

# AXIAL FLOW VALVES



**AMERICAN  
METER COMPANY**  
*Measurement Engineers Since 1886*

# The improved technology for pressure regulation

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The American Axial Flow™ Valve provides pressure and flow control in high capacity pipelines. It can be used for pressure regulation, overpressure relief, flow control or simply as an on/off valve.

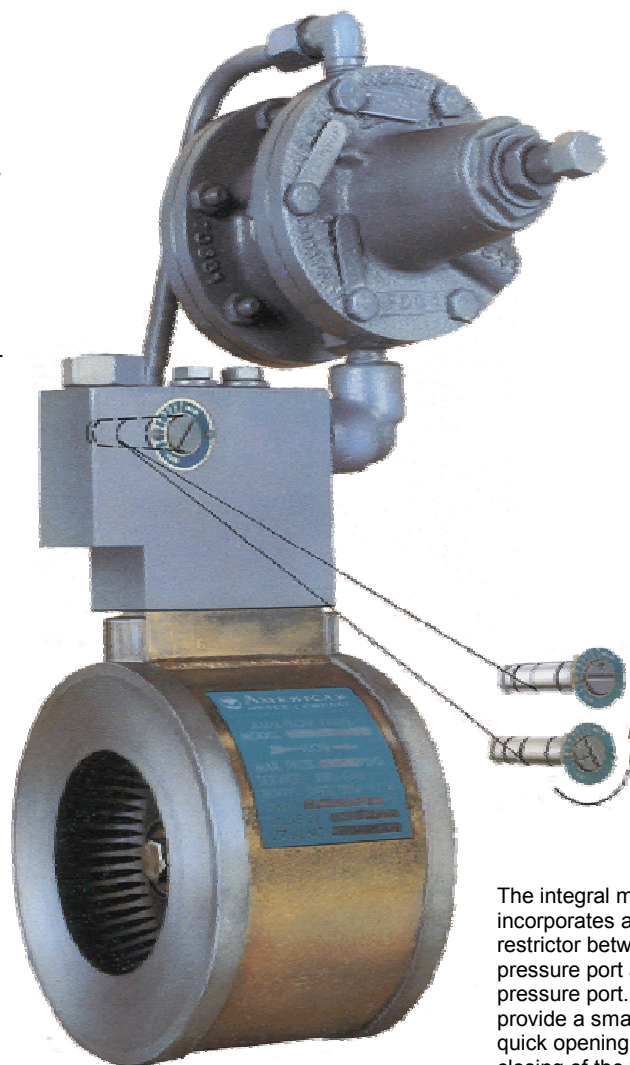
The AFV is unique in that there is no mechanical connection to the control element. Instead, the valve uses an elastomer sleeve which expands or contracts depending on the pressure differential across this sleeve. This principle provides a valve that is extremely compact and lightweight, easy to install and service, and one with a streamlined flow path for quiet operation. Because of its V-shaped design, the sleeve in an American Axial Flow Valve can be reversed for extended service life. This design also causes the sleeve to expand around its entire circumference, producing lower stresses for a given opening. The excellent flexibility of the sleeve material and the double sealing surfaces in the American design combine to provide a positive lockup characteristic for the valve.

Standard sleeve materials provide a wide working temperature range and excellent resistance to abrasion and swelling. They are field-proven in a variety of installations involving natural gas service. Specialized sleeve materials are also available for applications involving extreme temperatures, where chemical resistance is needed and for specialized services such as water scarfing.

American Axial Flow Valves install between the flanges of standard pipelines. Series 300 valves have a maximum working pressure of 720 psig and are available for 2", 3", 4", 6", 8" and 12" pipelines. Series 600 valves, with a maximum working pressure of 1440 psig, are available in 2", 4", 6" and 8" sizes.

Depending on the particular pilot used, the AFV can regulate output pressures from inches W.C. up to 600 psig. Higher pressures can be regulated with an instrument controller in place of a pilot. It can therefore be used to provide primary and secondary pressure cuts in a variety of transmission, distribution and industrial applications.

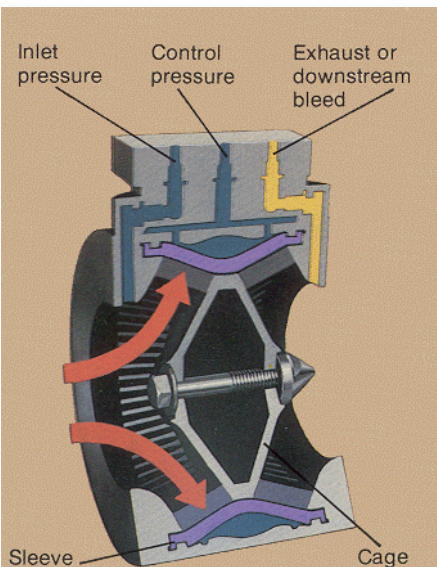
With the standard elastomer sleeve, the American Axial Flow Valve has an operating temperature range from -20 to 150°F. All components exposed to the flow path are fabricated of abrasion and corrosion resistant materials.



