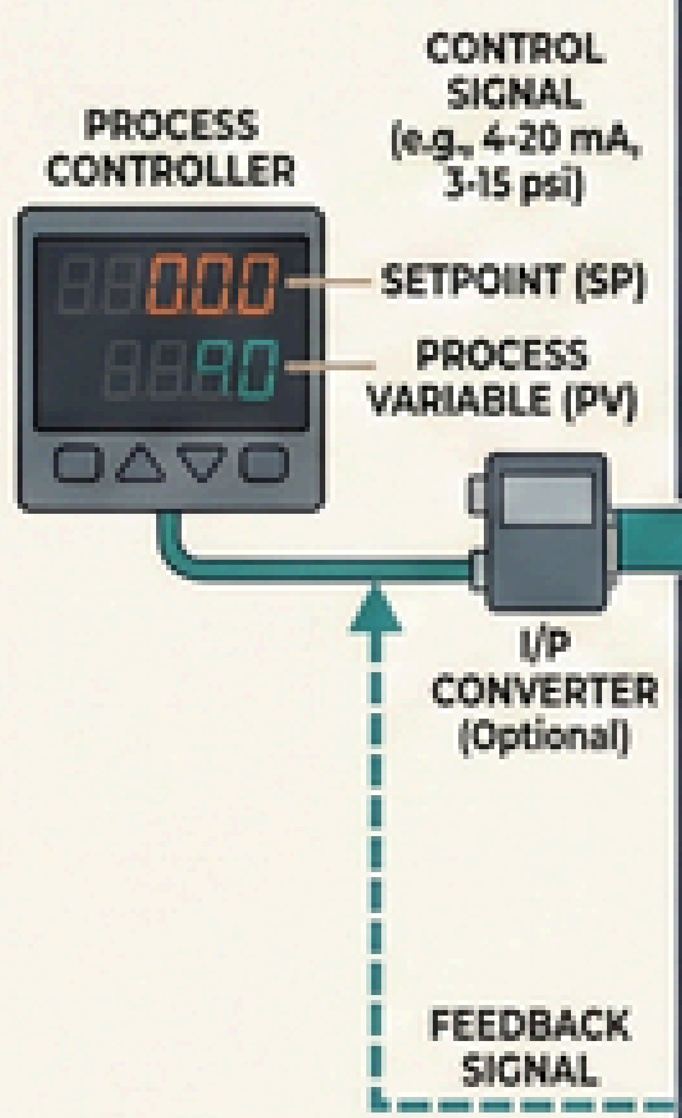
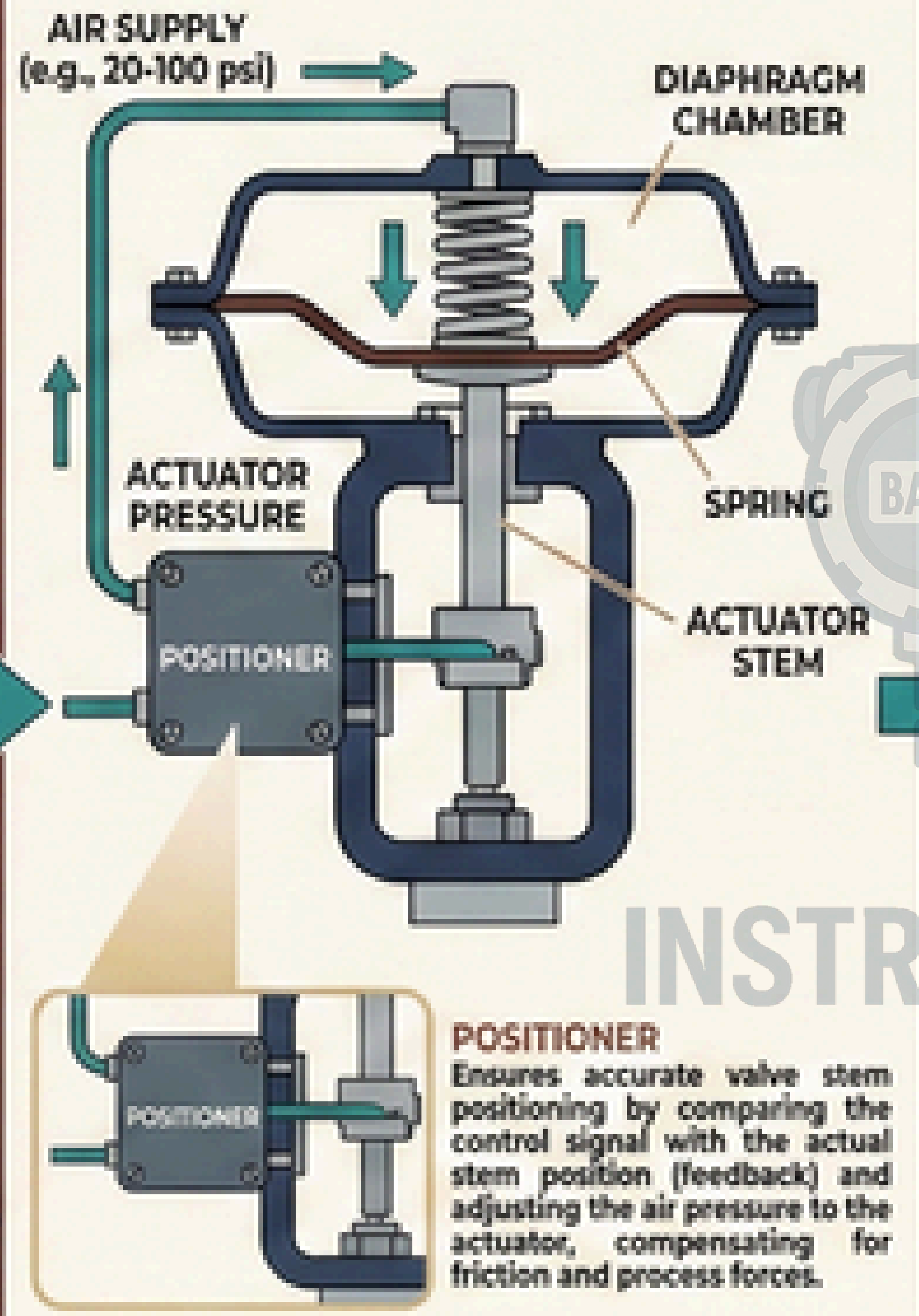
CONTROL VALVE WORKING PRINCIPLE

1. CONTROL SIGNAL & CONTROLLER



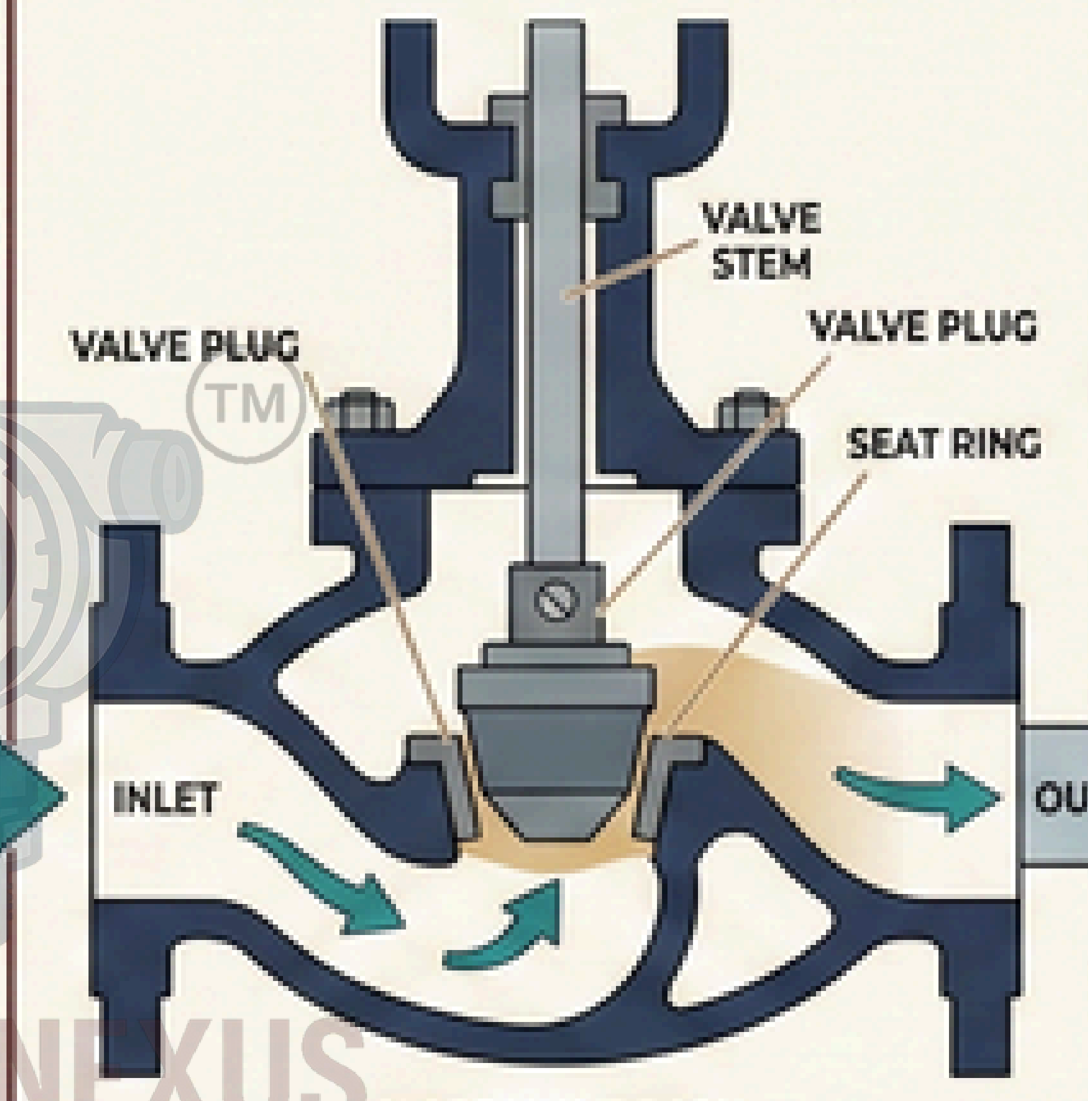
The process controller compares the Process Variable (PV) against the Setpoint (SP) and calculates the required error correction. It generates a standardized Control Signal (electrical or pneumatic) that dictates the desired valve position to bring the process back to the setpoint.

