

VALVE POSITIONER PRINCIPLES AND MAINTENANCE GUIDE

By,

Sangram Patnaik

Sr.Instrumentation Engineer

CONTENTS

- ❑ INTRODUCTION TO CONTROL VALVE
- ❑ INTRODUCTION TO POSITIONER.
- ❑ INTRODUCTION TO CONTROL LOOP.
- ❑ POSITIONER DESIGN AND APPLICATIONS.
- ❑ CALIBRATION TECHNIQUES.
- ❑ CONDITION MONITORING/PREVENTATIVE MAINTENANCE.
- ❑ TROUBLE SHOOTING OF POSITIONERS.
- ❑ LATEST DEVELOPMENT IN POSITIONERS.
- ❑ CONCLUSION.

INTRODUCTION TO CONTROL VALVE.

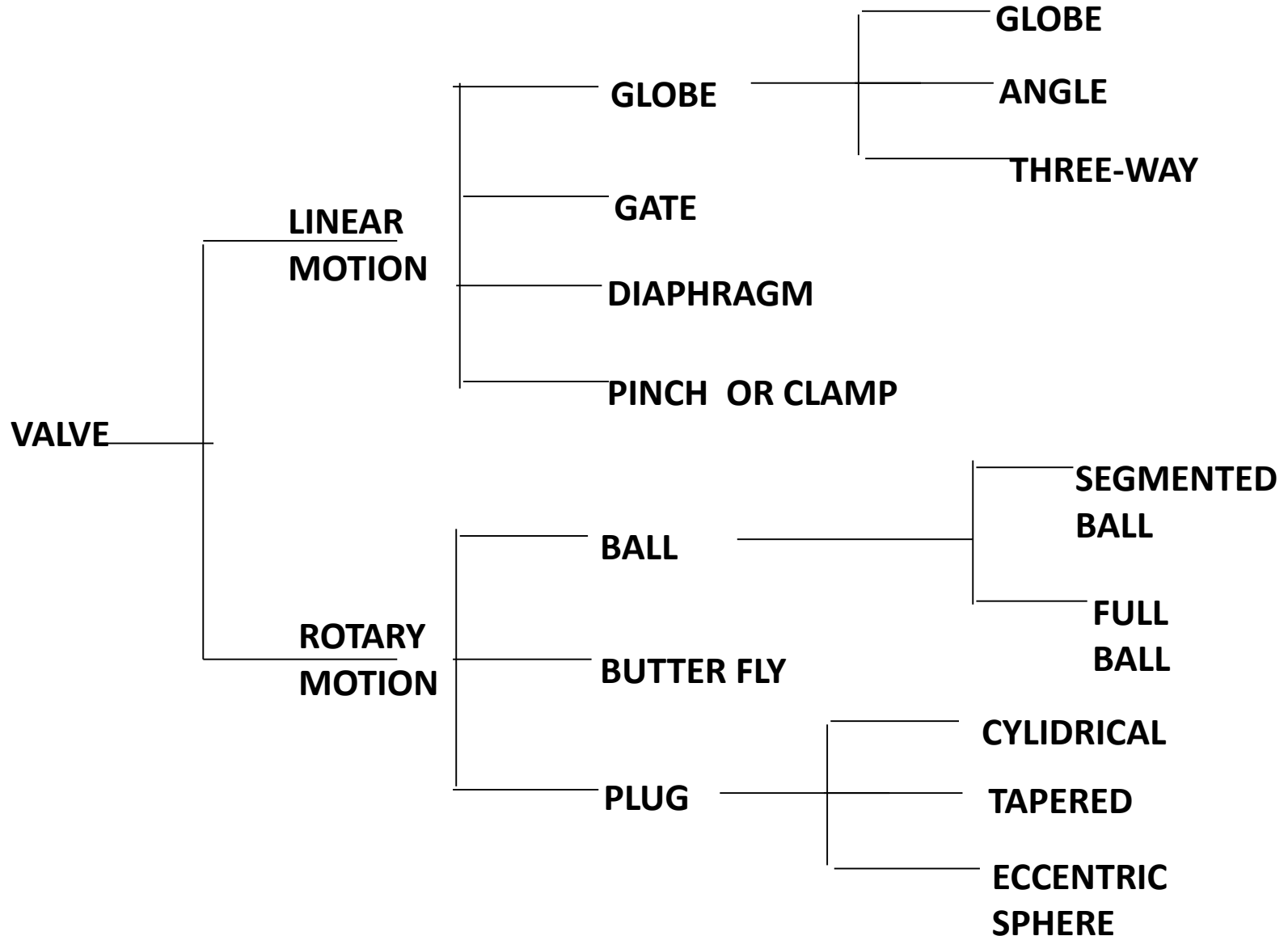
❑ A CONTROL VALVE IS A FINAL CONTROL ELEMENT AND A POWER OPERATED DEVICE WHICH MODIFIES THE FLOW RATE IN A PROCESS CONTROL SYSTEM.

It is used for

- Flowing fluid or gases
- Reduction of Pressure
- As a variable orifice
- As a throttling or modulating equipment



TYPES OF CONTROL VALVES



ACCESSORIES OF A CONTROL VALVE

- ☐ AIR FILTER REGULATOR
- ☐ VALVE POSITIONER
- ☐ VOLUME BOOSTER
- ☐ QUICK EXHAUST
- ☐ AIR LOCK RELAY
- ☐ LIMIT SWITCHES
- ☐ SOLENOID VALVE
- ☐ POSITION TRANSMITTERS

INTRODUCTION TO POSITIONER.

❑ **Positioner** is one of important accessory of the final control element i.e. Valves to maintain process parameters within its set point which is provided.

❑ A **valve positioner** is a device used to increase or decrease the air load pressure driving the actuator of a control **valve** until the **valve's** stem reaches a position balanced to the output signal from the process variable instrument controller.

❑ **Valve Positioners** are used on controlling valves where accurate and rapid control is required without error or hysteresis.