The integral manifold block incorporates a variable restrictor between the inlet pressure port and control pressure port. Low settings provide a smaller orifice and quick opening and slower closing of the valve. Higher settings, with their larger orifices, provide slower opening, quicker closing characteristics.

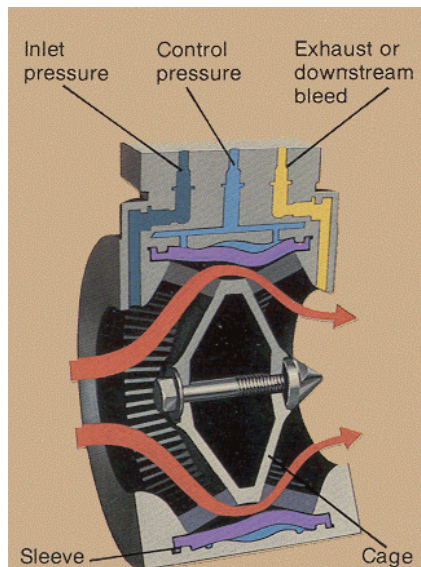
# Basic valve operation

Because there is no mechanical connection to the control element, there's no worry about shaft sealing. Except for the valve inlet and outlet, the only connections to the Axial Flow Valve are three pneumatic lines to the manifold: inlet pressure, control pressure and exhaust / downstream bleed. The valve responds to the difference in pressure between the inlet port and the control port. The different functions of the valve (downstream regulation, relief, etc.) are determined by the type of external pilot and the piping of the pilot. The operating characteristics of the valve (fast opening, slow closing, etc.) are determined by the setting of the adjustable restrictor in the manifold.



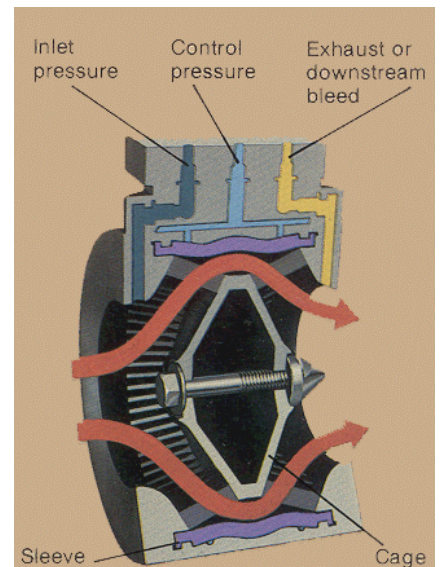
## Closed position

Inlet pressure is applied to the inner surface of the sleeve in the upstream section of the valve and control pressure is applied to the exterior of the sleeve. Because the sleeve is slightly smaller in diameter than the cage, when inlet and control pressure are equal the sleeve preload keeps the valve closed.



## Throttling position

As control pressure is reduced, the inlet pressure overcomes the preload and begins to force the sleeve away from the inlet cage. As the sleeve continues to expand, a portion of the downstream cage is uncovered and flow begins through the valve. When downstream demand is satisfied, the balanced forces on either side of the sleeve maintain it in an equilibrium position.



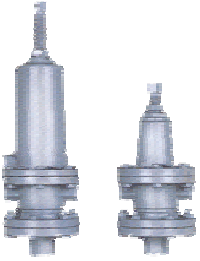
## Full open position

When fully opened, the downstream cage is completely exposed and the sleeve is expanded to the point where it is supported against the inner body of the valve. Since the control pressure is usually aspirated through the downstream bleed port, the control pressure is significantly lower than downstream pipeline pressure at high flow rates. This minimizes the differential between inlet and outlet required for full valve opening.



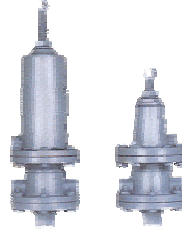
# Pilot regulators

These spring-loaded regulators are used to balance the pressure applied to the control port of an Axial Flow Valve. It is actually the choice of pilot that determines function (pressure reduction or backpressure) and output pressure or relief setting. The adjustable restrictor which is an integral part of the AFV determines operating characteristics; low settings for quick opening and slow closing, higher settings for slow opening and quick closing.



## Types ZSC-100 and ZSC-320-100

Both of these models are double diaphragm regulators for pressure reducing applications. The ZSC-100 supplies output pressures from 1 to 325 psi; the ZSC-320-100 has an output range of 200 to 600 psi.