2. ACTUATOR: SIGNAL TO FORCE CONVERSION



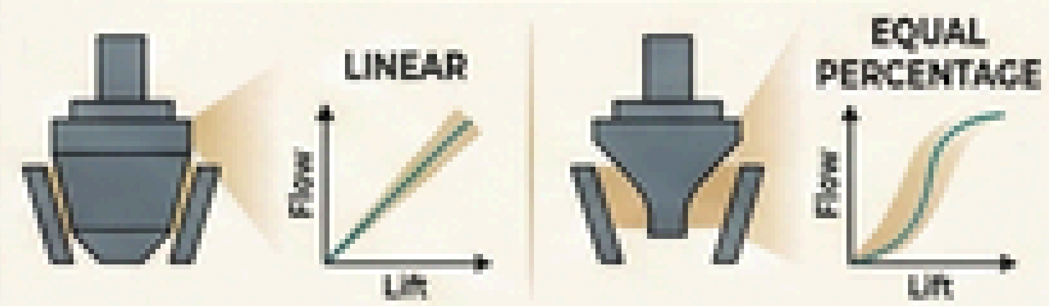
The actuator converts the low-energy control signal into a high-force mechanical motion. In a pneumatic actuator, regulated air pressure is applied to a diaphragm, creating a force that overcomes a spring's resistance. This force moves the actuator stem linearly (or rotarily for quarter-turn valves).

3. VALVE TRIM MOVEMENT & FLOW MODULATION



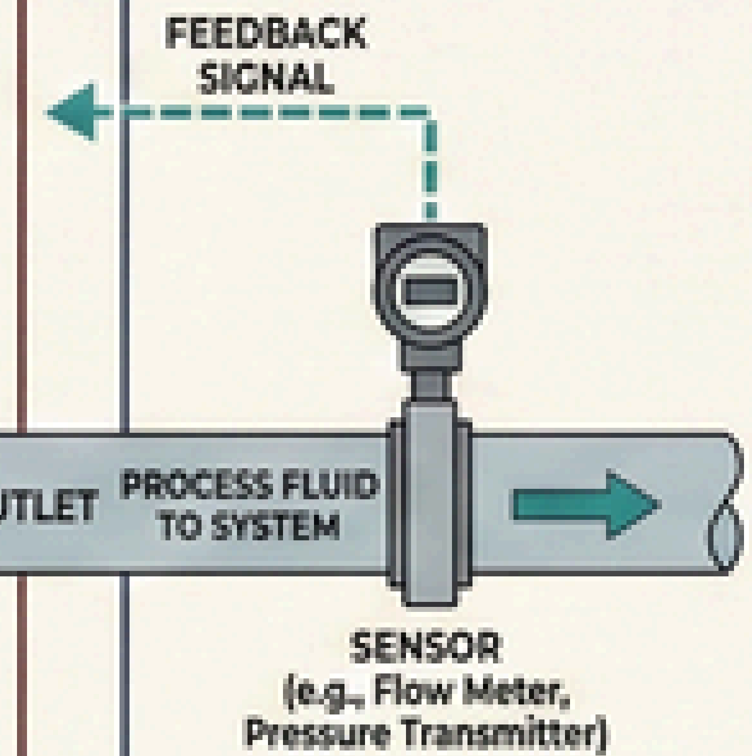
GLOBE VALVE BODY

The actuator stem movement is transmitted to the Valve Plug via the Valve Stem. The Plug moves relative to the stationary Seat Ring, changing the cross-sectional area available for fluid flow. By modulating this opening, the valve throttles the process fluid, regulating its flow rate, pressure, or temperature.



FLOW CHARACTERISTICS
The shape of the plug determines the flow characteristic, defining how the flow rate changes with valve lift.

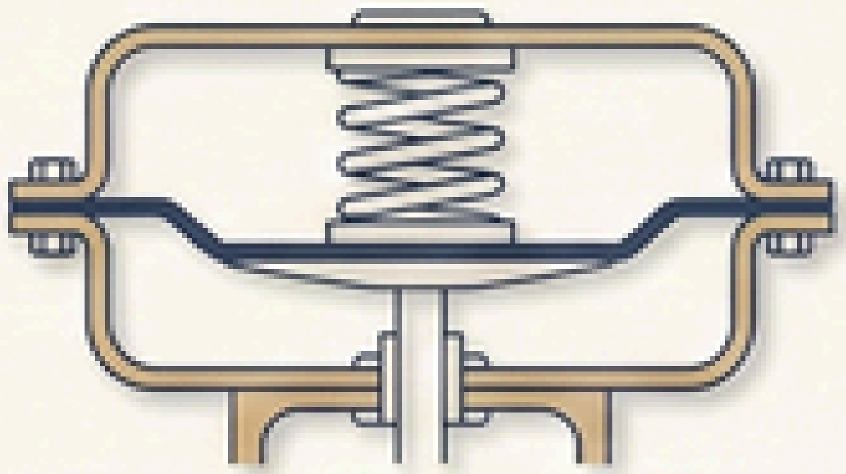
4. PROCESS & FEEDBACK LOOP



The regulated process fluid affects the downstream system. A sensor measures the resulting Process Variable (PV) and sends a feedback signal to the controller, closing the loop. The controller continuously adjusts the control signal to maintain the process at the desired setpoint, compensating for any disturbances.

CONTROL VALVE PARTS EXPLAINED

ACTUATOR (PNEUMATIC DIAPHRAGM)



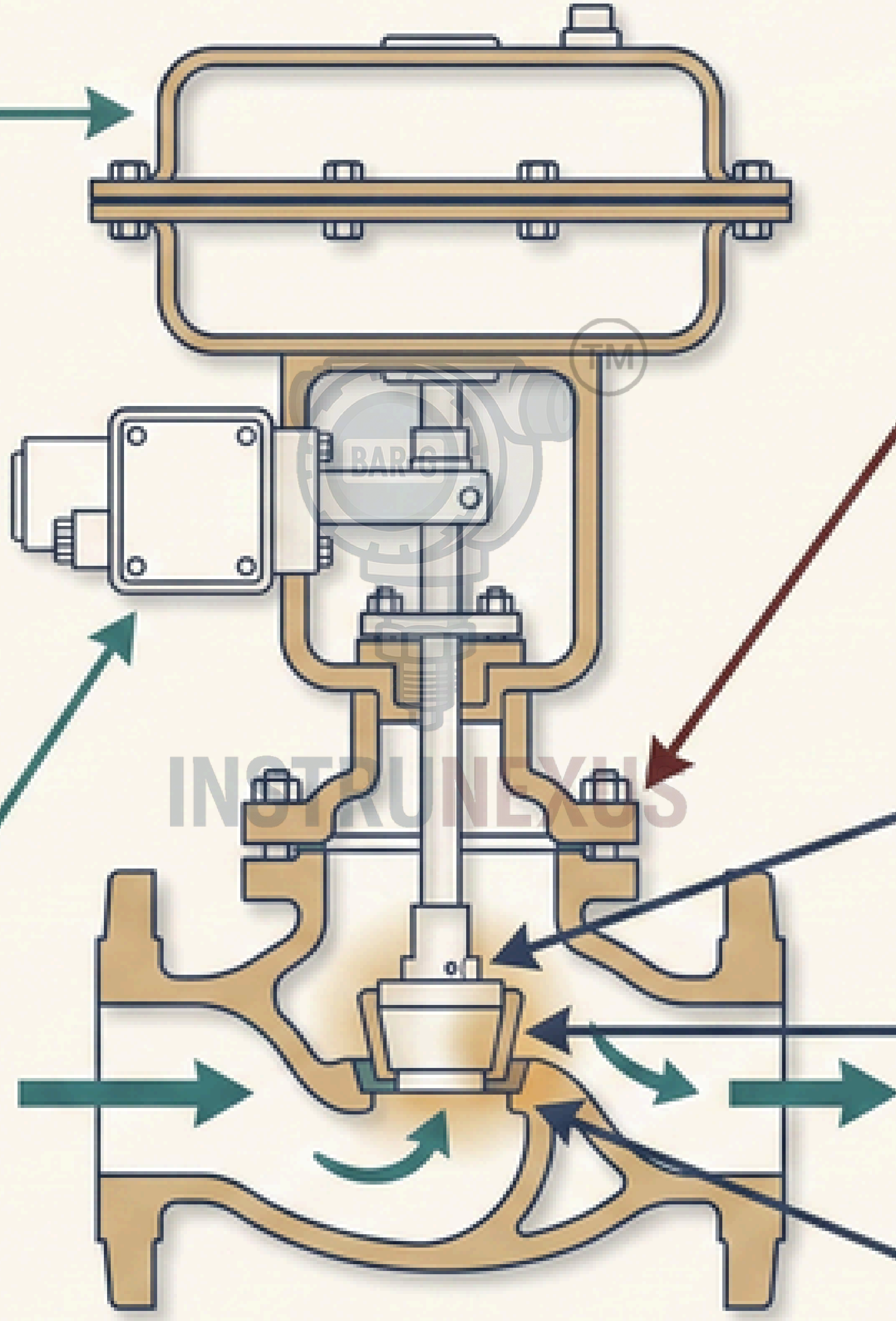
Converts control signal (air pressure) into mechanical motion to move the valve stem.

Provides force to open or close the valve against process pressure.

POSITIONER

Compares the control signal with the actual valve position and adjusts the actuator air pressure to ensure accurate positioning.

Often mounted on the actuator.



VALVE BODY & BONNET

The pressure-containing vessel that directs fluid flow.

The bonnet connects the actuator to the body and provides a seal for the stem.

VALVE TRIM

STEM

Connects the actuator to the plug, transmitting motion.

