Back Pressure Regulators 101
The Control Loop

- **Final Control Element**
- **Input**
- **Manipulated Variable**
- **Load Changes/ Disturbances**
- **PROCESS**
- **Set Point**
- **Controller**
- **Measurement**
- **Output**
- **Controlled Variable**
3 Major Elements of a Control Loop

- **Sensing element** – measures the process variable being controlled, and sends an output to the controlling instrument.
- **Controlling instrument** – calculates the error (difference in signal from sensing element and the desired setpoint) and sends corrective signal to final control element.
- **Final control element** – varies the flow to change the controlled variable to the required setpoint.
The Regulator: A Proportional Controller

- Adjustment Screw
- Spring
- Diaphragm
- Valve Plug
- Set Point Adjustment
- Controller
- Sensor
- Negative Feedback Mechanism
Back Pressure Regulators (BPRV’s)

- Designed to modulate to hold a specific back pressure (not a safety relief valve)
- Monitors & regulates upstream pressure
- Aka reverse acting regulators
- Droop = “pressure build-up”
What to Expect From a BPRV

- Accurate regulation
- Tight shutoff
- Fast response
- Minimum maintenance
- Low noise
- Low initial cost
BPRV Advantages

- No external power is needed to position the valve
- No need for separate measuring elements or feedback controllers
- Designs tend to be simple, providing low cost, high reliability, and easy maintainability.
- Absence of stem packing eliminates external leakage and a source of high friction
- BPRVs are in direct contact with the controlled variable and offer very fast response
BPRV Limitations

- The controlled media must be relatively clean and benign as material of construction are limited.
- BPRVs lose controllability when the pressure drop across the valve becomes small because the media cannot supply enough operating power.
- Operating points are not constant due to pressure build up.
- BPRVs cannot accommodate anti-noise/cavitation trims.
- Failure modes fixed.
Do Not Use a BPRV When...

- The desired pressure or temperature set point is beyond the range of a BPRV
- Process offset cannot be tolerated
- The pressure drop is extremely small or extremely great
- When “fail open” is required
- The system requires control of a multi-variable process
- Feedback is required
Set point adjustment

Springs keep BPRV in the normally closed position

Upstream pressure is sensed beneath the diaphragm

Flow P2

Flow P1 controlled variable
Typical Back Pressure Regulator Applications

- Systems requiring control within 2 to 30 percent
- A myriad of “set and forget” functions
  - Pump bypass
  - Return to tank
  - Tank blanketing (De-Pad)
  - Various backpressure relief functions
Pressure Build Up – Inaccuracy in BPRVs

- aka – Proportional Band, Offset.
  - Deviation from set point as flow increases through the regulator.
  - Pressure rises above set point in BPRV.
  - The lower the build up, the better the regulator.
  - Manufacturers typically specify ranges from 2%-30% for properly sized BPRV.
Pressure Build Up – Inaccuracy in BPRVs

- Three things determine pressure build up in back pressure regulators
  - Stroke Length – the shorter, the better.
  - Diaphragm Area – the larger, the more accurate.
  - Spring Rate – the lighter the spring, the more sensitive the BPRV.
BP Regulator Accuracy & Characteristics

- Regulated Pressure
- Establish Setpoint
- Lockup
- Setpoint
- Pressure Build Up

Flow
Back Pressure Regulator Sizing

- A correctly sized valve is essential for accurate control

- Information needed for valve sizing
  - Required flow capacity of valve
    - Normal (Minimum, Normal, Maximum)
  - Inlet pressure to valve (P1)
  - Outlet pressure desired (P2) Can be zero
  - Service
    - Viscosity
    - Specific Gravity
Process Information Requirements

- **REQUIRED**
  - INLET or SET PRESSURE (P1)
  - OUTLET PRESSURE (P2)
  - FLOW RATE (Q)
  - MEDIUM

- **DESIRE**
  - MIN/NORM/MAX FLOW RATE
  - TEMPERATURE
  - SERVICE
  - VISCOSITY
  - SPECIFIC GRAVITY (DENSITY)
Back Pressure Regulators (BPRVs)

- Self-Operated devices which work off the medium alone
- Back Pressure Reducing Valve – BPRV
  - Hold upstream pressure to desired set point
Piloted Back Pressure Regulators

- Set point determined by pilot (a direct acting regulator) that controls the flow to or from the diaphragm of a larger valve.
- May have minimum differential pressure requirements.
Piloted Back Pressure Regulators

- Larger line sizes for higher flows
- Very accurate
- Higher turndown ratios
- Requires minimum differential pressure and downstream sensing tap
Advantages of Piloted BPRVs

- More Accurate (rivals a control system)
- Less Pressure Build Up
- More Sensitive (Higher Gain)
  - Small change in pilot = large change in main valve
  - Can also be a disadvantage
- Higher Rangeability (35 - 50:1)
Disadvantages of Piloted BPRVs

- More Sensitive (Higher Gain)
  - Can create oscillations within a system
  - Can also be an advantage
- Not good for rapidly changing systems
- Requires a minimum pressure drop to operate (typically 10 - 15 psi)
Dome Loaded BPRV

- Elimination of spring – extremely accurate
- Air signal across top of diaphragm
- Needs an air regulator or I/P – faster than a control loop
- Increased rangeability
- Low minimum $\Delta P$ requirement
- Good for frequently changing set points or remote installations
Tank Blanketing Regulators

- Gas de-pad or other low pressure air / gas applications
- Extremely large elastomer diaphragms for increased sensitivity
- Very light springs
- Set points as low as 2” w.c.
Regulator Accuracy Hierarchy

- Self-Acting or ‘Direct’ acting BPRVs
  - 10%-30% pressure build

- Piloted BPRVs
  - Small pilot capacities
  - Enlarged diaphragm surface areas – 5-10% pressure build typical

- Air loaded BPRVs
  - Elimination of spring – virtually zero pressure build
  - Allows the use of extended range I/P’s
    - Control via 4-20 mA
    - Faster response than a control loop
# How Do I Choose?

## Pressure Build Rangeability

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<thead>
<tr>
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<th>Pressure Build</th>
<th>Rangeability</th>
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<tbody>
<tr>
<td>Self Operated BPRVs</td>
<td>10-30%</td>
<td>10:1</td>
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<tr>
<td>Pilot Operated BPRVs</td>
<td>2-10%</td>
<td>35:1 to 50:1</td>
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## Accuracy Capacity Speed of Response Cost

<table>
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<th>Speed of Response</th>
<th>Cost</th>
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<tbody>
<tr>
<td>Self Operated BPRVs</td>
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Summary

Back Pressure regulators, if sized correctly and properly applied, will provide accurate regulation, dependable performance, fast response, low noise and minimum maintenance.
The End
Thank You for Attending Today’s Webinar

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Upcoming Webinar:

Fuel Trains 101
Thursday, February 18 9am CST

Featured Speaker
A.J. Piskor
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Webinar invitation e-mail coming soon...