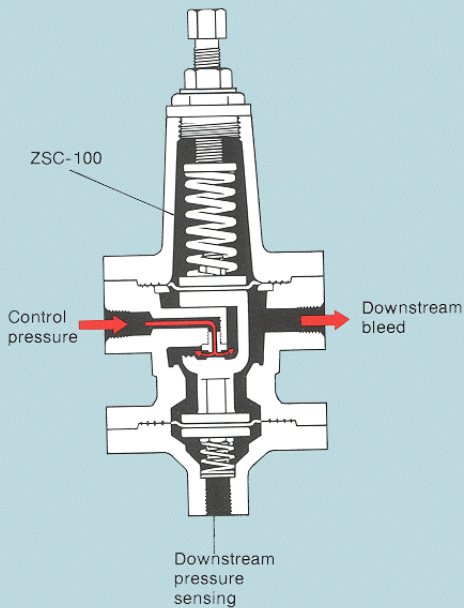
## Types ZCS-150 and ZSC-320-150

These double diaphragm regulators are for backpressure or pressure relief applications. The ZSC-150 provides setpoints from 1 to 225 psi, while the ZSC-320-150 has a range of 200 to 600 psi.

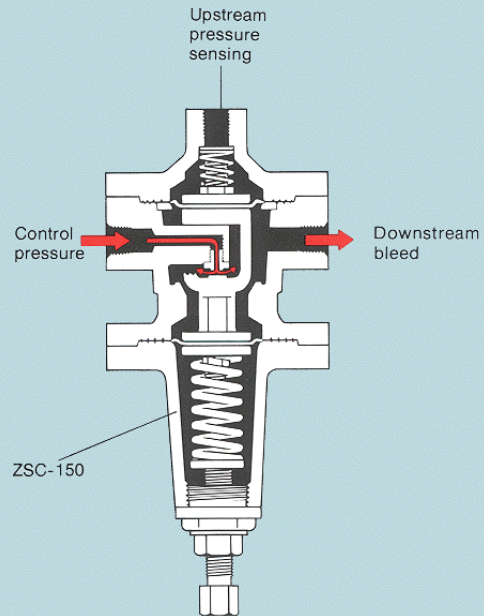


## Type 1203

This family of regulators is for pressure reducing service requiring output pressures from 5 inches W.C. to 5 psi.

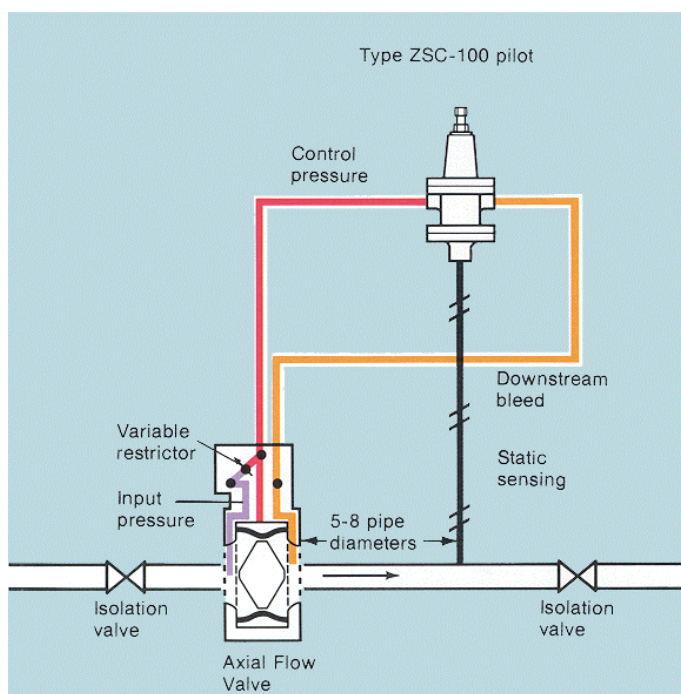


Spring force tends to hold the regulator open. This force is counterbalanced by pressure applied to the downstream sensing chamber diaphragm. When the downstream pressure decreases, the regulator is opened wider, increasing flow. This produces a larger drop across the restrictor and a decrease in control pressure to the AFV, thereby increasing flow to satisfy downstream demand.