PLUG

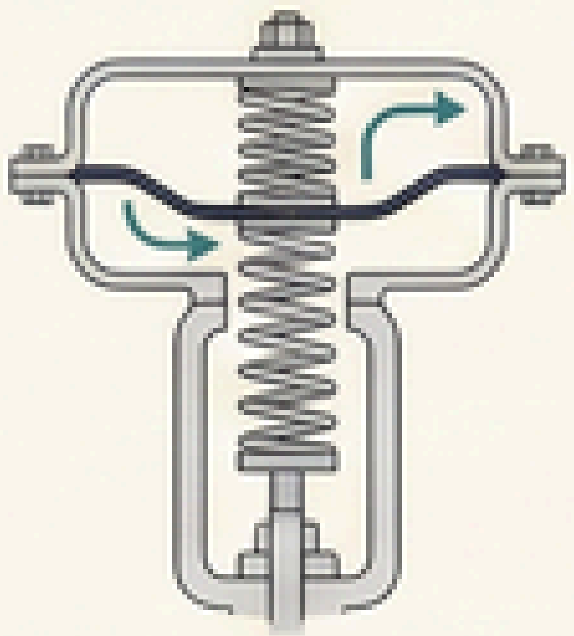
Movable element that throttles flow by changing its position relative to the seat.

SEAT

Stationary ring that the plug seals against to stop flow.

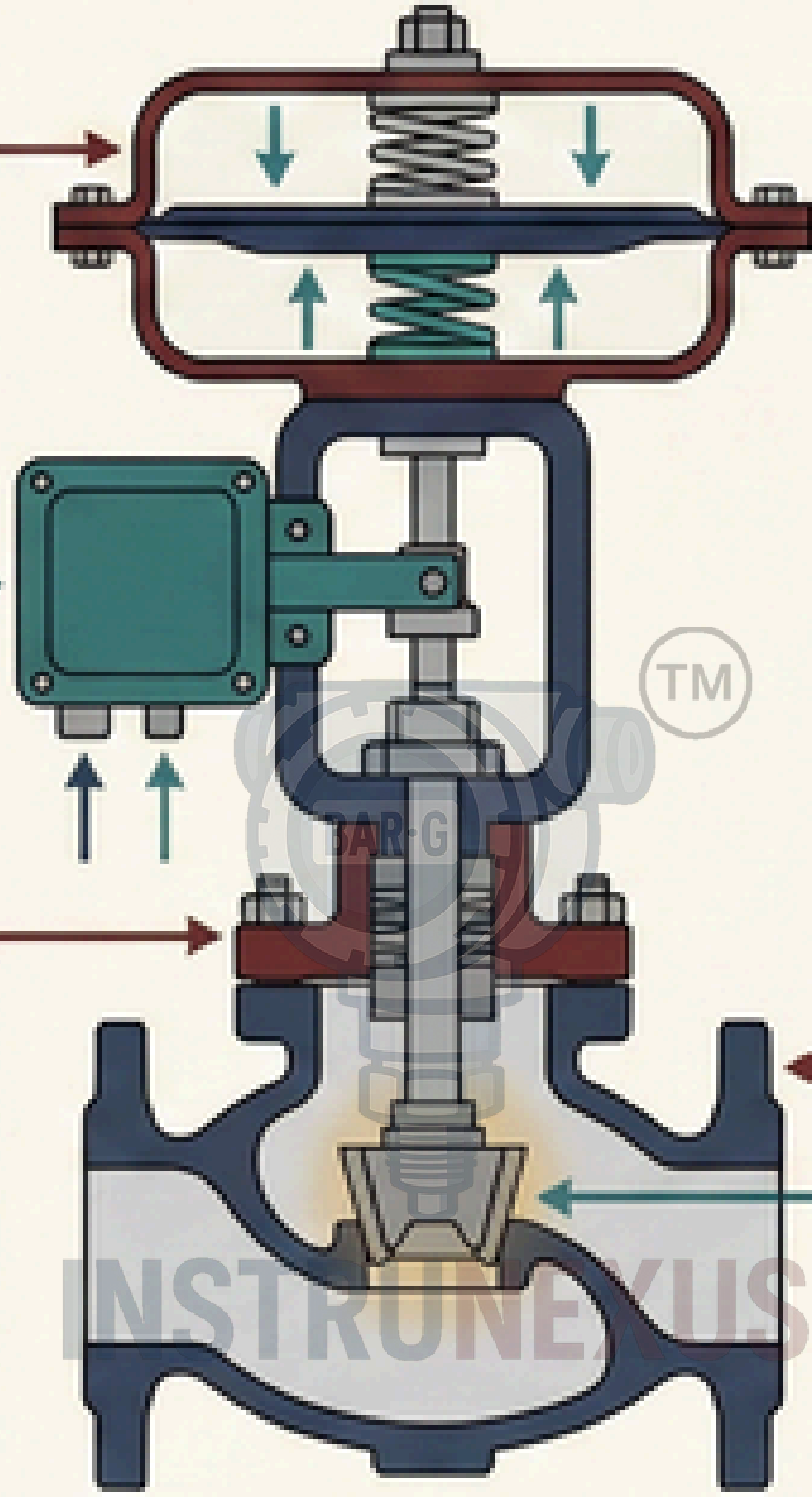
CONTROL VALVE PARTS EXPLAINED

1. ACTUATOR (PNEUMATIC DIAPHRAGM)

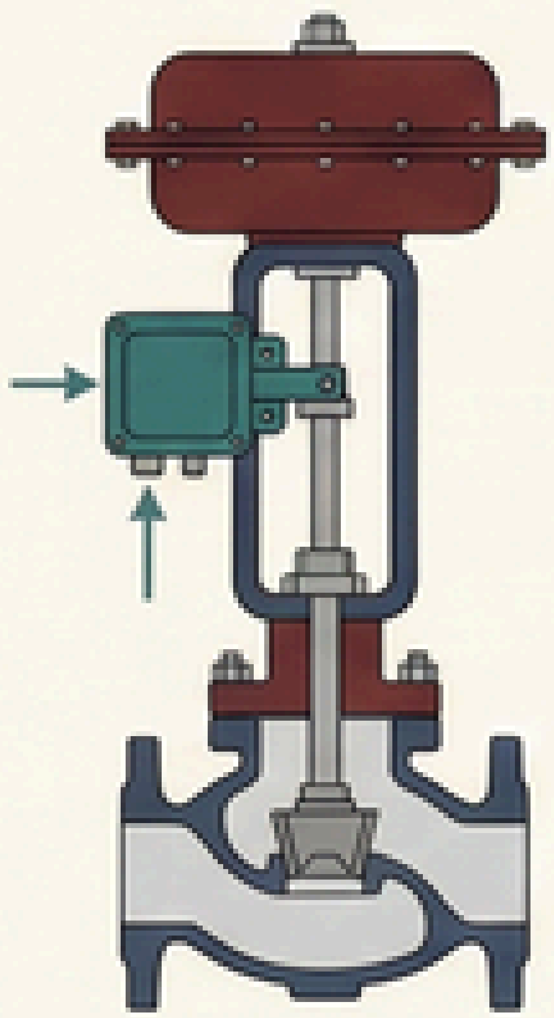


The actuator is the power source of the control valve, responsible for moving the valve to the desired position based on the control signal.

In a pneumatic diaphragm actuator, a flexible diaphragm, often made of reinforced rubber, separates an air chamber from a spring. When a pneumatic control signal (typically 3-15 psi) is applied to the air chamber, the pressure exerts a force on the diaphragm. This force overcomes the spring compression, causing the diaphragm and the connected valve stem to move. The movement drives the valve plug, thereby controlling the fluid flow through the valve body. The spring provides the restoring force to return the valve to its fail-safe position (either open or closed) upon loss of air pressure.



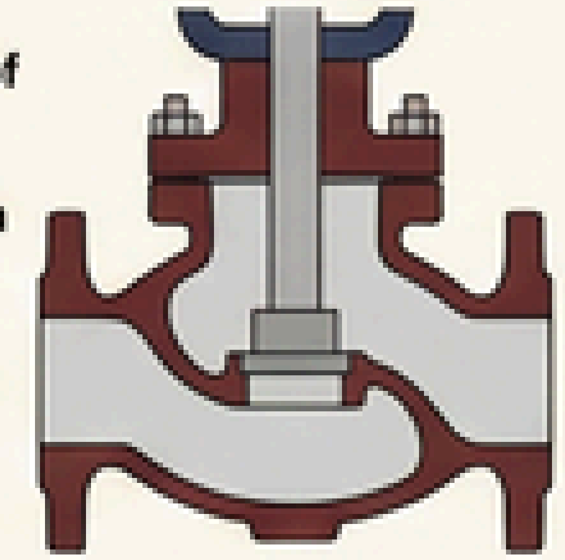
2. POSITIONER



A valve positioner is a precision instrument that acts as an interface between the control system and the actuator. Its primary function is to ensure that the valve stem accurately follows the control signal, compensating for friction, packing tightness, and process pressure forces.

The positioner receives the command signal from a controller and a feedback signal from a mechanical linkage connected to the valve stem, representing the actual valve position. It compares these two signals and adjusts the output air pressure to the actuator until the valve reaches the exact position commanded by the controller. This leads to morcurate, stable, and faster valve response.

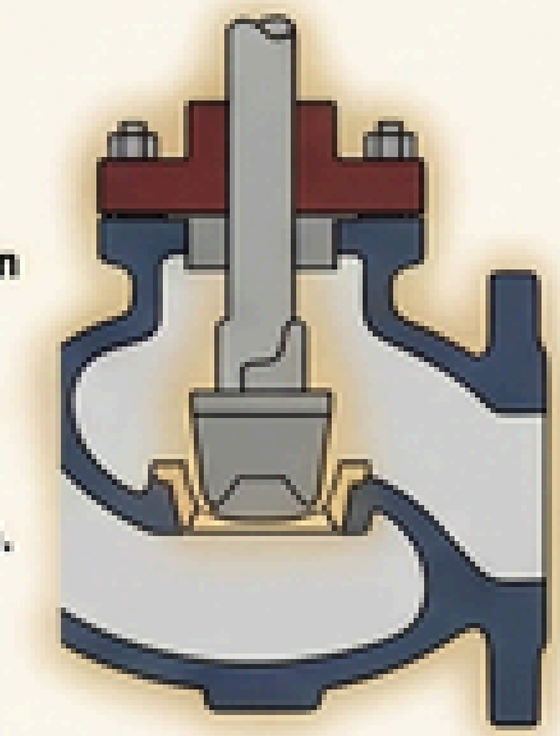
3. VALVE BODY & BONNET



The valve body is the primary pressure-retaining component of the control valve, providing the flow passage for the process fluid. It contains the internal trim components and connects to the pipeline via flanges, threaded ends, or welded ends. The material of the valve body must be compatible with the fluid's pressure, temperature, and corrosive properties.
The bonnet is an upper component that is bolted or threaded onto the valve body. It houses the valve stem and the packing box, which creates a dynamic seal to prevent leakage of the process fluid along the stem. The bonnet also serves as the mounting base for the actuator yoke and guides the stem assembly.