INSTRUMENTATION DEPARTMENT

EVOLUTION OF POSITIONERS



INDUSTRIAL INSTRUMENTATION REVOLUTION

1980-1990 : PNEUMATIC POSITIONER

1990-2000 : ELECTRO-PNEUMATIC POSITIONER

2000-2010 : ELECTRONIC POSITIONER

2010-2020 : SMART POSITIONER

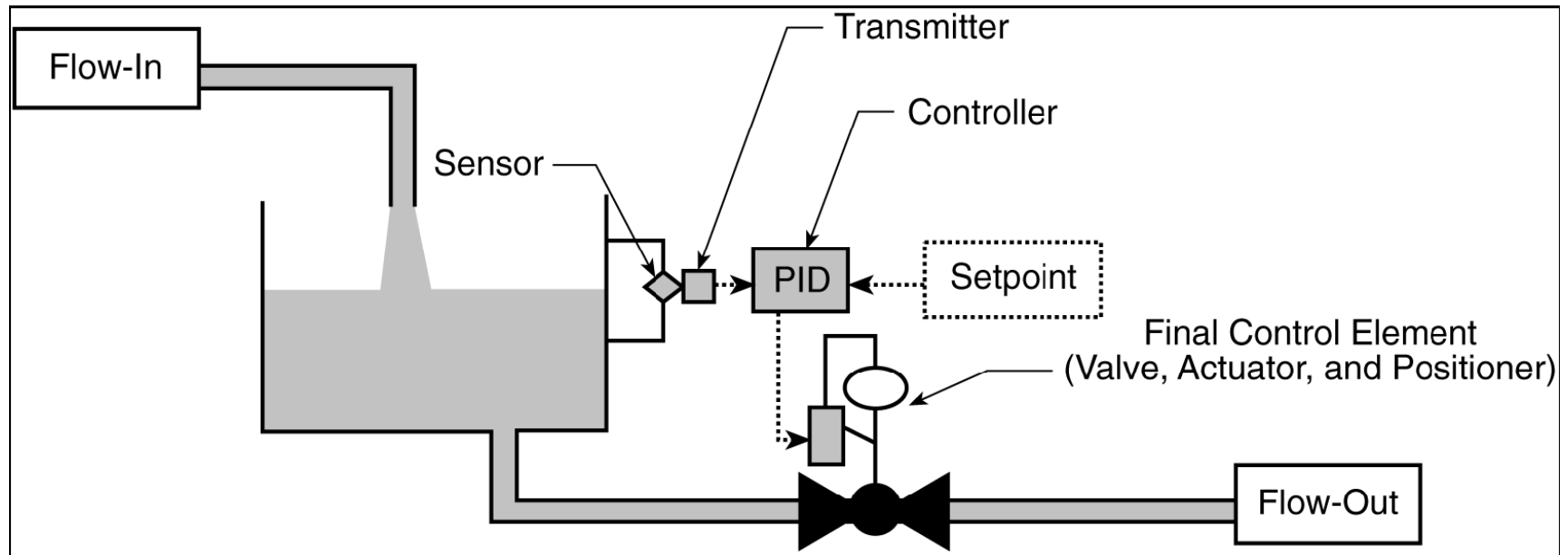
TYPES OF POSITIONERS

1. **Pneumatic Positioner** : A Pneumatic signal(3-15 psig) is supplied to positioner. The positioner translates this to a required valve position and supplies the valve actuator with the required air pressure to move the valve to the correct position.
2. **Electro-Pneumatic Positioner** : This Positioner performs the same function as the pneumatic type, but uses electrical current usually 4-20 mA instead of air as the input signal which uses I/P convertors.
3. **Electronic positioner** : This Positioner replaces the I/P convertor with an microprocessor inside the positioner itself to perform the same function as the Electro-Pneumatic Positioner.
4. **Digital/Smart positioner** : This type of positioner uses a microprocessor to position the valve actuator and monitor and record data. They are very accurate, use less air than analogue positioners, and allow for online digital diagnostics.

INTRODUCTION TO CONTROL LOOP.