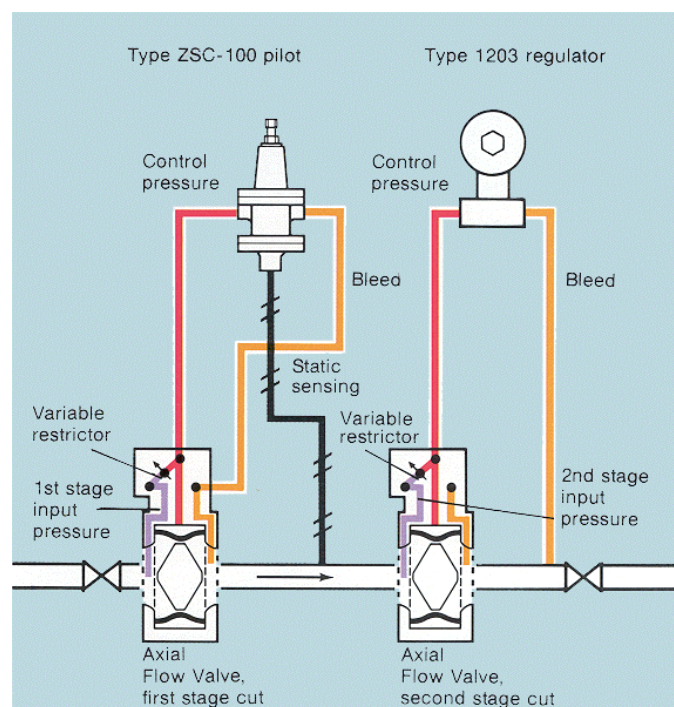


As long as the spring force is greater than the force of the upstream pressure acting on the upstream sensing chamber diaphragm, the regulator is held closed. When upstream pressure increases beyond the setpoint, the regulator opens. Since the exhaust is normally at close-to-zero pressure, a large flow occurs through the regulator, quickly opening the AFV to relieve the overpressure condition.

# Applications

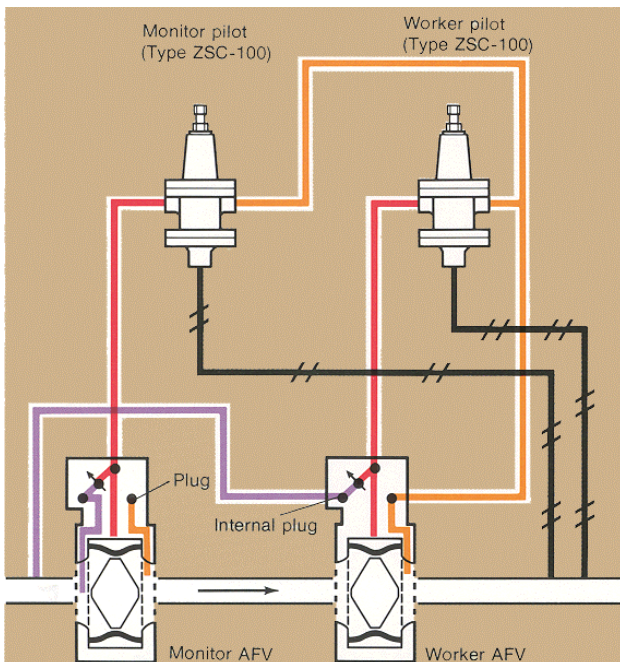


**Single-stage pressure reduction.** When downstream pressure decreases, spring force increases the effective opening of the pilot. The increase in flow produces a larger pressure drop across the variable restrictor, reducing control pressure to the AFV and increasing flow in the line.

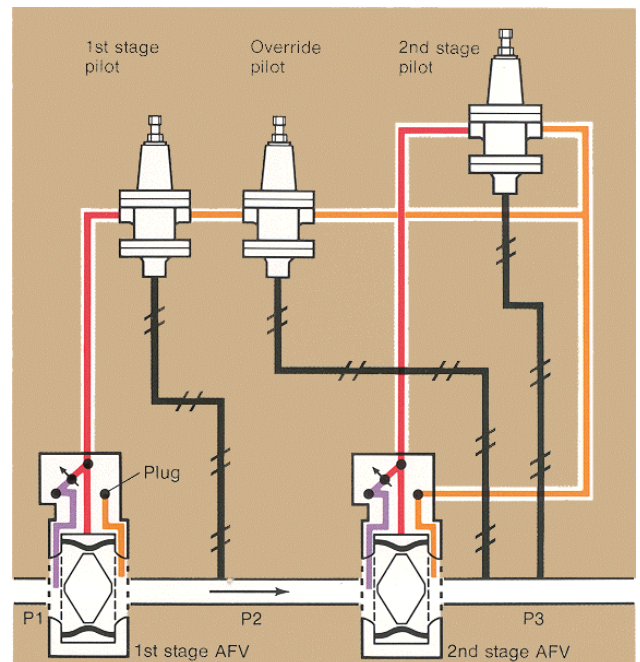


**Two-stage pressure reduction: psi to psi to in. W.C.** When large reductions in pressure are required, the cut can be made in two stages. Here an American AFV and Type ZSC-100 pilot control a psi to psi cut. The second stage incorporates a Type 1203 regulator to give a final output pressure in the inches W.C. range.