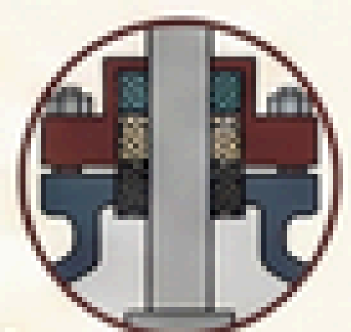
4. VALVE TRIM (STEM, PLUG, SEAT)

The valve trim refers to the internal parts of the valve that are in direct contact with the process fluid and are responsible for throttling the flow.



- STEM: A rod that connects the actuator to the valve plug, transmitting the linear or rotary motion required to position the plug.
- PLUG: The movable element within the valve body that controls the flow area by its position relative to the seat. The shape of the plug determines the valve's inherent flow characteristic (e.g., linear, equal percentage, quick-opening).
SEAT (SEAT RING): A stationary ring fixed within the valve body against which the plug seals to shut off the flow. The interaction between the plug and the seat determines the valve's shut-off tightness and flow capacity.

5. PACKING BOX ASSEMBLY

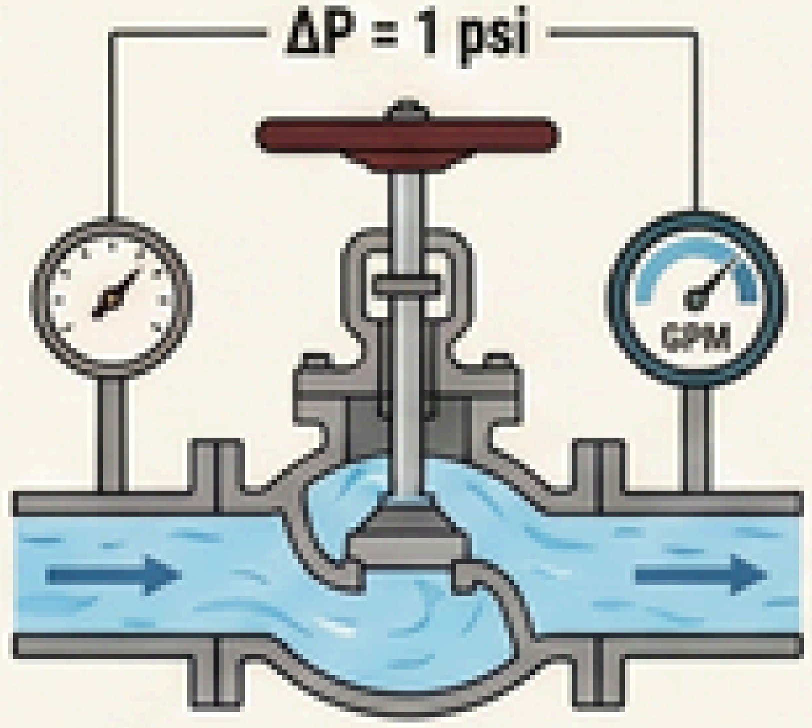


Located within the bonnet, the packing box assembly provides a dynamic seal between the moving valve stem and the valve body, preventing fluid leakage to the atmosphere. It typically consists of several rings of packing material (such as PTFE or graphite) compressed by a gland flange and packing bolts. The compression applies radial force to the stem, creating the seal while allowing stem movement. Proper selection and maintenance of packing are crucial for preventing environmental contamination and ensuring operational safety.

CONTROL VALVE Cv EXPLAINED

1. WHAT IS Cv? (VALVE FLOW COEFFICIENT)

Cv is a standardized measure of a valve's flow capacity. It represents the number of U.S. gallons of water per minute (GPM) that will flow through a valve with a pressure drop of 1 psi at a temperature of 60°F.



$$Cv = Q \cdot \sqrt{\frac{SG}{\Delta P}}$$

Q = Flow Rate (GPM)
SG = Specific Gravity of fluid (Water = 1)
ΔP = Pressure Drop (psi)

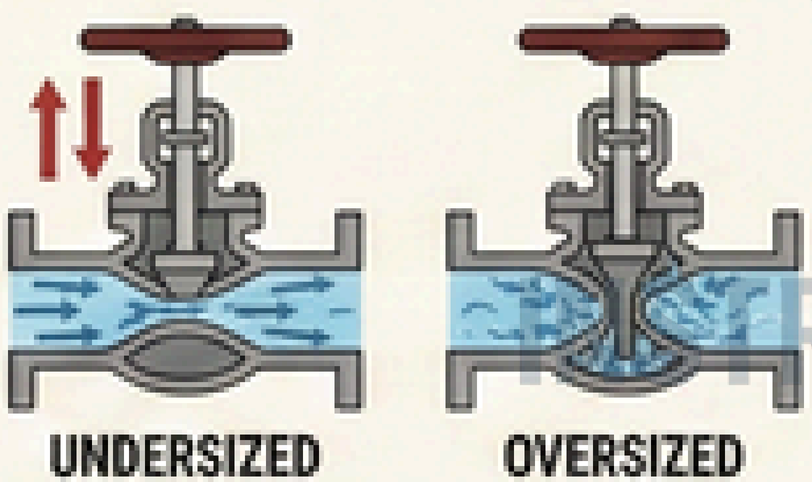
2. IMPORTANCE OF Cv

SIZING & SELECTION

Crucial for selecting the correctly sized valve for a specific application.

An undersized valve (low Cv) will cause excessive pressure drop, limit flow, and may lead to cavitation or flashing.

An oversized valve (high Cv) will operate near the closed position, causing poor control, instability, and premature wear.



PROCESS OPTIMIZATION

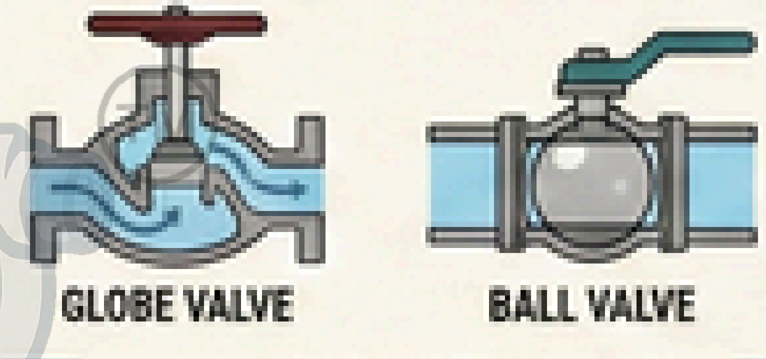
Ensures efficient and stable process control, minimizes energy consumption, and prevents system damage.

Correct Cv matches the valve's capacity to the process requirements over the entire operating range.

3. FACTORS AFFECTING Cv

VALVE TYPE & DESIGN

Different valve types (e.g., Globe, Ball, Butterfly) have inherent flow capacities due to their internal geometry.

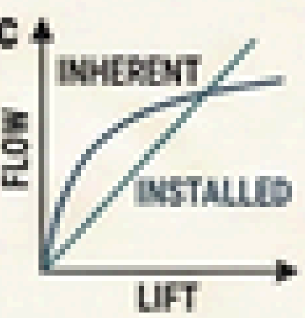


VALVE TRIM & SIZE

The size and shape of the internal trim (plug, seat, cage) directly influence the flow area and turbulence.
Reduced trim options are available for lower flow requirements within the same valve body size.

FLOW CHARACTERISTICS

The relationship between valve opening (lift) and flow rate.
The inherent characteristic is determined by the trim design, while the installed characteristic is affected by the system's pressure drop.



4. CALCULATING & USING Cv

1. GATHER PROCESS DATA

Flow Rate (Q)
Inlet Pressure (P1)
Outlet Pressure (P2)
Fluid Specific Gravity (SG)
Temperature (T)

2. DETERMINE PRESSURE DROP (ΔP)

ΔP = P1 - P2
Check for choked flow conditions (cavitation/flashing) which limit the effective ΔP.

3. CALCULATE REQUIRED Cv

Use the appropriate formula for the fluid type (liquid, gas, or steam).
For liquids:
Cv = Q * sqrt(SG / ΔP)

4. SELECT VALVE Cv

Choose a valve with a rated Cv that is slightly higher than the calculated required Cv, typically operating between 20% and 80% opening for optimal control.

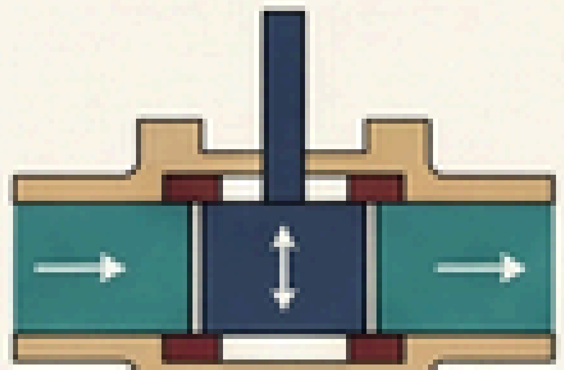
EXAMPLE: Water flow of 500 GPM
P1 = 100 psi, P2 = 90 psi. ΔP = 10 psi. SG = 1
Cv = 500 * sqrt(1 / 10) = 500 * 0.316 = 158
Select a valve with a Cv rating of approximately 200 for good controllability.

CONTROL VALVE TYPES: A COMPREHENSIVE GUIDE TO DESIGN, OPERATION, & APPLICATIONS

Control valves are the final control elements in industrial process loops, regulating fluid flow rate, pressure, temperature, or liquid level by varying the size of the flow passage as directed by a signal from a controller. Proper selection is critical for process efficiency, safety, and reliability. This guide categorizes valves based on their mechanical motion and closure mechanism.

LINEAR MOTION VALVES

GATE VALVE



MECHANISM: Operates by lifting a rectangular or circular gate (wedge) out of the path of the fluid. Designed primarily for on/off service, not throttling.

ADVANTAGES
- Provides a straight-through flow path with minimal pressure drop when fully open.
- Bi-directional sealing capability.