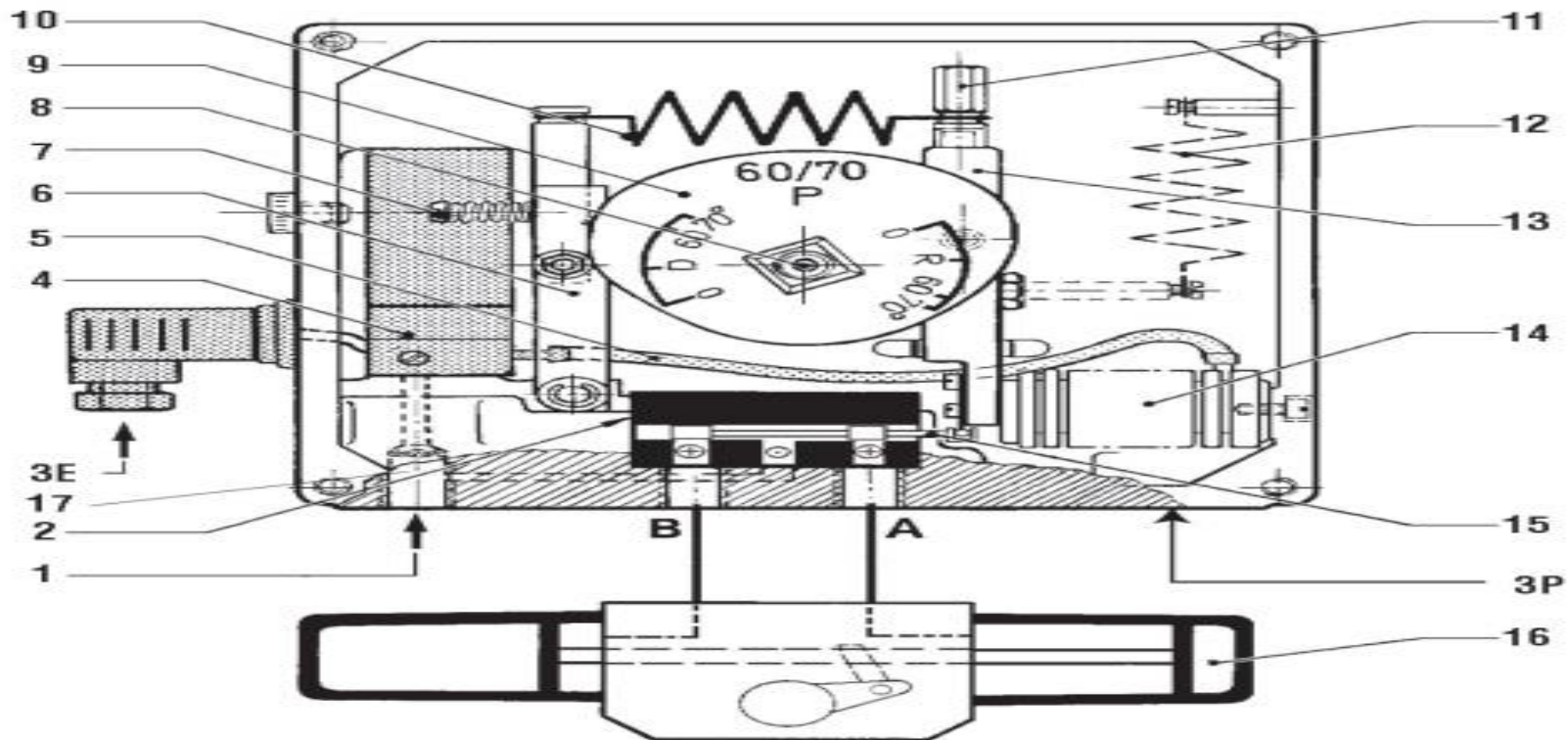
- ❑ Positioners are part of a control loop. If not specified properly or if not maintained properly, positioners can have an unacceptable effect on process control, costing both maintenance time and materials.
- ❑ The control loop is fundamentally nothing more than a group of individual components in a series, each of which responds to input from the previous component by supplying output to the next component. The goal of the loop is to work together to control a process as desired when challenged by some disturbance.
- ❑ Each process control loop may be described in terms of process variables and control elements. The control elements include a sensor, transmitter (usually lumped with the sensor), controller, and final control element.

EXAMPLE :



- ❑ The tank level is measured by the level sensor, and the level transmitter sends a corresponding signal to the controlling device.
- ❑ In most cases, this signal is electrical and has been scaled to correspond to a maximum and minimum level of interest. In the controlling device, the level signal is compared to a signal that corresponds to the desired tank level (the set point).

POSITIONER DESIGN AND APPLICATIONS.



(Table 1)

Item No	Part
1	Supply air
2	Control valve
3E	Electrical control signal*
3P	Pneumatic control signal**
4	I/P-converter*
5	Airpipe (internal connection)*
6	Cam follower arm
7	Zero adjustment screw
8	Spindle

(Table 2)

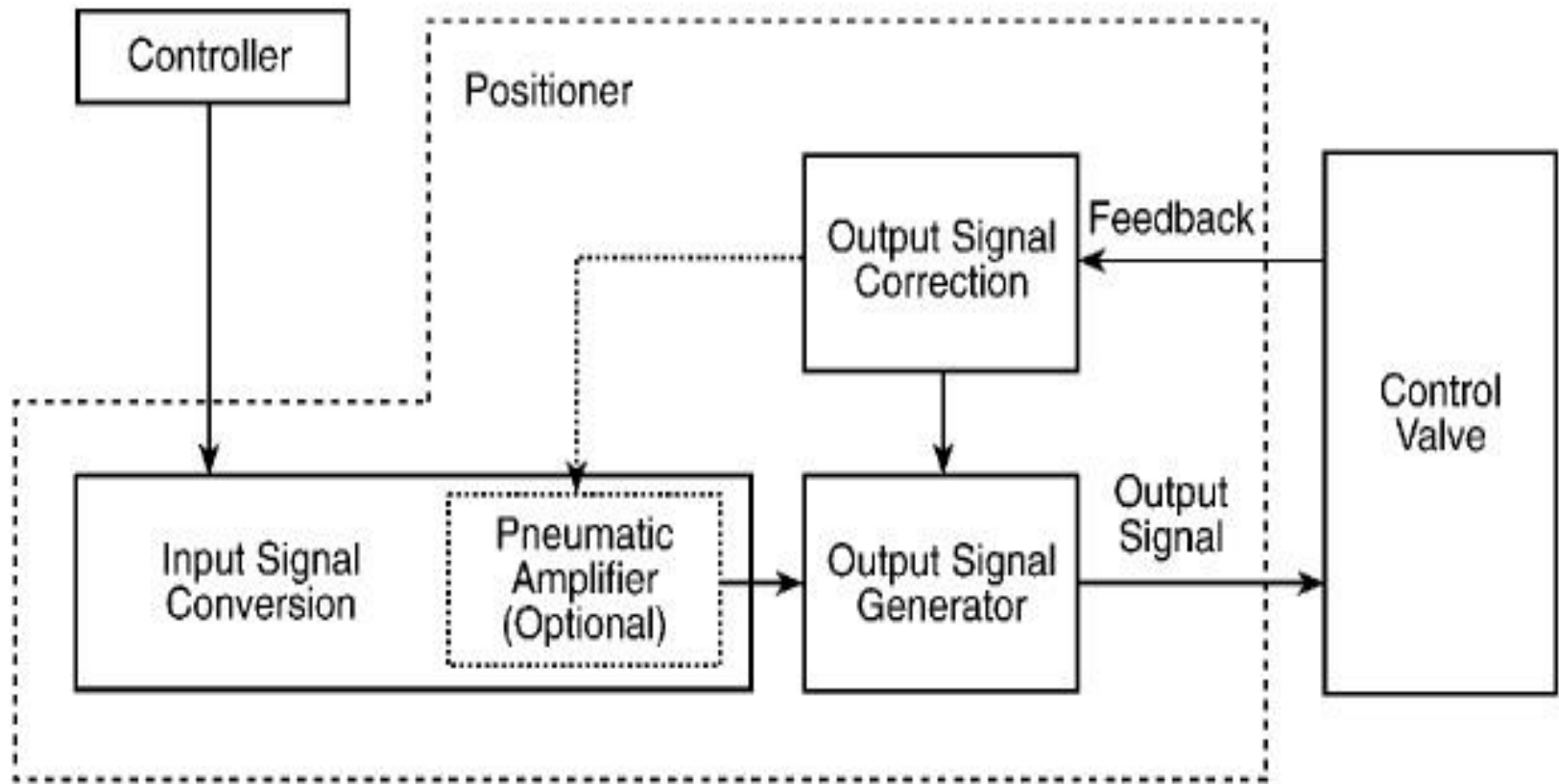
Item No	Part
9	Cam disc
10	Spring
11	Range adjustment screw
12	Spring for "Split-range"
13	Balance arm
14	Input signal bellows
15	Slide
16	Actuator
17	Separator

