# CAE 438/538 Control of Building Environmental Systems

Fall 2021

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## September 21, 2021

Control Devices: Dampers and Valves (2)

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**Dr. Mohammad Heidarinejad, Ph.D., P.E.**
Civil, Architectural and Environmental Engineering
Illinois Institute of Technology
muh182@iit.edu

# ASSIGNMENT

# Assignment

- Assignment 1 will be graded later this week
- Assignment 2 is on Blackboard

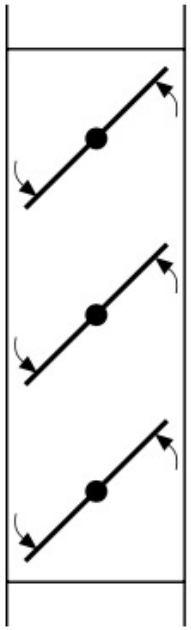
# RECAP

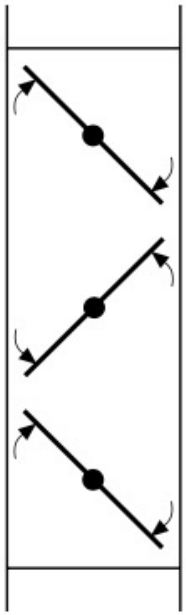
# Recap

- Controlled devices in the building systems could vary from a wide range of:
  - ❑ Dampers
  - ❑ Valves
  - ❑ Variable speed or frequency drives
  - ❑ Refrigeration compressors
  - ❑ Gas valves
  - ❑ Electric heating elements

# Recap

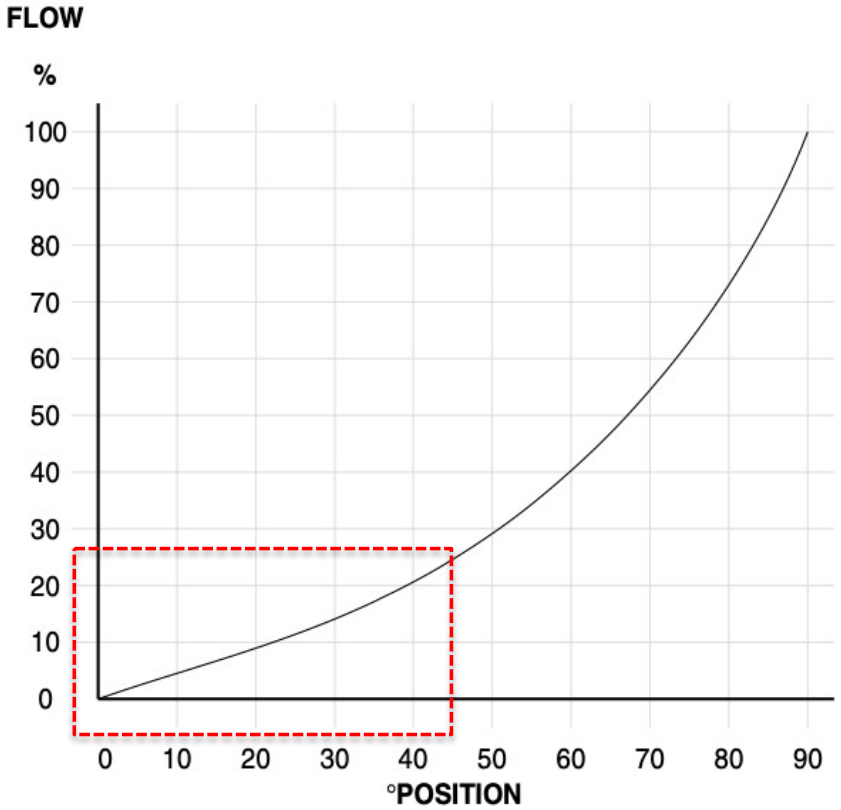
- The two main damper types are:
  - ❑ Parallel: Blades move in the same direction
  - ❑ Opposite: Blades next to each other move in the opposite direction