DISADVANTAGES
- Poor throttling characteristics; partially open gate can vibrate and erode. Slow operation (multi-turn actuation).
- Susceptible to seat wear in abrasive services.

APPLICATIONS: Isolation in pipelines, wastewater, and general utility where tight shutoff is required and operation is infrequent.

GLOBE VALVE

MECHANISM: A movable plug or disc with a stem moves linearly to close against a stationary ring seat. The flow path is changing direction, forcing fluid up through the seat area.

ADVANTAGES
- Excellent throttling and flow regulation capabilities.
- Good shutoff capability due to high seating force.
- Easy to maintain with replaceable seats and plugs.

DISADVANTAGES
- High pressure drop due to the tortuous flow path.
- Requires greater actuator force to operate against line pressure.
- Can cavitate at high pressure drops.

APPLICATIONS: Cooling water systems, fuel oil systems, feedwater and chemical feed systems where precise flow control is needed.

DIAPHRAGM VALVE

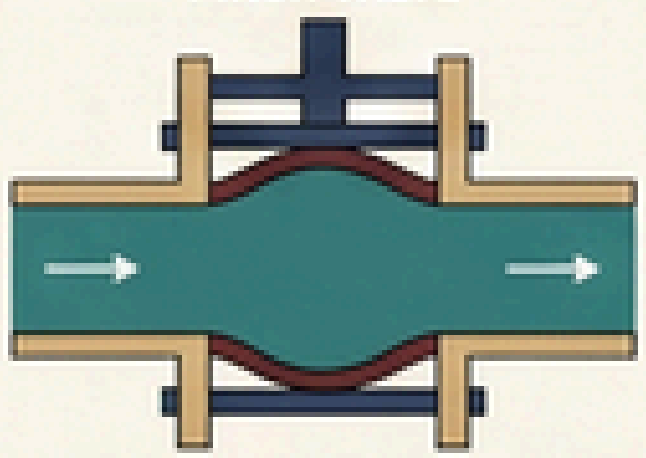
MECHANISM: Uses a flexible diaphragm to isolate the operating mechanism from the process fluid and to seal against a weir or the valve body. Two main types: weir-type and straight-through.

ADVANTAGES
- Leak-proof sealing, ideal for corrosive, abrasive, or high-purity fluids as the fluid only contacts the body and diaphragm.
- No stem packing required, eliminating fugitive emissions.

DISADVANTAGES
- Limited temperature and pressure ratings due to diaphragm material limitations.
- Poor throttling characteristics at low flows (especially straight-through type).

APPLICATIONS: Pharmaceuticals, food & beverage, corrosive chemical handling, and slurry services.

PINCH VALVE



MECHANISM: Consists of a replaceable elastic sleeve enclosed in a body. Pinching bars compress the sleeve to stop flow. The sleeve is the only wetted part.

ADVANTAGES
- Full-bore, straight-through flow path offering very low pressure drop. Excellent for handling abrasive slurries, sludges, and solids in suspension.
- Zero dead volume.

DISADVANTAGES
- Limited operating pressure and temperature capability.
- High actuation force required for large sizes.
- Sleeve wear is the primary maintenance concern.

APPLICATIONS: Mining slurry lines, wastewater treatment sludge, cement, and pneumatic conveying systems.

ROTARY MOTION VALVES

BALL VALVE

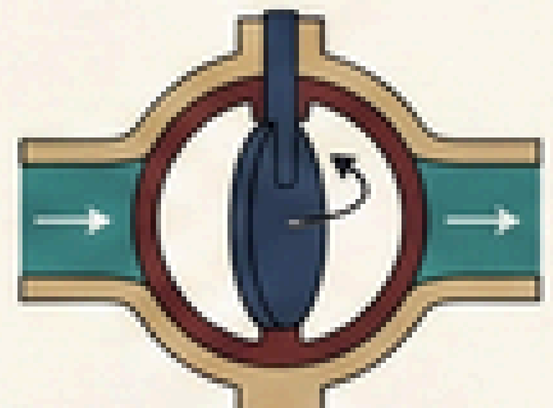
MECHANISM: A spherical closure element (ball) with a bored passage rotates to align or block the flow path. Quarter-turn operation provides quick opening and closing.

ADVANTAGES
- Tight shutoff with low torque.
- High flow capacity and low pressure drop (full port design).
- Compact and economical.
- V-port designs allow for throttling.

DISADVANTAGES
- Standard designs have poor throttling control and can cause water hammer due to fast operation. Fluid can be trapped in the body cavity, which may require venting.

APPLICATIONS: Natural gas lines, chemical processing, and general industrial on/off applications. V-port balls for control.

BUTTERFLY VALVE



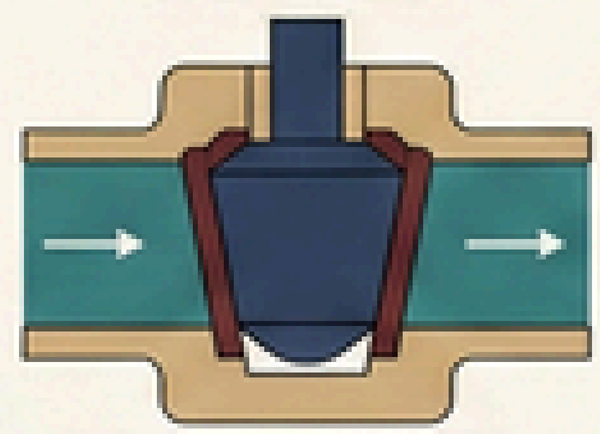
MECHANISM: A circular disc or vane rotates at right angles to the flow direction. When the disc is parallel to the flow, the valve is open; when perpendicular, it is closed.

ADVANTAGES
- Lightweight, compact, and low cost, especially in large sizes.
- Quick quarter-turn operation.
- Good for handling large flows at low pressure drops.

DISADVANTAGES
- Throttling is limited to a narrow range (typically 30°-70° opening).
- High torque required to unseat.
- Disc is always in the flow stream, can catch debris.

APPLICATIONS: Water distribution, cooling air & gas systems, and low-pressure slurry services.

PLUG VALVE



MECHANISM: Similar to a ball valve but uses a cylindrical or tapered plug with a bored passage. The plug rotates inside the valve body to control flow. Often lubricated or sleeved for sealing.

ADVANTAGES
- Simple, rugged, and reliable design.
- Provides bubble-tight shutoff.
- Good for on/off service in difficult conditions.
- Offers multi-port configurations (3-way, 4-way).

DISADVANTAGES
- High operating torque due to large seating area friction.
- Poor throttling ability.
- Lubricated types require periodic maintenance.

APPLICATIONS: Oil & gas manifolds, chemical processing, and slurry services where reliable shutoff is priority.

ECCENTRIC ROTARY PLUG VALVE (Cam-Flex)

MECHANISM: A hybrid design where the plug rotates eccentrically, lifting off the seat immediately upon opening to reduce friction and wear. Combines features of globe and rotary valves.

ADVANTAGES
- Excellent throttling control and rangeability (often > 100:1).
- High flow capacity compared to globe valves.
- Tight shutoff and extended seat life due to camming action.

DISADVANTAGES
- More complex actuation than simple quarter-turn valves.
- Can be susceptible to cavitation in certain orientations.

APPLICATIONS: Pulp & paper stock, chemical slurries, and steam control where both high capacity and precise control are needed.

SELECTION CRITERIA & CONCLUSION

Criteria	Linear Motion	Rotary Motion
Throttling	Good/Excellent	Fair/Poor (except V-ball/Eccentric)
Shutoff	Good/Excellent	Good/Excellent
Pressure Drop	High (Globe)	Low (Gate/Ball/Butterfly)
Solids Handling	Fair/Good (Pinch/Diaphragm)	Good (Ball/Plug)
Cost/Size	Higher/Larger	Lower/Compact

Selecting the right control valve requires careful consideration of fluid properties (corrosivity, abrasiveness), operating conditions (pressure, temperature, flow rate), required control precision (throttling vs. on/off), and budget. No single valve type is universal, understanding the inherent advantages and limitations of each design is paramount for optimizing process performance and ensuring long-term operational safety.

CONTROL VALVE POSITIONER: PRINCIPLES, TYPES & BENEFITS

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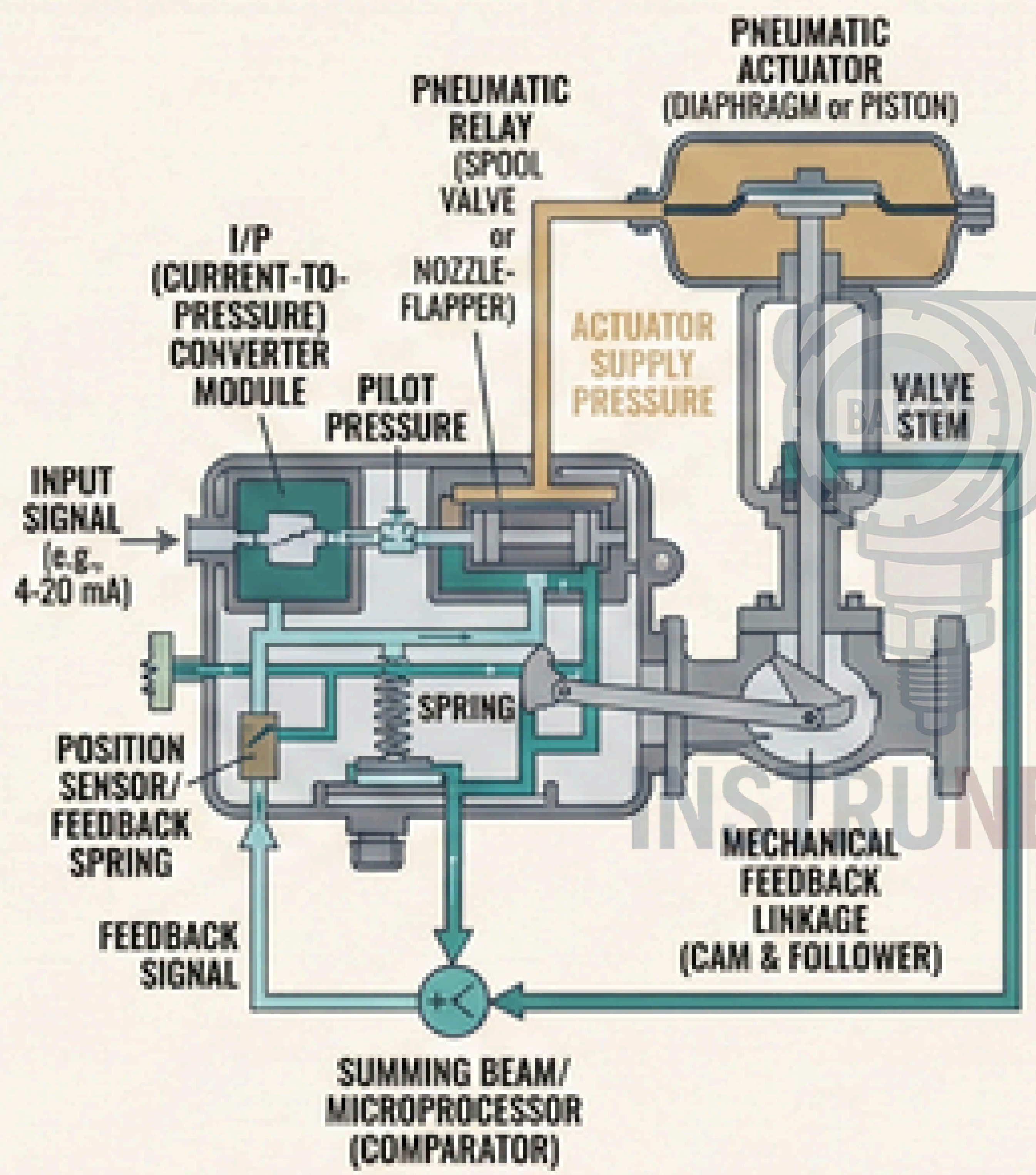
1. WHAT IS A VALVE POSITIONER? & PURPOSE

