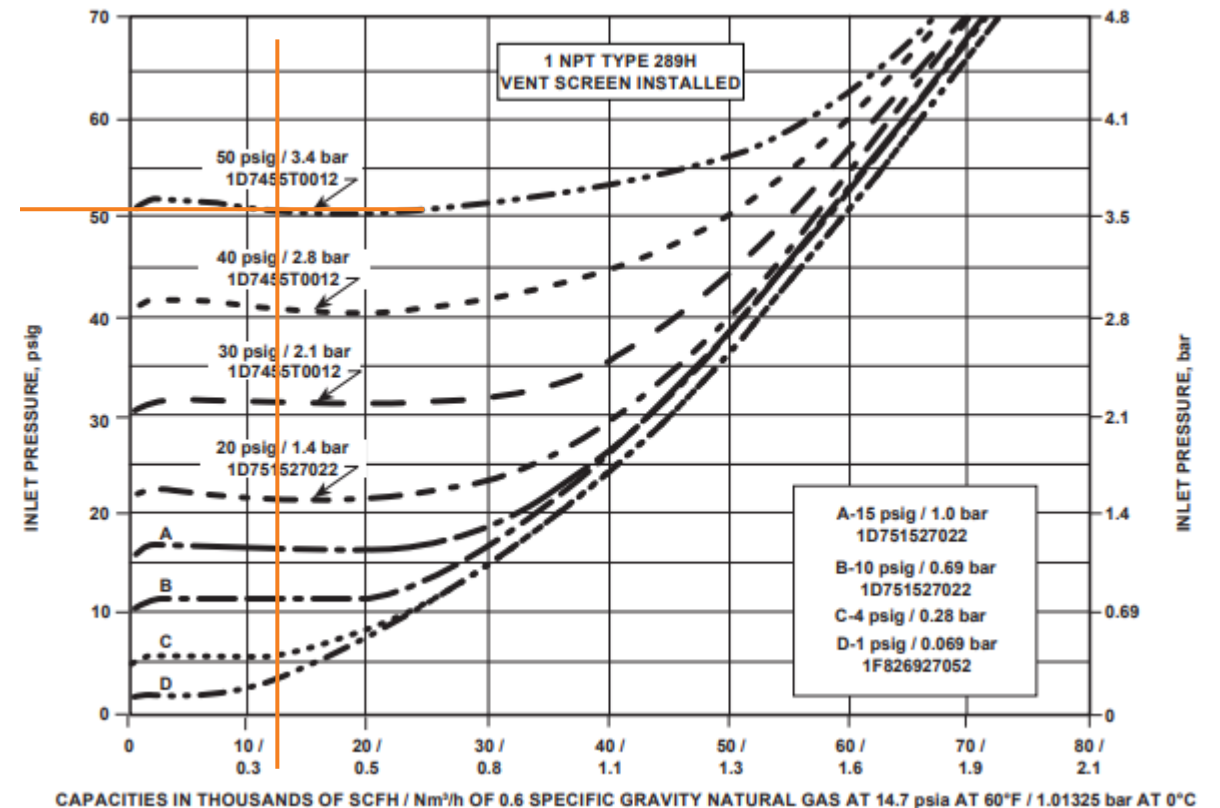
- Relief Capacity = approx. 56 MCFH
- Enough Capacity