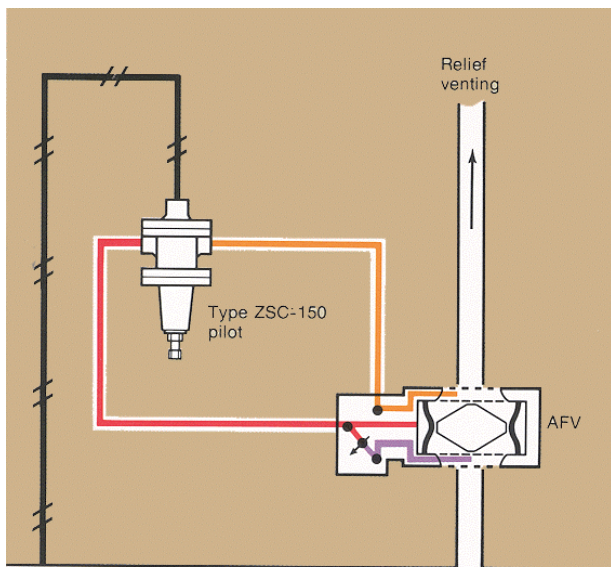




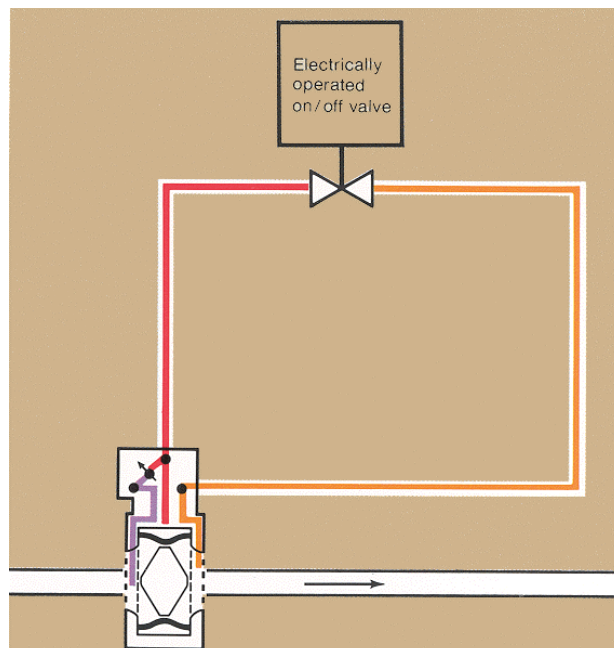
**Pressure reduction with monitor.** During normal operation, a single AVF, the worker, performs the pressure cut. The monitoring pilot is set at an output pressure slightly higher than the working pilot. Since the monitoring pilot is always open, the monitor AFV is held in the full open position. If a malfunction occurs on the worker side, the output pressure rises to the monitor setpoint and it assumes control. The roles of worker and monitor can be reversed by simply resetting the pilots.



**Two-stage regulators with monitor override.** Under normal conditions, both AFV's are performing pressure cuts. However, they are sized so either one can handle the entire cut in the event of a malfunction. If a problem occurs in the 1st stage, P2 increases and the 2nd stage makes a correspondingly larger cut. If the 2nd stage malfunctions, P3 increases and the override pilot assumes control of the 1st stage AFV, causing it to take a larger single stage pressure cut. The maximum interstage pressure, P2, is limited to the maximum spring adjustment of the 1st stage pilot -325 psi for the SZC or 600 psi for the ZSC-320.

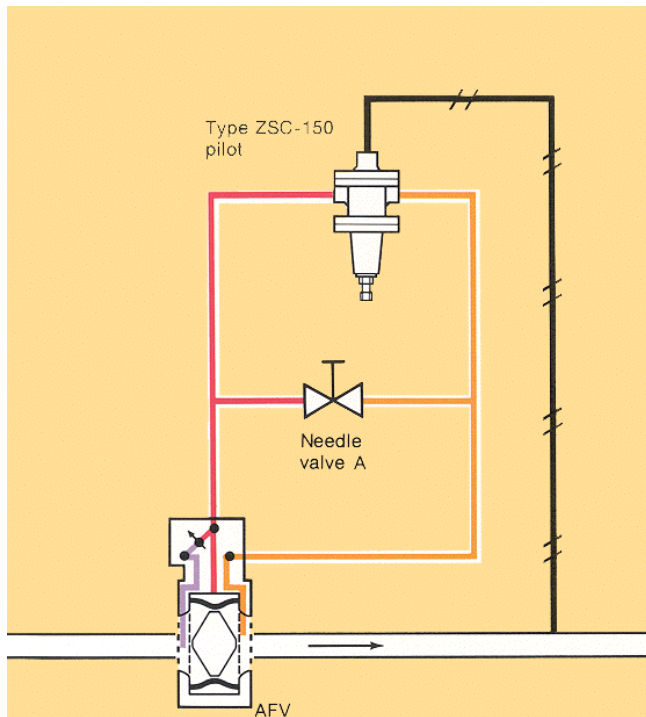


**Pressure relief valve.** With the ZSC-150 pilot, the AFV is closed as long as upstream pressure is below the setpoint. Because the exhaust port is normally at atmosphere, once the regulator opens, a large drop occurs across the restrictor, causing the AFV to open quickly.