* NAF 370300, 370505 only, Electro-pneumatic
 ** NAF 370210, 370215 only, Pneumatic

1. POSITIONER FUNCTIONS :

- ☐ Provide an output pressure that tracks the input signal closely. This does not necessarily mean that the input and output pressures are the same.
- ☐ Provide an output pressure that increases (or decreases) rapidly whenever there is a difference between the desired position and the corresponding input pressure.
- ☐ Provide for tracking in which the output pressure increases with the input pressure increase (direct acting), or in which the output pressure decreases with the input pressure increase (reverse acting).

2. POSITIONER BUILDING BLOCKS :



2.1 Input signal conversion: The pneumatic input is converted to a mechanical motion. Positioner gain may be developed here using a pneumatic amplifier.

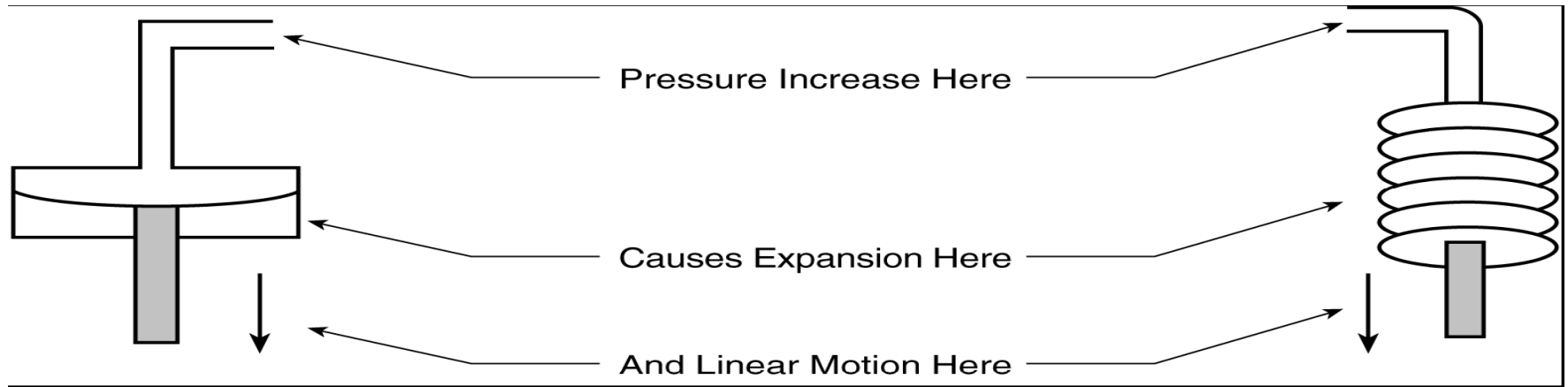
2.2 Output signal generation: A mechanical motion causes a directional control valve to change position and supply air to (or exhaust air from) the actuator.