Check Downstream Pressure

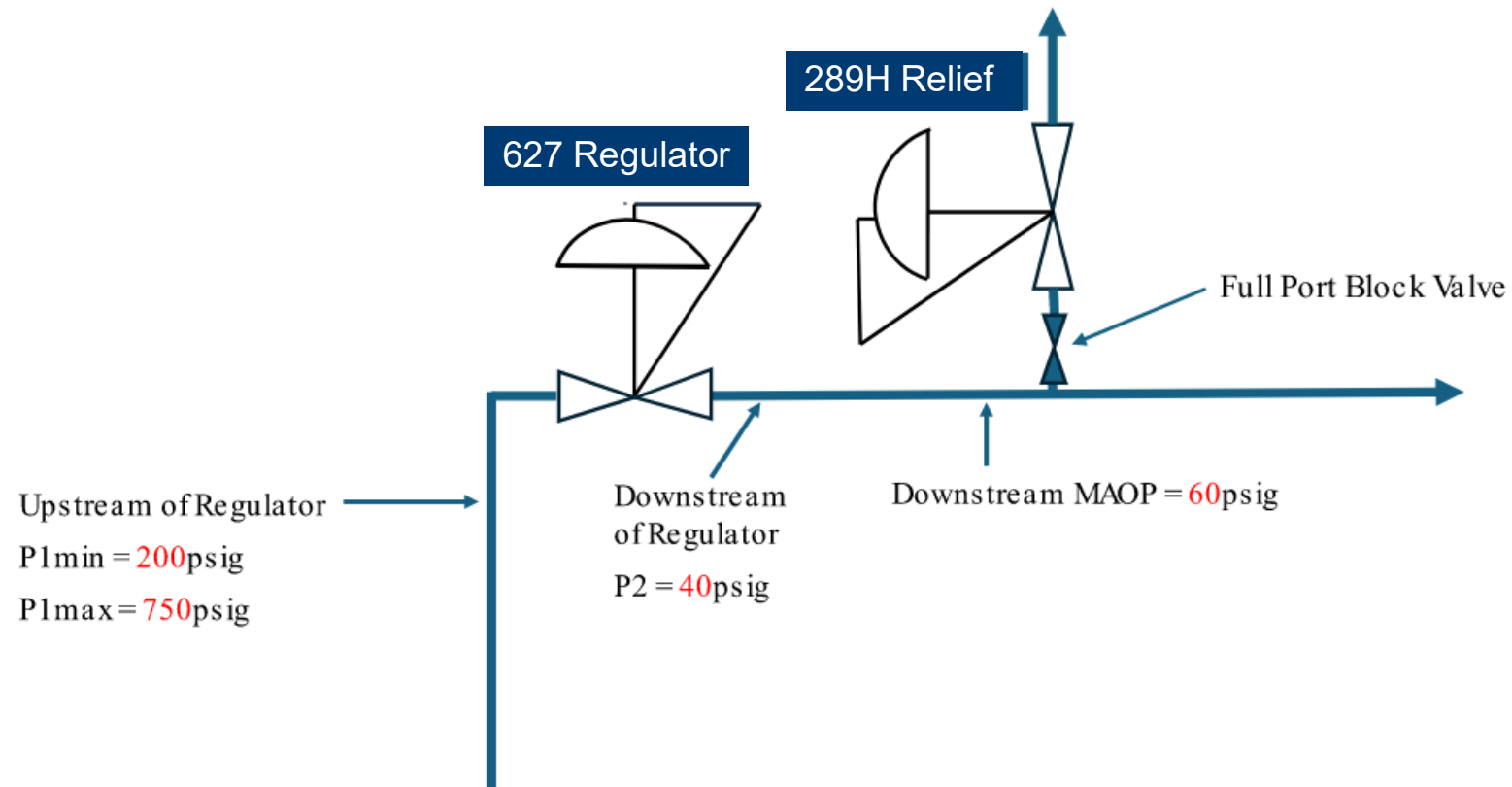
Table 1. Maximum Allowable Relief (Inlet) Pressure

AVAILABLE CONFIGURATION	BODY SIZE, NPT	SPRING PART NUMBER
Type 289A	1/4	0Z056327022 1B268227022
Type 289H	1	1F826927052 1D892327022 1D751527022 1D7455T0012
	2	1B536527052 1B536627052 1B536827062 1B536927052
Type 289HH	1	1D7455T0012

MAXIMUM ALLOWABLE RELIEF (INLET) PRESSURE ⁽¹⁾	
psig	bar
45	3.1
100	6.9
25	1.7
100	6.9



Final Design



Q&A

Thank you!