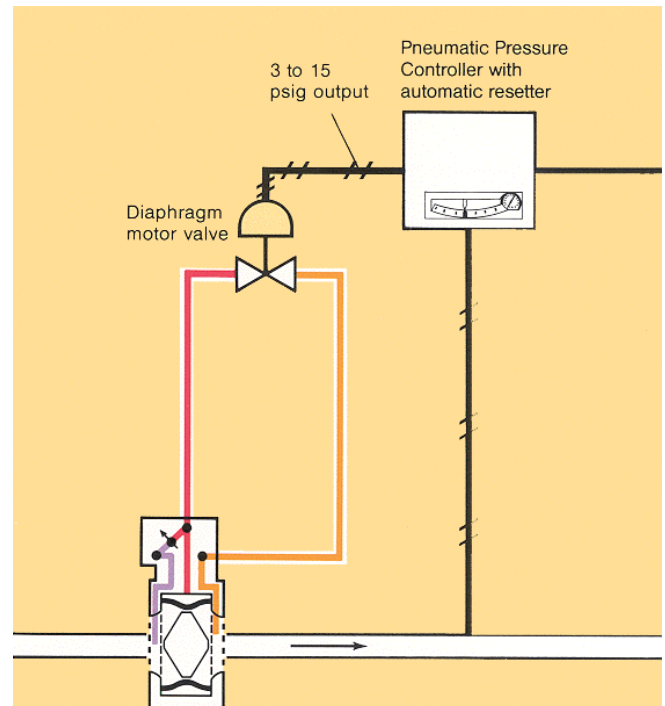


**On/off control of flow in a pipeline.** When the electrically operated valve is open, the input pressure is bled downstream causing a drop across the restrictor. Since the control pressure is less than the input pressure, the AFV opens to allow flow in the pipeline. Closing the electrically operated valve causes the control pressure to build up to the input pressure, closing the AFV.