2.3 Output signal correction: The gain developed earlier is reduced to zero.

Input Signal Conversion

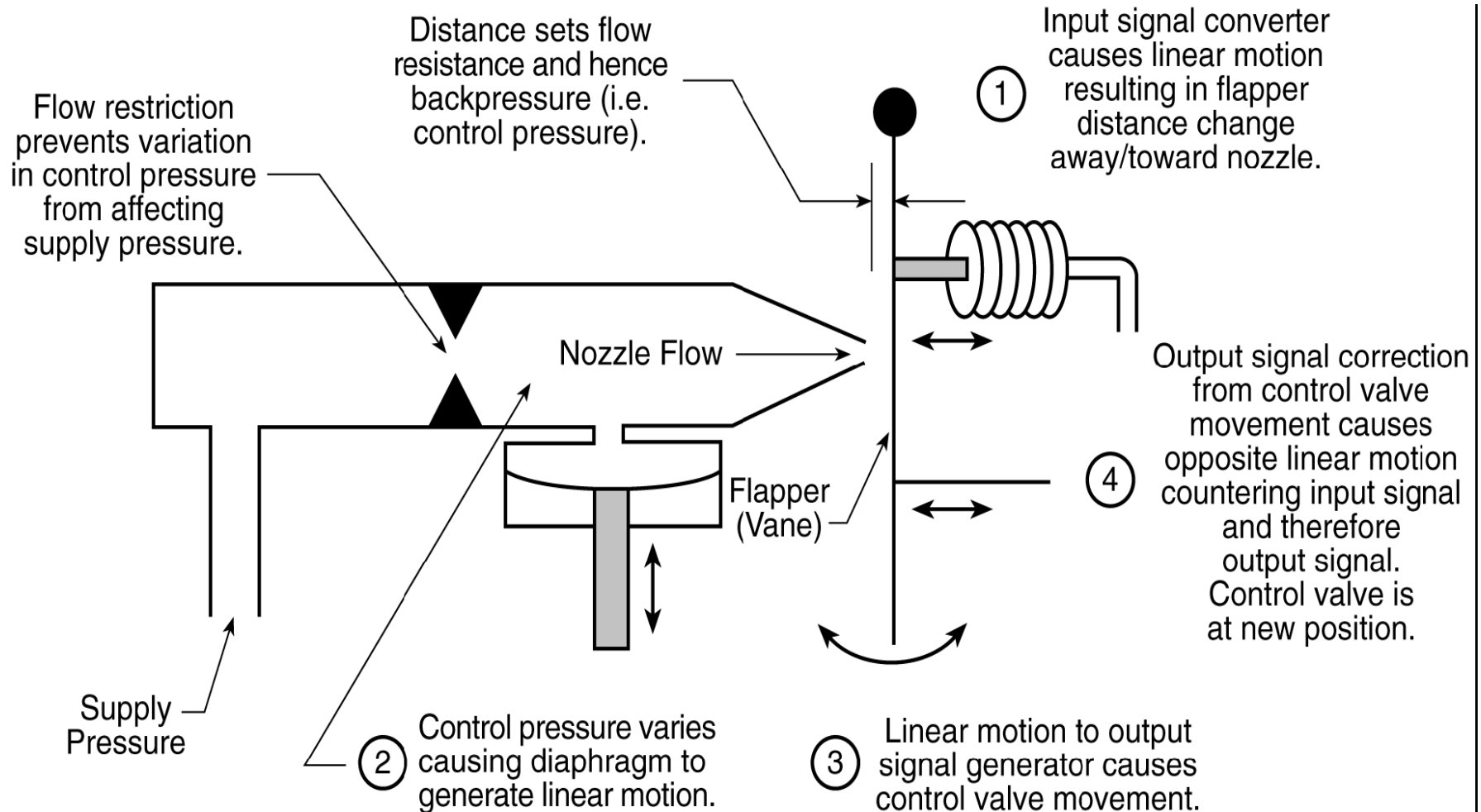
The input signal can be sent to the positioner is one of two ways:

- A pneumatic signal 3–15 psig directly from the controller.
- An electrical signal (4–20ma, 10–50ma, 0–10v) from the controller that is converted to a pneumatic signal by a current to pneumatic (I/P) converter or a voltage to pneumatic (E/P) converter that is either external or internal to the positioner.



- The pneumatic signal must be converted to a mechanical motion.
- This conversion process always begins with a diaphragm or bellows chamber.
- The changing pressure is transformed to a linear motion.
- The linear motion is now used directly to position a directional control valve within the positioner, or it is used to modulate the flapper of a nozzle-flapper.