A **valve positioner** is a motion control device (servomechanism) designed to ensure that the position of a control valve's stem (or shaft) matches the command signal from a process controller. It acts as an interface, overcoming friction, unbalanced process forces, and actuator hysteresis to achieve precise and stable valve positioning.

Purpose: To improve the valve's **speed of response, accuracy, linearity**, and **repeatability**, especially in critical applications or with large/high-friction valves.

CONTROLLER (Signal) → POSITIONER (Output Pressure)
↓
VALVE STEM (Position) → ACTUATOR (Force)
↓
POSITIONER (Comparator) → FEEDBACK (Linkage) → ACTUATOR

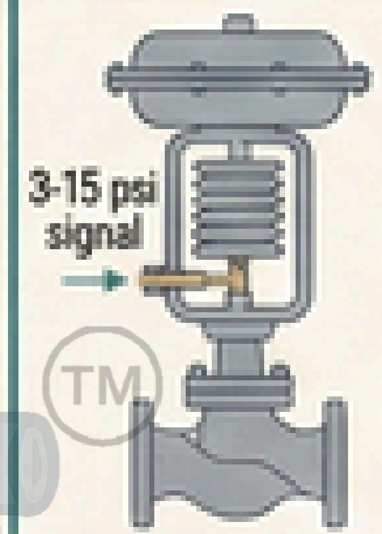
2. WORKING PRINCIPLE: THE FEEDBACK LOOP (ELECTRO-PNEUMATIC EXAMPLE)



1. **Command Signal:** Controller sends desired position signal.
2. **Conversion & Amplification:** I/P converts signal to pilot pressure; Relay amplifies it to actuator pressure.
3. **Actuator Movement:** Pressure moves valve stem.
4. **Position Feedback:** Linkage measures actual stem position.
5. **Comparison:** Feedback is compared to command signal.
6. **Correction:** If there's an error (difference), the relay adjusts the actuator pressure until the stem reaches the correct position and the system is balanced.

3. TYPES OF POSITIONERS

A. PNEUMATIC-PNEUMATIC (P/P)



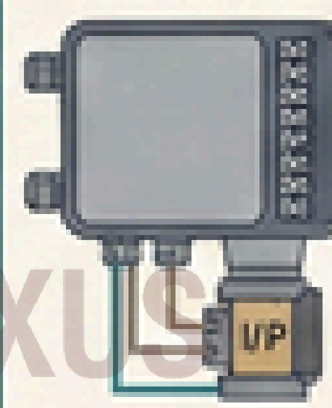
Input: Pneumatic Signal (e.g., 3-15 psi).

Operation: Purely mechanical force-balance or motion-balance system using bellows, springs, and a nozzle-flapper.

Pros: Simple, reliable, inherently intrinsically safe, no electrical power required.

Cons: Slower response, less accurate than electronic types, no diagnostics.

B. ELECTRO-PNEUMATIC (E/P, ANALOG)



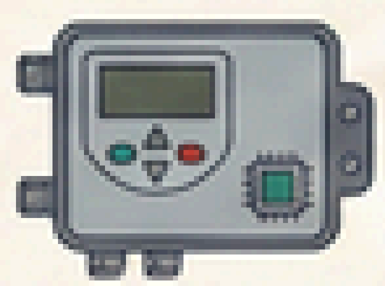
Input: Analog Electrical Signal (e.g., 4-20 mA dc).

Operation: Uses an internal I/P converter to change the electrical current into a pneumatic pilot pressure, then amplifies it.

Pros: Fast response, compatible with modern electronic controllers, higher accuracy than P/P.

Cons: Requires electrical power, susceptible to electrical noise, limited diagnostics.

C. DIGITAL (SMART) POSITIONER



Input: Digital Signal (e.g., HART, Fieldbus, Profibus) overlaid on 4-20 mA or pure digital.

Operation: Uses a microprocessor for control, feedback processing, and diagnostics. Often features non-contact position sensors.

Pros: Highest accuracy, auto-calibration, advanced diagnostics (friction, air leak, valve signature), programmable characteristics, remote communication.

Cons: Higher cost, requires digital infrastructure, more complex setup.

4. KEY BENEFITS & FEATURES

FASTER RESPONSE: Minimizes process lag by quickly supplying high-volume air to the actuator.

HIGHER ACCURACY & LINEARITY: Ensures precise valve positioning, reducing process variability.

OVERCOMES FORCES: Powers through high static friction (stiction) and large dynamic process forces on the valve plug.

ADVANCED DIAGNOSTICS (Smart): Enables predictive maintenance by monitoring valve health, friction trends, and air consumption.

SPLIT-RANGING CAPABILITY: Allows one control signal to operate two or more valves in sequence (e.g., 4-12mA for Valve A, 12-20mA for Valve B).

IMPROVED TEMPERATURE STABILITY: Compensates for ambient temperature changes affecting actuator diaphragm stiffness.

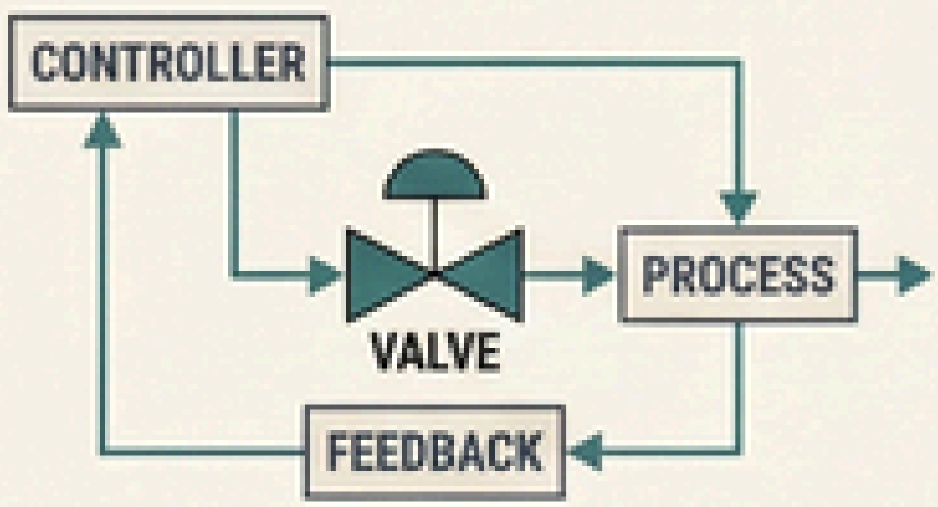
CONTROL VALVE CHARACTERISTICS: INHERENT VS. INSTALLED

1. FUNDAMENTALS OF CONTROL VALVE CHARACTERISTICS

A control valve's flow characteristic describes the relationship between the valve's flow capacity (Q) and its travel or lift (h) from the closed to open position. This relationship is crucial for achieving stable and accurate process control.

The characteristic determines how the flow rate changes as the controller adjusts the valve position. It is not just about the valve itself but how it interacts with the entire piping system.

A fundamental distinction must be made between the Inherent and Installed characteristics.



Inherent vs. Installed

Inherent Characteristic: The ideal relationship determined solely by the valve's trim geometry (plug and seat design) under ***constant pressure drop (ΔP)*** conditions across the valve. This is the manufacturer's published curve.

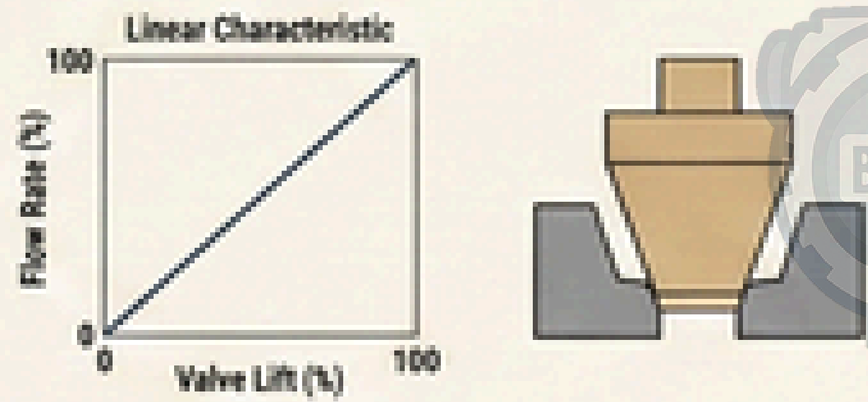
Installed Characteristic: The ***actual*** relationship observed when the valve is installed in a specific system. It is affected by the changing pressure drop across the valve as it throttles, due to series resistance from pipes, fittings, and other equipment. The installed characteristic ultimately dictates process controllability.