# Applications

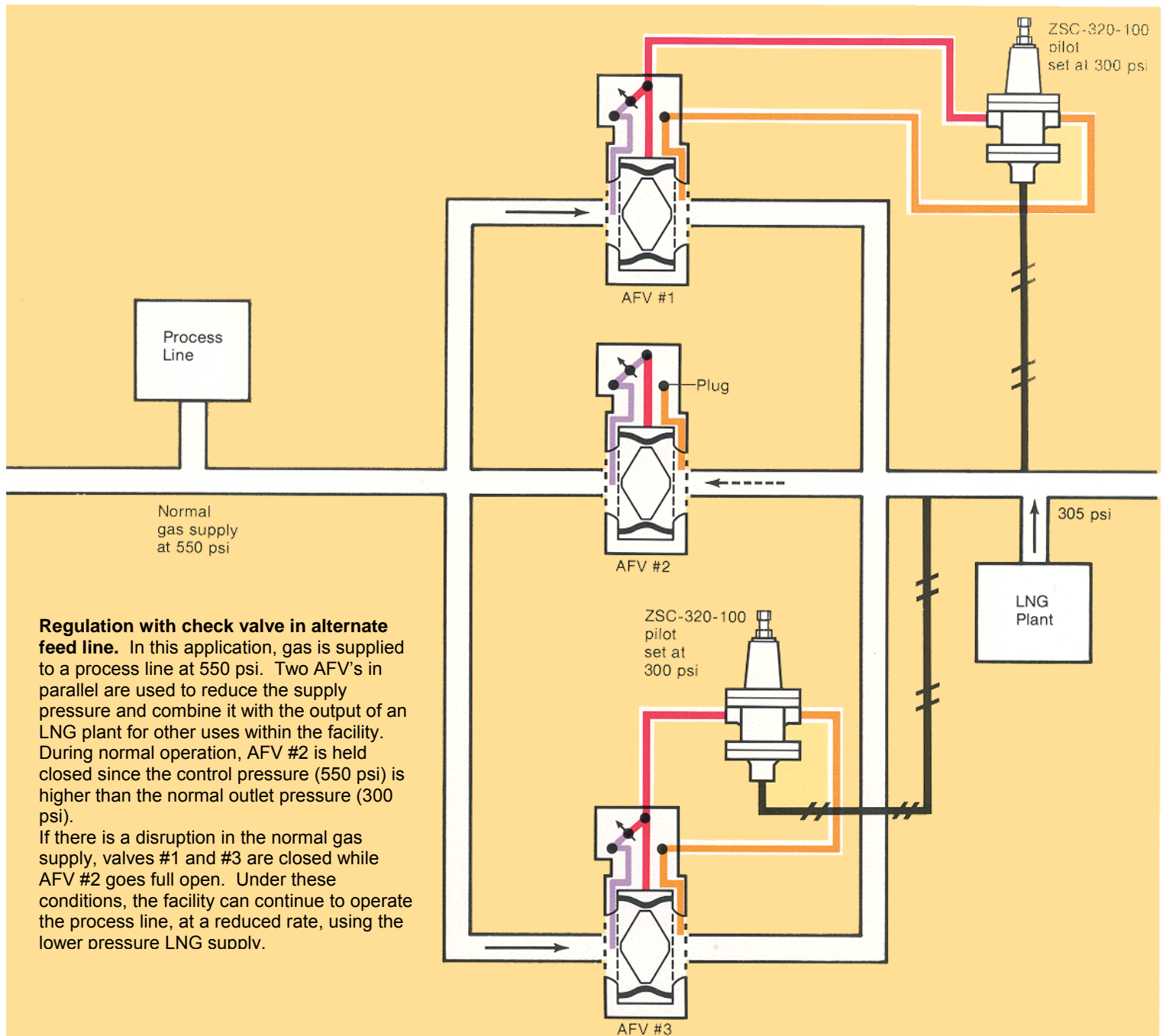


**Underpressure shutoff.** As long as the downstream pressure is above the setpoint, the pilot is held open causing a drop across the restrictor and allowing the valve to remain open. If downstream pressure decreases below the setpoint, the pilot is forced closed and inlet pressure is applied to the control port of the AFV, equalizing the pressure across the sleeve and closing the valve. The needle valve is used to start up and reset the system. With Valve A open, there is a pressure drop across the restrictor, allowing the AFV to open. Once the downstream system is pressurized, close valve A.



**Pressure regulation with instrument controller.** To overcome the limitations of spring-loaded regulators, the AFV can be used as the final control element with a pressure controller and a small diaphragm motor valve. Among the advantages are overcoming spring droop, responding to the rate of change in downstream demand and the ability to regulate pressures above 600 psig (up to 1440 psig).





# Sizing the American AFV for pressure reducing service

To properly size an axial flow valve for a pressure regulation application, three parameters are needed:

- the maximum flow rate through the valve in MSCFH
  - the pressure range at the inlet in psig
  - the controlled, or regulated pressure at the outlet in psig
- As an example, consider an application with a maximum expected flow rate of 2000 MSCFH, an inlet pressure range of 275 to 300 psig and a desired outlet pressure of 125 psig. The fluid is natural gas, 0.6 gravity, 14.73 psia, 60°F base.

AFV Series	Sleeve Number	Minimum		Maximum	
		Cracking	Full Open	Continuous	Intermittent
300	H-5L *	1.5 psid	5 psid	30 psid	50 psid
300	H-5	3.5 psid	15 psid	125 psid	180 psid
300	H-7	14 psid	30 psid	500 psid	720 psid
600	B-7	30 psid	60 psid	1000 psid	1440 psid

1. Determine the maximum differential pressure across the valve and use this value to select the appropriate sleeve. Specifications on standard sleeves are as shown below.

\*2", 3", 4" and 6" sizes only

In this case, the maximum differential is 300 – 125 = 175 psid and the H-7 sleeve will be required.

2. Using the valve capacity tables from American Meter, select the appropriate valve size based on the lowest inlet pressure. The tables show capacity with the valve fully open. It is good practice to size the valve based on 75% of the maximum capacity to allow for variations in piping, pilots, etc.

In the example, this value would be:

$$2000 \text{ MSCFH} = \text{MSCFH}$$

$$0.75$$

From the capacity table, a six inch Series 300 valve, with an inlet pressure of 275 psig has a maximum capacity of 3279 MSCFH at 100 psig outlet and 3273 MSCFH at 150 psig outlet. Interpolating for an outlet pressure of 125 psig shows a maximum capacity of 3276 MSCFH, sufficient for the application.

3. Select a pilot with a spring suitable for the desired set point using

Pilot Type	Outlet Pressure	Part Number
ZSC-100 And ZSC-150	1 to 5 psi	71411P010
	2 to 10 psi	71411P043
	3 to 30 psi	71411P011
	10 to 75 psi	71411P012
	25 to 150 psi	71411P014
	100 to 225 psi	71411P009
ZSC-320-100 ZSC-320-150	200 to 600 psi	71421P008
1203 (125 psig max. inlet pressure)	5 to 9" W.C.	70017P001
	9 to 15" W.C.	70017P002
	14" W.C. to 2 psi	70017P073
	2 to 5 psi	70017P078

the lowest outlet pressure range covering the set point.

4. Determine the outlet pipe size required to maintain the 200 ft/sec limits commonly used in the gas industry:

$$D=2 \sqrt{\frac{Q}{P_2}}$$

Where: D = outlet pipe diameter (inches)

Q = flow rate (MSCFH)

P<sub>2</sub> = downstream pressure (psia)

In our example,

$$D=2 \sqrt{\frac{3276}{125 + 14.73}} = 9.684''$$

Therefore, the outlet of the 6" AFV should be expanded to a 10" pipe using 15" cones at the outlet or within 5d(30") of the outlet. The sensing tap should be 5d to 8d downstream of the valve or cone outlet. The smaller the valve size, the more critical the need for expanding the outlet piping in order to achieve the full capacity of the valve.