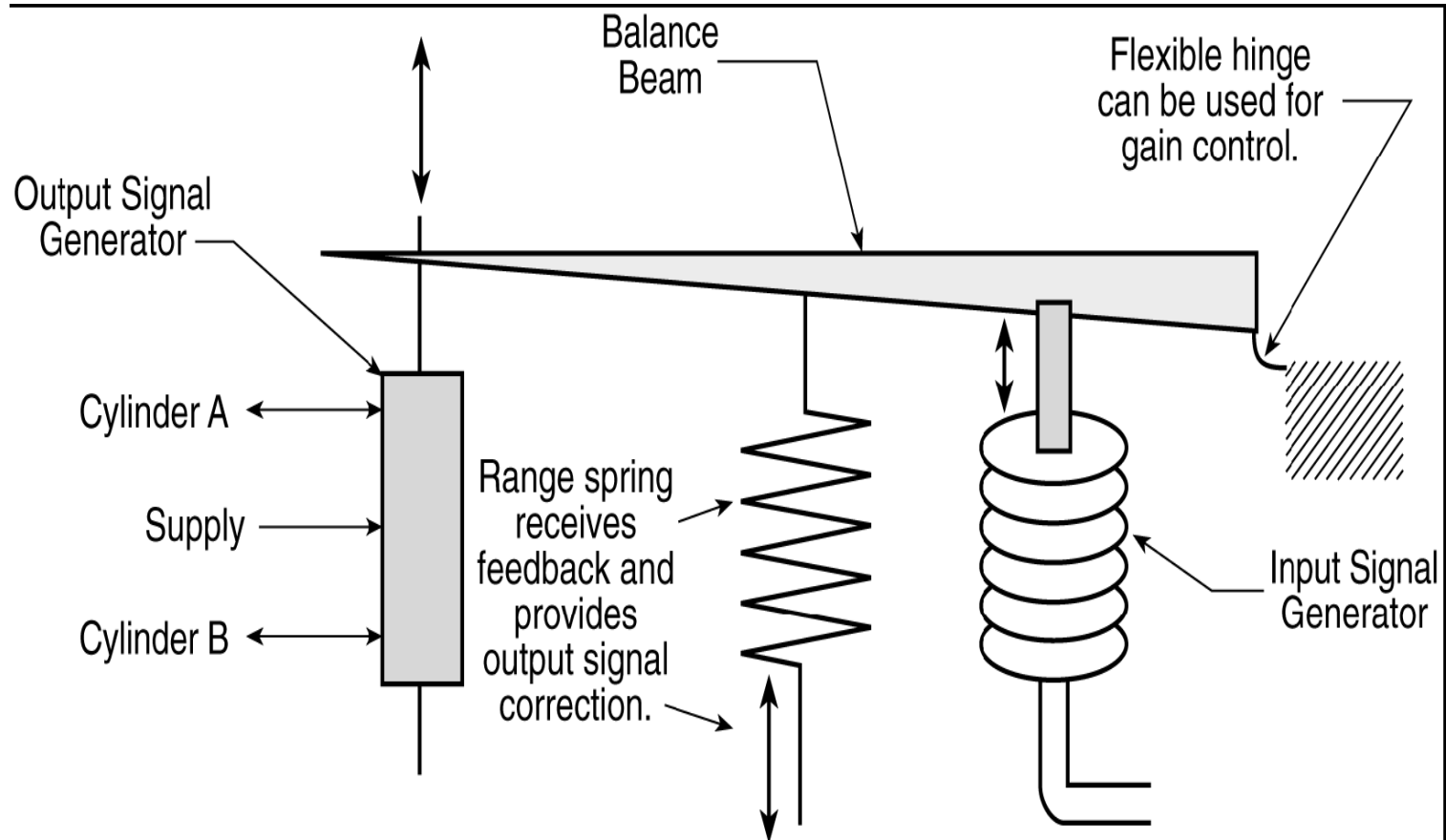
FLAPPER-NOZZLE



- During a steady state operation, supply air passes through two restrictions. The first restriction is a fixed orifice and sized to permit adequate flow for nozzle-flapper operation without affecting the supply pressure.
- The second restriction is caused by the flapper moving toward/away from the nozzle. Moving the flapper toward the nozzle increases the pressure in the nozzle chamber and vice versa.
- In other words, the orifice restriction size is smaller than the nozzle restriction size, which allows the supply pressure to bleed to atmosphere faster than it enters the unit through the fixed restriction when the flapper is away from the nozzle.
- Thus, a small pressure change in the input will produce a large change in the nozzle chamber pressure.

OUTPUT SIGNAL GENERATOR

1. Connecting the Input Converter to Output Generator



The input signal converter sends a linear motion that is used by the output signal generator in one of two ways:

- The linear motion is used directly to cause the output signal generator to move and to transmit an output signal. For example, an input diaphragm linear motion is connected directly to the stem of a sliding spool directional control valve.
- The linear motion is used to move a balance beam that causes the output signal generator to move and to generate an output signal.

2. Types of Output Signal Generators:

The term output signal generator describes the function of several different types of mechanisms that are used to provide the output signal. The manufacturers' terms used to describe the output signal generator function vary widely and include pilot valve, pneumatic relay, pneumatic amplifier, and relay.

3. Output Signal Correction:

The output signal correction is to use the feedback to nullify or balance the output when the desired position is achieved.

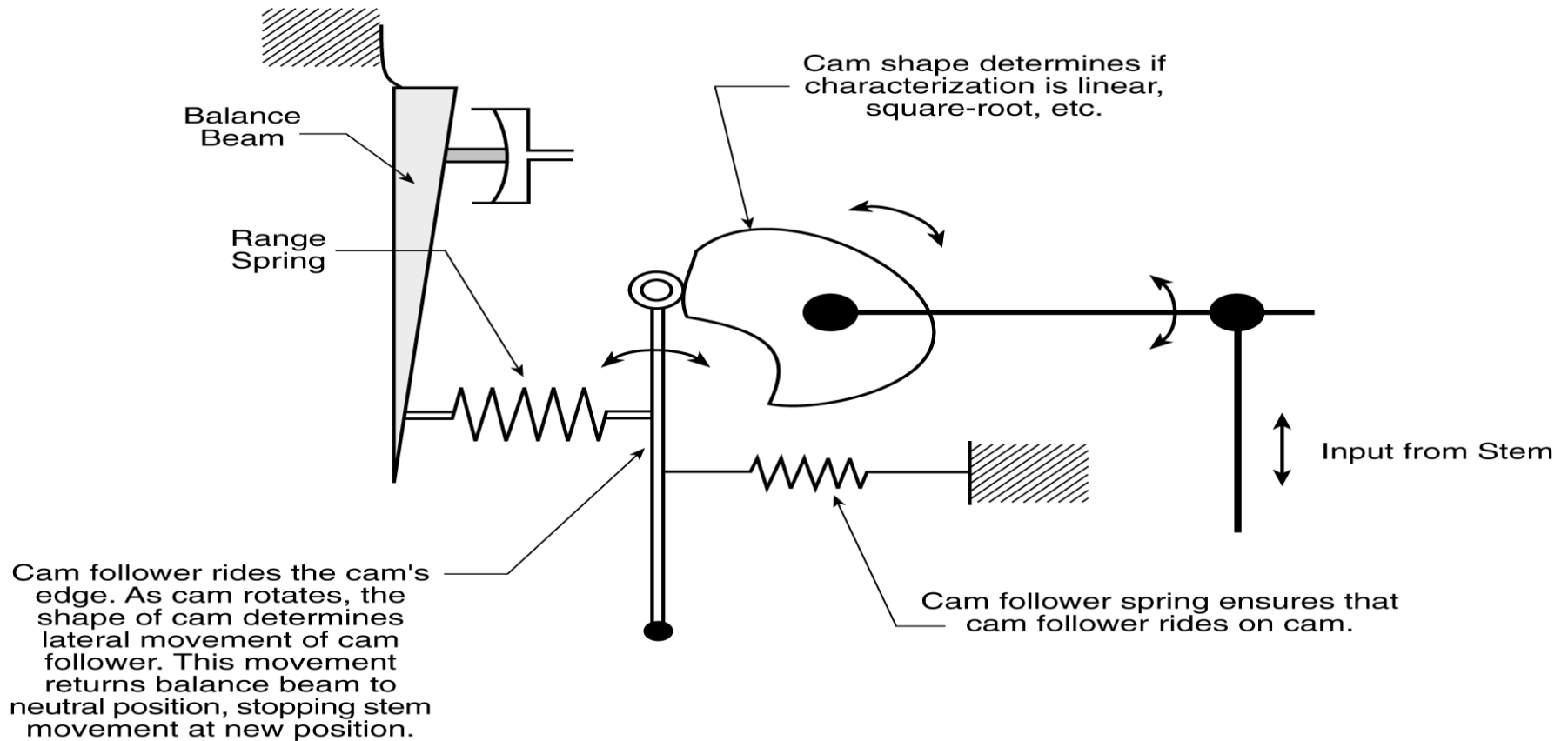
Interface Between Valve and Positioner

- To begin the balancing process, a rod, bracket, or other suitable device is attached to the stem.
- The device is mechanically routed to the positioner (for example, using linkages) to provide the appropriate motion used by the positioner: rotation or linear push-pull. If the motion is rotation,
- the input to the positioner is a lever.