2. INHERENT FLOW CHARACTERISTICS (CONSTANT ΔP)

These characteristics are defined by the shape of the valve plug and assume a constant ΔP across the valve throughout its travel. They provide a baseline for comparison.

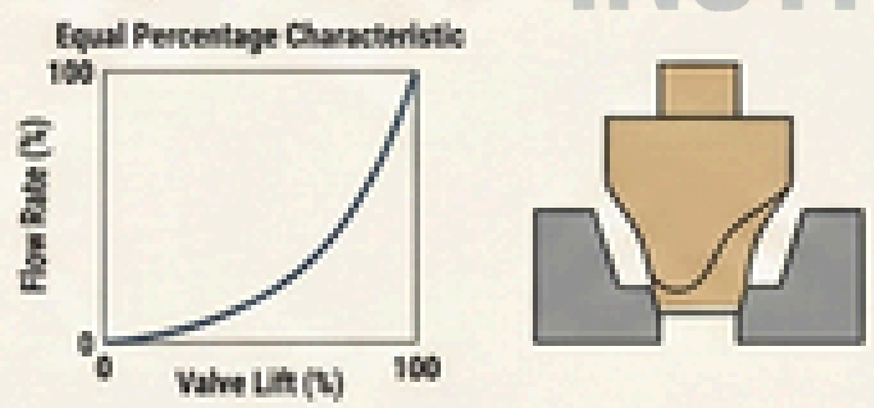
A. Linear

Flow rate is directly proportional to valve travel. A 50% valve opening yields 50% of maximum flow capacity. The gain (rate of change of flow with lift) is constant.



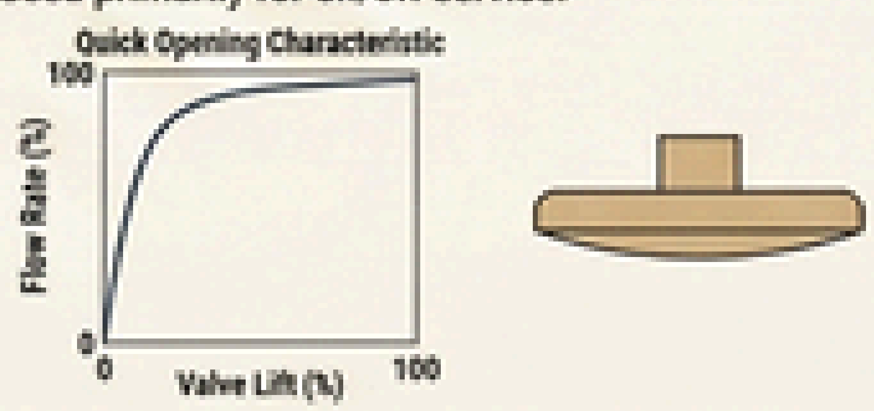
B. Equal Percentage

Equal increments of valve travel produce equal *percentage* changes in the existing flow rate. The change in flow is proportional to the flow rate just before the change. The slope (gain) increases with valve travel.



C. Quick Opening

Provides large changes in flow for very small initial changes in valve lift. Maximum flow capacity is reached at a relatively low percentage of lift (e.g., 30-50%). Used primarily for on/off service.



3. INSTALLED FLOW CHARACTERISTICS (VARIABLE ΔP)

In a real system, ΔP across the valve is not constant. As the valve opens and flow increases, pressure drop due to friction in pipes and equipment (ΔP_{system}) increases.

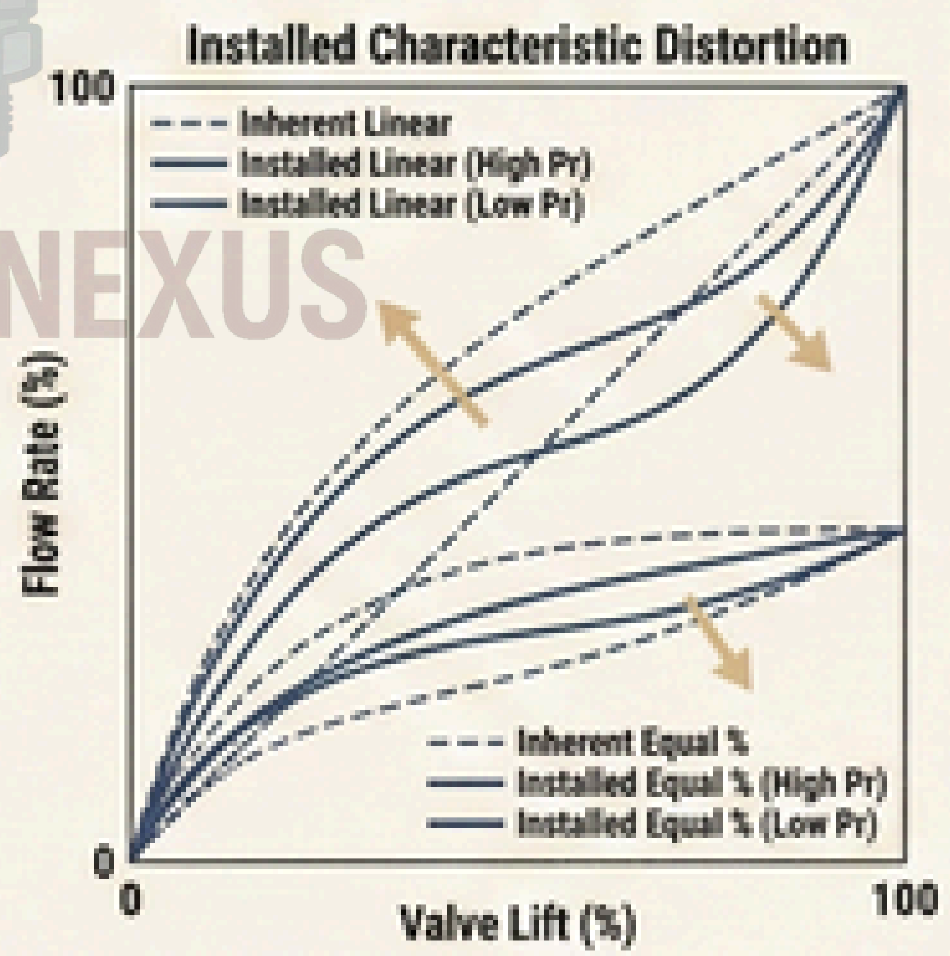
Consequently, the ΔP available ***across the valve*** decreases.

This dynamic pressure drop alters the inherent characteristic, known as 'distortion'.

The Pressure Drop Ratio (Pr)

Distortion is governed by the Valve Authority or Pressure Drop Ratio, $P_r = \Delta P_{valve\_min} / \Delta P_{valve\_max}$

A low P_r indicates significant distortion; a high P_r (close to 1) means the installed characteristic closely matches the inherent one.



Distortion Effects: An inherent Linear valve in a system with series resistance behaves more like a Quick Opening valve. An inherent Equal Percentage valve has its characteristic flattened, moving towards a Linear relationship, which is often the desired effect to compensate for system non-linearities.

4. SELECTION GUIDELINES & SYSTEM INTEGRATION

Selecting the correct inherent characteristic is critical. The goal is often to achieve a ***linear installed characteristic*** for the combination of valve and process, resulting in a constant process gain and stable control.

Selection Rules of Thumb

- **If ΔP is Constant (High Pr > 0.5):** Use a **Linear** inherent characteristic. The installed curve will remain linear. (e.g., Level control with constant head).
- **If ΔP Decreases with Flow (Low Pr < 0.5):** Use an **Equal Percentage** inherent characteristic. System distortion will flatten the curve to a more linear installed response. (Common in flow/pressure control with long piping).
- **For On/Off Service:** Use a **Quick Opening** characteristic for rapid response.
- **Consider Process Non-Linearity:** Select a valve characteristic that acts as a 'mirror image' to the process non-linearity to linearize the overall loop gain.

The Role of the Positioner

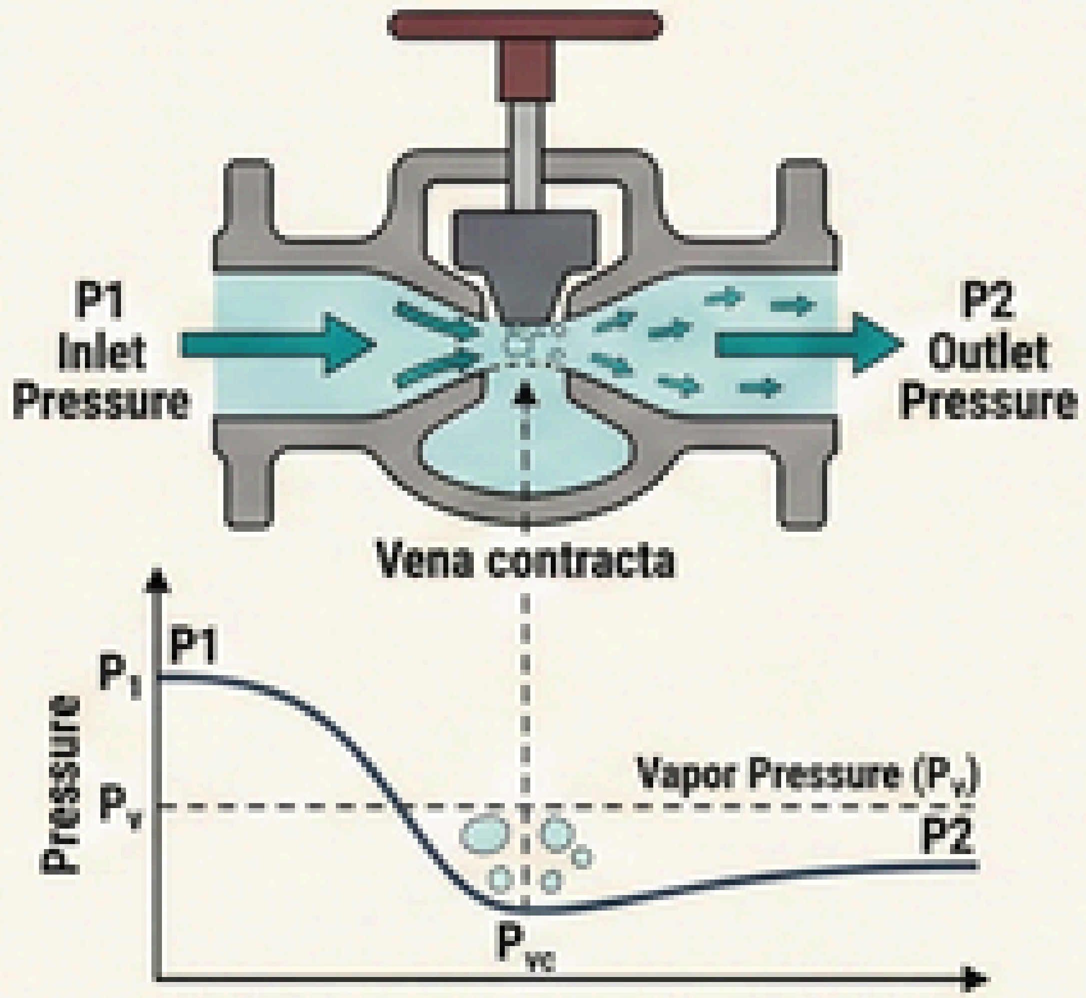
Modern digital positioners can electronically 'characterize' the valve's response, making one physical characteristic behave like another to the control signal. While useful, it's best to select the correct physical trim first. The positioner's primary role is accurate positioning and overcoming friction.