When using two similar size AFV's in series, such as a monitor and worker, size should be based on 71% of the maximum values in the capacity table *before* applying the 75% allowance for variations.

# Sizing the American AFV for pressure relief service

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When sizing an AFV for relief services, it's necessary to determine the allowable pressure rise above the set (relief) point and to assure that the relief valve has a capacity that is large enough to fully discharge the open capacity of the control (working) regulator). Generally the relief valve will be one or two sizes larger than the working regulator.

A typical situation might be an application using a 3 inch Series 300 AFV with a ZSC-100 pilot as an operating regulator. The inlet pressure to the worker is 75 to 150 psig and the worker is set at 50 psig. Maximum flow rate is 654 MSCFH, based on 150 psi maximum inlet pressure. The maximum allowable operating pressure is 60 psig, and the maximum pressure buildup above the relief point is 6 psig.

1. Determine the range and type of control pilot operator.

$$60 \text{ psig MAOP} + 6 \text{ psig max buildup} = 66 \text{ psig}$$

From the pressure spring table, select a ZSC-150 pilot (backpressure type) with spring 71411P012 (10 to 75 psig). The pressure buildup above the setpoint is 5% of the maximum of the spring range, in this case  $0.05 \times 75 = 3.75 \text{ psig}$ . (This is a characteristic of the ZSC-150 with the standard 3/32" orifice as used with AFV's)

2. Determine the maximum relief valve setting, maximum permitted line pressure minus pressure buildup.

$$66 \text{ psig} - 3.75 \text{ psig} = 62.25 \text{ psig}$$

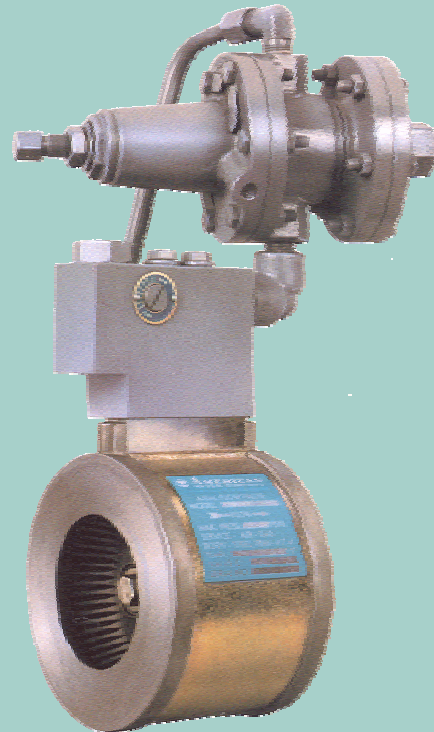
3. Establish the size of the relief valve using 644 MSCFH and the maximum permitted line pressure of 66 psig. Using the capacity tables find the smallest valve that will discharge 654 MSCFH at 66 psig inlet pressure and 0 psig outlet pressure. The 66 psig inlet pressure will require interpolation.

A 4 inch valve has a capacity of 548 MSCFH. While this capacity is too small, this type of situation might justify a closer look at the specified 644 MSCFH for economic reasons.

If the 654 MSCFH is validated, a 6 inch American AFV will discharge 980 MSCFH. To fully realize the relief capacity of the AFV, the discharge should be to atmosphere or no more than 5d of equivalent pipe at the outlet. If outlet piping is required in excess of 100 ft/sec, the relieved gas generates excessive reactive forces and the relief system must be supported.

Other parameters necessary to obtain the full relief capacity are:

- ☐ pilot downstream bleed should be connected to the AFV aspirator port
- ☐ restrictor setting should be 3 or less consistent with stability and speed of opening
- ☐ the upstream sensing line tap should be 2d to 3d from the inlet of the AFV





The Bulletins listed here provide additional information on American Axial Flow Valves. Copies can be requested from your nearest sales office, or by contacting the American Meter home office.

- ❑ Axial Flow Valve Accessories – Descriptive Bulletin SB 9525
- ❑ Low differential Pressure Axial Flow Valves – Descriptive Bulletin 9520
- ❑ Axial Flow Valve Capacity Tables – Technical Data Bulletin 9610
- ❑ Axial Flow Valve Operation & Installation – Descriptive Bulletin 9710
- ❑ Series Z Pilot Regulators – Descriptive Bulletin 8545
- ❑ Series 1200 Regulator – Descriptive Bulletin 8505



**AMERICAN  
METER COMPANY**

300 WELSH ROAD ■ BUILDING ONE ■ HORSHAM, PA 19044-2234

(215) 830-1800 ■ FAX # (215) 830-1891