Positioner Input

- ❑ A linear feedback motion always results in a proportional feedback to provide a balance force to nullify the output. In other words, no matter where the stem is, any amount of movement of the stem always results in the same but proportional amount of movement at the positioner.
- ❑ There may be an interface that allows the input range to be adjusted, but the motion remains linear. Sometimes it is necessary to modify this input. This is where the rotary motion comes in.
- ❑ Rotary motion is used in the positioner to modify the feedback in a non-linear way if desired. The reason for making it non-linear is to compensate for some non-linearity in the control loop. The universal method for doing this is by using a cam. Input from the stem causes the input lever to rotate the cam.

- ❑ The cam follower rides on the edge of the cam and follows the cam contour. This allows the original input lever motion to be changed, or characterized, before it is used to correct the output through the balance beam.



3. POSITIONERS APPLICATIONS :

- ☐ Limiting Control Valve Dead Band.
- ☐ Mitigating Stiction or Stick-Slip.
- ☐ Change Valve Response.
- ☐ Control Double Acting Actuator.
- ☐ Increase Shutoff Forces.
- ☐ Split-Ranging.
- ☐ Delays Due to Distance Between Controller or I/P Converter and Valve.

CALIBRATION.

The goal of calibration, or alignment, is to ensure that the positioner is functioning correctly within design tolerances.

The basic calibration process consists of three steps:

- I. Bench set confirmation
- II. Feedback linkage alignment, including cam alignment
- III. Zero and span adjustment
- IV. Inline or Online Calibration.

BENCH SET CONFIRMATION

This Type of Calibration is generally followed before installing a new valve into the process line. This calibration ensures proper actuator operation with air pressure as specified by the manufacturer. This calibration also mostly important for air-to-open and air-to-fail valves before installation.

Feedback linkage alignment, including cam alignment

The purpose of this calibration is to ensure that the zero and span of the feedback mechanism position correspond to the fully open (closed) and fully closed (open) valve travel positions.

Feedback alignment consists of the following:

1. Verifying that the installation is in accordance with appropriate vendor information and plant documents to determine specific requirements.
2. Verifying that the positioner is mounted rigidly to the valve.
3. Inspecting to determine that linkage is tight and that appropriate washers are installed.
4. Checking and adjusting feedback linkage so that it is within allowable limits.
5. Making sure there is freedom of movement throughout the range of travel so that the positioner is not “in the stops” at the ends of travel.

6. Verifying that the appropriate cam is installed or, if the cam is a multiple type, that the feedback mechanism is on the correct range, for example, linear, square, or square root.
7. Setting the feedback mechanism to the zero position on the cam.
8. If applicable, setting the stroke lever parallel to the spring lever at midstroke.
9. Stroking the valve and adjusting the appropriate linkages to ensure that the cam rotates in the correct direction, stops at the 100% position, and returns to zero as appropriate

Zero and span adjustment

❑ The purpose of the zero and the span adjustments is to synchronize the valve position to positioner demand. At first, this seems to be just varying the input pressure from the bottom to the top of the control range (for example, 3–15 psig [20.7–103.4 kPa]) and making sure that the valve strokes appropriately.

- ❑ Before beginning the zero and span adjustment, determine if the positioner is a motion balance type, for example, Metso,YTC. If the motion beam has been repaired or otherwise affected by maintenance, then beam or flapper levelling is required before the zero and span adjustments.
- ❑ Before Zero and Span one should go through the technical manual of the positioner.
- ❑ Zero adjustments are always done in conjunction with span adjustments. In other words, after the span has been adjusted, the zero adjustment must be re-verified to ensure that the zero adjustment has not changed.

INLINE OR ONLINE CALIBRATION

- ❑ Online Calibration can only be performed in smart or digital positioner. The calibration is performed online in the field itself ensuring both inlet and outlet manual valves adjacent are in close condition.
- ❑ This Calibration the positioner itself has an option in its display to calibrate the valve in the process line. Based on the calibration results the decision of removing the valve outside the line or not can be judged.

CONDITION MONITORING/PREVENTATIVE MAINTENANCE.

- ❑ Condition monitoring for positioners is primarily the continuation of the calibration process. Calibration must be done carefully and consistently for condition monitoring/preventive maintenance to be effective. Persistent, significant calibration drifts can be used to identify the need for positioner repair or replacement.
- ❑ All condition-monitoring processes rely on the ability to trend the right data accurately. In the hands of trained and experience personnel, a digital acquisition system not only gathers data accurately but does it quickly, efficiently and consistently monitor the condition of the positioner before it gets fail.

The **Preventative Maintenance** of the Positioner can be achieved through three important preventative maintenance actions in the field .They are :

1. Air supply check
2. Walk down inspection
3. Internal inspections (as applicable)

Air Supply Check

1. Verify air quality.
 - a. Air quality affects air positioner performance. Some positioner manufacturers specify to maintain air quality within 3 to 7 microns.
 - b. The dew point may also be a factor and should be reviewed to ensure that the air supply is per the manufacturer's specification.
 - c. The oil or hydrocarbon content can be detrimental to elastomers, thus increasing the likelihood of air leaks.

2. Blow down the regulator, and inspect the effluent for contaminants.
3. Verify the air supply pressure to detect regulator set point drift.
4. Inspect the regulator, tubing and fittings, and positioner for air leaks using a soap solution or equivalent.
5. Inspect tubing for cracks and kinking.

Walk Down Inspection

A recommended checklist may contain the elements inspected in the following tasks:

1. Observe the exterior to detect signs of physical damage to the housing, connections, pipe/tubing, hoses, feedback and linkage.
2. Feel the housing, and carefully determine if it is firmly attached to the valve.
3. Inspect for air leaks. If possible, check all pneumatic connections with a soapsuds solution to detect any leakage.