Conclusion: The installed characteristic is the true measure of performance. Understanding the interplay between inherent design and system dynamics is essential for stable, efficient process control.

CONTROL VALVE PHENOMENA: FLASHING, CAVITATION & CHOKED FLOW EXPLAINED

Understanding Fluid Dynamics, Damage Mechanisms, and Mitigation Strategies in Process Control

1. FLASHING: VAPOR BUBBLE FORMATION & SUSTAINMENT



DESCRIPTION: Flashing occurs when the process liquid's pressure drops below its vapor pressure (P_v) due to high velocity at the valve's restriction (vena contracta), causing it to boil and valve's restriction (vena contracta), causing it to boil and form vapor bubbles. Crucially, the downstream pressure (P2) remains below P_v, so the bubbles do not collapse but continue as a two-phase flow.

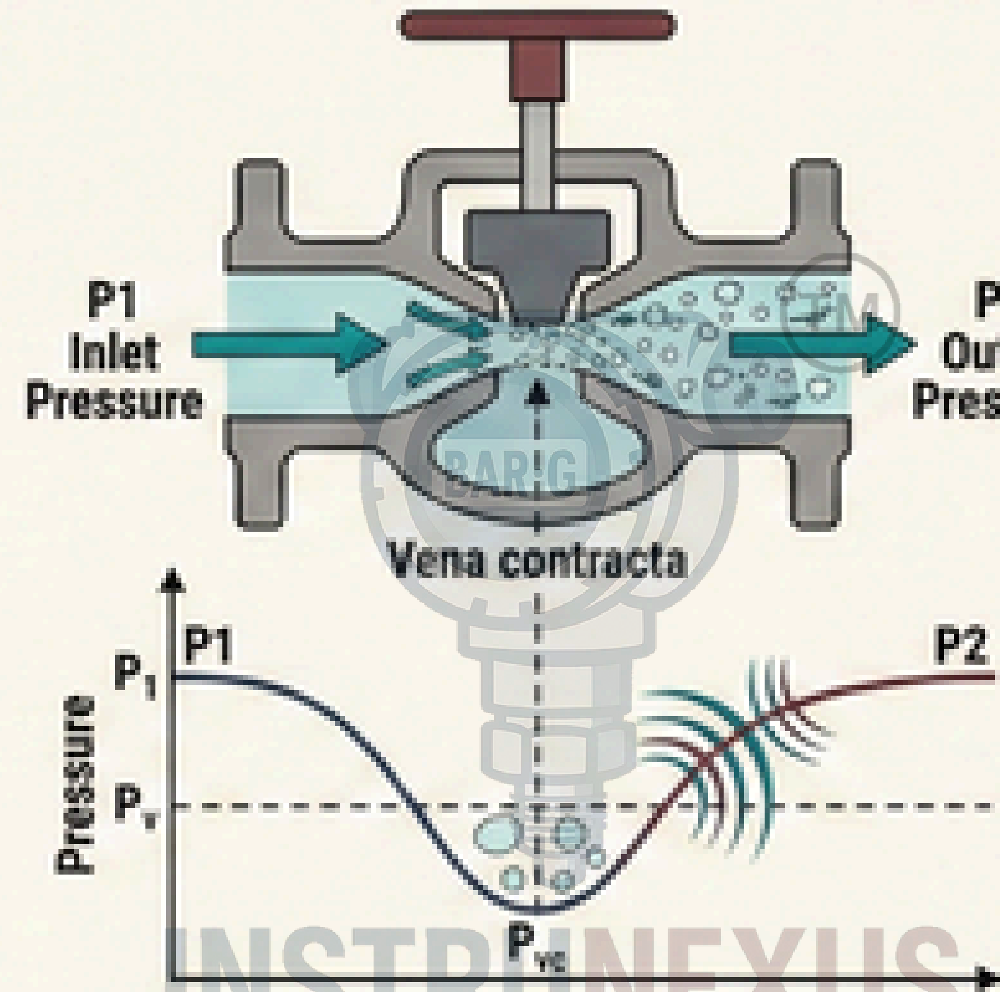
CAUSES: High pressure drop (ΔP), high fluid temperature (close to saturation), low outlet pressure.

EFFECTS: Material erosion (sandblasted appearance) on valve body and downstream piping, reduced flow capacity, noise, vibration.

MITIGATION: Increase backpressure (P2), use hard trim materials (e.g., Stellite), employ anti-flashing valve designs with expanded outlets.

Hardened Trim

2. CAVITATION: VAPOR BUBBLE FORMATION & VIOLENT COLLAPSE



DESCRIPTION: Cavitation starts like flashing, with pressure dropping below P_v at the vena contracta, forming vapor bubbles. However, the downstream pressure (P2) recovers to **above** the vapor pressure. This causes the unstable vapor bubbles to collapse or implode with extreme force, generating intense micro-jets and shockwaves.

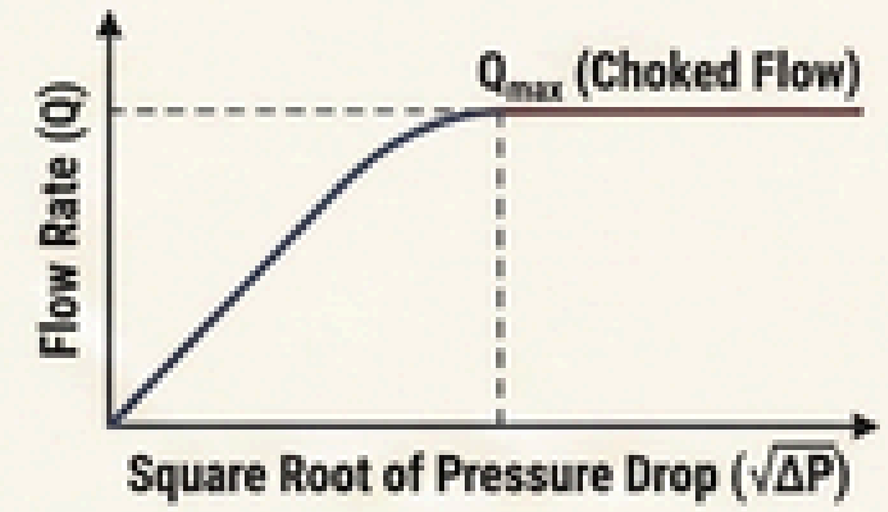
CAUSES: High pressure drop, high fluid temperature, insufficient backpressure to prevent recovery above P_v.

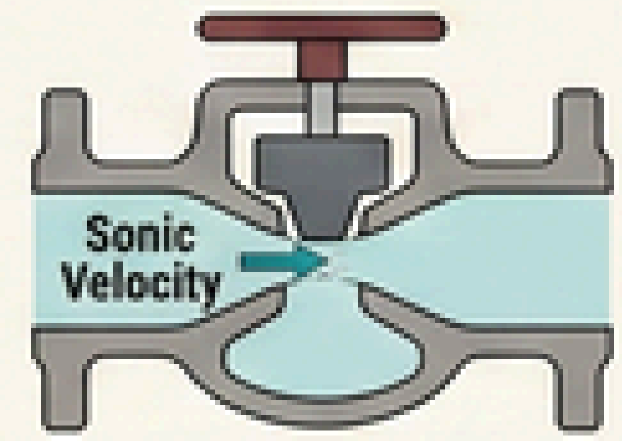
EFFECTS: Severe material damage (pitted, spongy, or honeycomb appearance) to plug, seat, and body; intense noise (like gravel flowing); high vibration; potential mechanical failure.

MITIGATION: Use multi-stage pressure drop trims to gradually reduce pressure, increase backpressure (P2), use hardened materials, install valve at a lower elevation.

Multi-Stage Trim

3. CHOKED FLOW: MAXIMUM FLOW LIMITATION



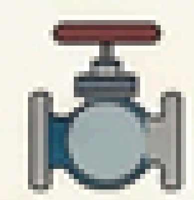


DESCRIPTION: Choked flow is a limiting condition where an increase in pressure drop (by lowering P2) no longer results in an increase in flow rate. The fluid velocity at the vena contracta has reached its maximum possible speed (sonic velocity for gases, or a limit imposed by flashing/cavitation for liquids). The flow becomes independent of the downstream pressure.

CAUSES: High pressure drop ratio, reaching sonic velocity (gases), severe flashing or cavitation (liquids) creating a flow blockage.

EFFECTS: Flow rate is capped regardless of valve opening beyond the choke point, control becomes insensitive to downstream pressure changes, potential for high noise and vibration.

MITIGATION: Select a valve with a higher flow coefficient (C_v), use a high-recovery valve for liquids to delay choking, increase upstream pressure (P1) if possible.



High-Recovery Valve

Larger Valve Size

LEGEND:
Navy Blue = Structural Elements/Main Titles;
Maroon = Section Headers/Highlights;
Teal = Liquid/Flow/Vapor/Diagram Accents;
Sand = Dividers/Footer/Icons.