4. Observe the pressure gages, and note if pressures are consistent with required supply pressures, expected signal pressure for valve position, and expected output pressure for the valve position.
5. If the feedback cam position is visible, determine if its position is consistent with the valve position.
6. Observe the valve motion to see if the response is consistent with the changes in signal/output pressure variation.

Internal Inspection(Applicable)

It is recommended that the air supply be isolated when performing the following internal inspections:

1. Inspect the pilot valves for sign of scarring and wear; clean or replace them as necessary.
2. Ensure that the pilot valve is properly aligned.
3. Inspect the flapper for signs of pitting or damage.
4. Inspect the nozzle for signs of erosion or damage.

5. Inspect the cam and cam roller for signs of wear.
6. Ensure that the cam roller rotates freely and is properly oriented.
7. Ensure that the cam roller snap rings are installed properly.
8. Ensure that the proper cam is installed and correctly oriented.
9. Inspect the springs, and verify that all are connected and of the proper type.
10. Inspect the gaskets, O-rings, and filters. Clean or replace them as necessary.
11. Replace the over-ranged gauges.
12. Ensure that the bypass block, relay and gauge block manifold are tightened properly.
13. Clean the restrictions; for example, clean out the plunger.

Note : Internal Inspection should only performed during any shutdowns or after process clearance.

Trouble-Shooting.

❑ Troubleshooting is the systematic approach to data collection, failure analysis, and the use of a test/measurement plan that collectively result in high confidence that the complete cause of system/equipment degradation has been corrected and that the system/equipment has been restored to normal operation.

❑ Ideally, troubleshooting is a continuation of condition monitoring/preventive maintenance. In Walk-down Preventative Maintenance method the positioner operation can be obtained by following symptoms based approach to determine the symptoms of the positioner mounted in the field.

INSTRUMENTATION DEPARTMENT

CAUSE	PROBLEM							
	Erratic or Jerky Throttling	Failure to Fully Retract	Failure to Fully Extend	Cycling	Failure to Stroke	Sluggish/ Slow	Slow in Increasing Air Pressure Direction	Slow in Decreasing Air Pressure Direction
Actuator Supply Pressure Low		X	X		X	X		
Actuator Supply Pressure High	X				X ¹			
Actuator Supply Erratic	X			X				
Unsteady Signal	X			X				
Improper Bench Set		X	X					
Positioner	X				X	X	X	X
Wrong Travel Stops/ Calibration		X	X					
Increased Packing Friction						X		
Actuator Spring Too Large							X	
Actuator Spring Too Small								X

INSTRUMENTATION DEPARTMENT

CAUSE	PROBLEM							
	Erratic or Jerky Throttling	Failure to Fully Retract	Failure to Fully Extend	Cycling	Failure to Stroke	Sluggish/ Slow	Slow in Increasing Air Pressure Direction	Slow in Decreasing Air Pressure Direction
Actuator Spring Too Large							X	
Actuator Spring Too Small								X
Air Leak (Diaphragm, Stem Seal, or Case Joint)							X	
Leaks		X	X		X	X		
Solenoid Valve Failure				X	X	X		
Air Supply Tubing Crimped, Too Small						X		
Actuator Too Large						X		
Piston Lubrication ²		X	X		X	X		
Damage Cylinder or Piston Rings/ Seals		X	X	X	X	X		

¹ Can cause positioner to fail.

² Lack of lubrication permits the actuator supply air to migrate to the opposite side of the piston.

Based on the Symptom the Following causes can be derived to solve the problem.

Symptom	Possible Cause
Erratic or jerky throttling	Feedback linkage from control valve element loose Excessive packing friction Positioner output pressure too low Internal air leaks, including pressure gauges Output signal generator spool valve sticking
Failure to stroke (not moving from minimum travel position)	Leak in signal circuit Cam reversed Airlines reversed (double acting actuator) or airline in wrong port (single acting actuator) Air supply starved (line too small or crimped) Output relay or pilot stuck/not functioning properly Actuator handwheel in wrong position

INSTRUMENTATION DEPARTMENT

Symptom	Possible Cause
Failure to stroke (not moving from one end of stroke)	Output signal generator (pneumatic relay) leaking Supply breakdown orifice to nozzle-flapper chamber plugged Air line(s) in wrong port Actuator handwheel in wrong position
Slow in increasing or decreasing air pressure direction	Output pressure too high or too low Blockage in output lines or output valves Pneumatic relay not responding correctly Booster not adjusted properly.
Positioner not calibrating for full range.	Leak in signal circuit Improper feedback alignment Motion balance positioner not properly balanced Pre-alignment problem Actuator air leakage Air supply pressure incorrect Internal air leaks External handwheel incorrectly positioned Positioner in bypass Worn cam and/or cam roller Pilot valve or output relay not responding properly Starved air supply Vent paths blocked Cam not installed properly Wrong range spring

INSTRUMENTATION DEPARTMENT

Symptom	Possible Cause
Control Valve Oscillating During Checkout or Calibration	Feedback linkage from control valve element loose Positioner gain too high Positioner output pressure too low Booster not adjusted properly Excessive packing friction Valve plug/stem separation Internal air leaks in pressure gauges Worn cam and/or cam roller
Excessive Air Consumption	Leakage at joints of manifold assembly or pneumatic relay assembly

LATEST DEVELOPMENT IN POSITIONERS

**FLowsERVE ANNOUNCES TECHNOLOGY
BREAKTHROUGH WITH POSITIONER FOR WIRELESS
CONTROL OF VALVES**

**SMAR INTRODUCES HALL SENSOR THE
TECHNOLOGY OF LATEST-GENERATION
INTELLIGENT POSITIONER.**

CONCLUSION

From this , we can conclude the positioner is the integral part of the valve opening and closing . It also plays an crucial role in process loop control for controlling flow, pressure and temperature in application in the industry.

From decades to decades with change in industrial revolution, the positioner shape and size may change but not its main function to control the valve operation.



**Thank
You!!!**

www.thebodytransformation.com

Suggestions Please