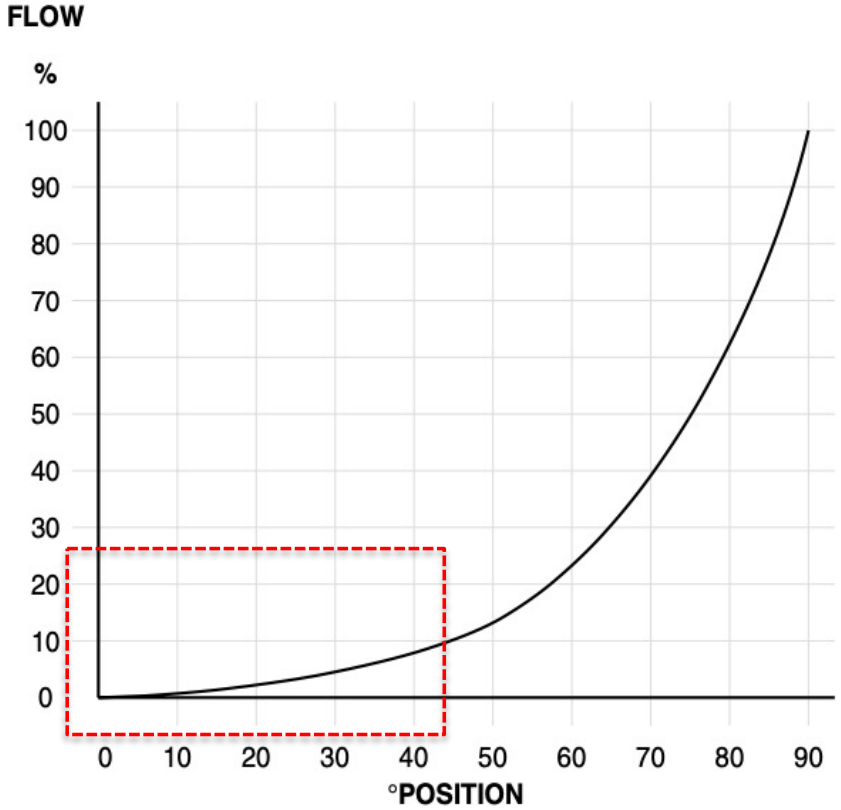




# Recap

- Flow characteristics of these two dampers are different:



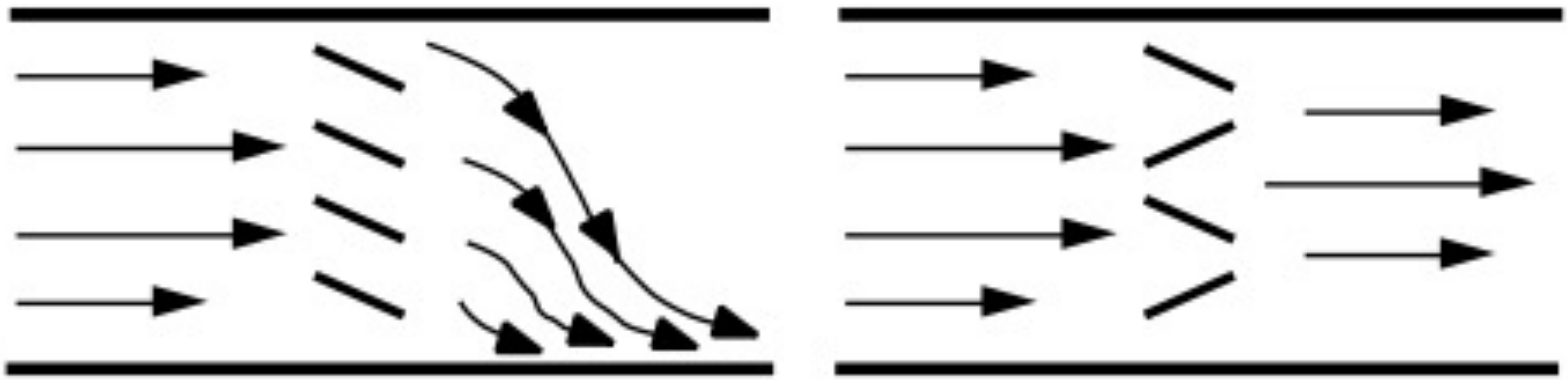






*Belimo: Damper actuator applications Guide*

# Recap

- Opposed dampers are recommended when other components exist in the air duct



PARALLEL BLADE
DAMPER ILLUSTRATING
DIVERTED FLOW

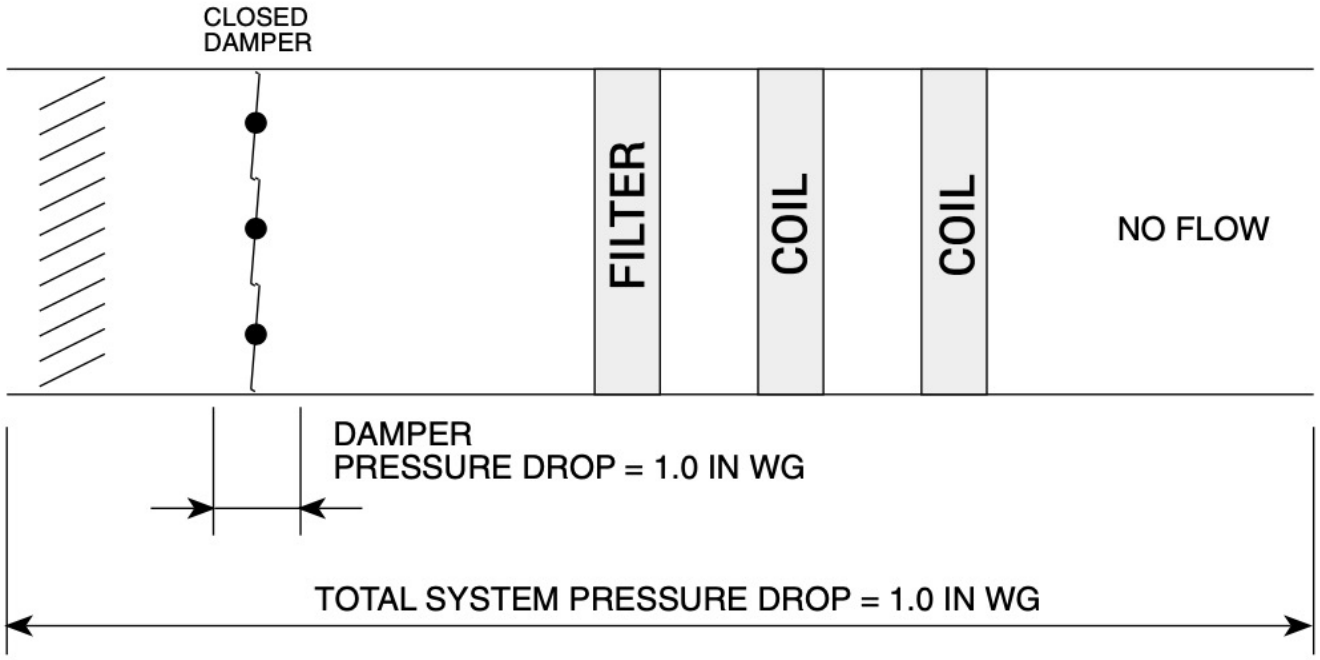
OPPOSED BLADE
DAMPER ILLUSTRATING
NON - DIVERTED FLOW



*Engineering manual of automatic control*

# Recap

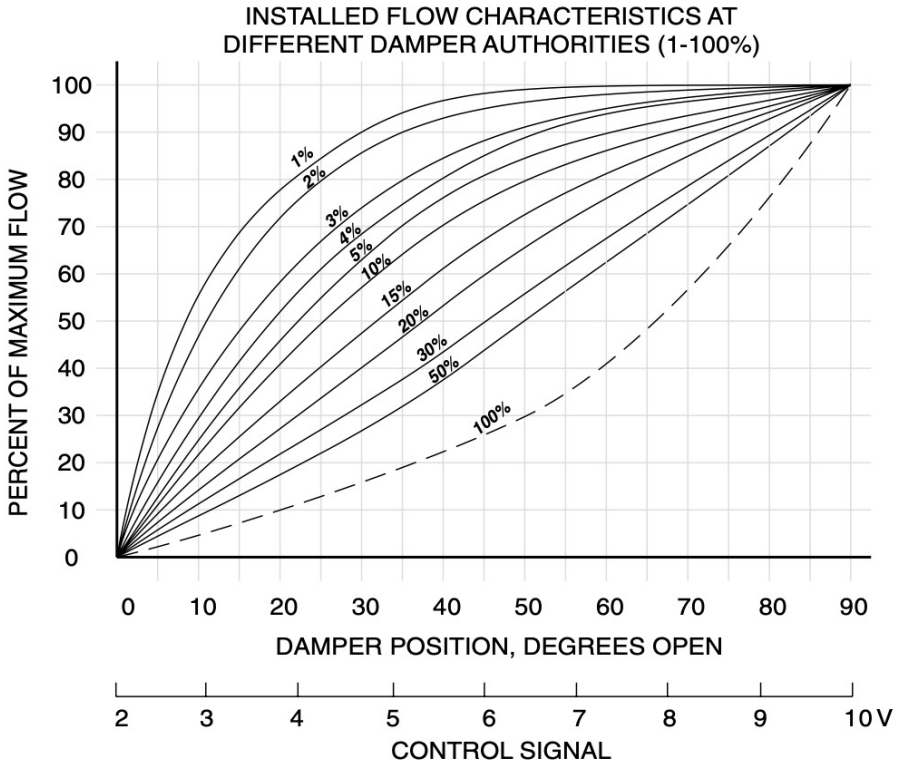
- Damper is NOT the only equipment that affects the flow and pressure drop and the flow characteristics is different.

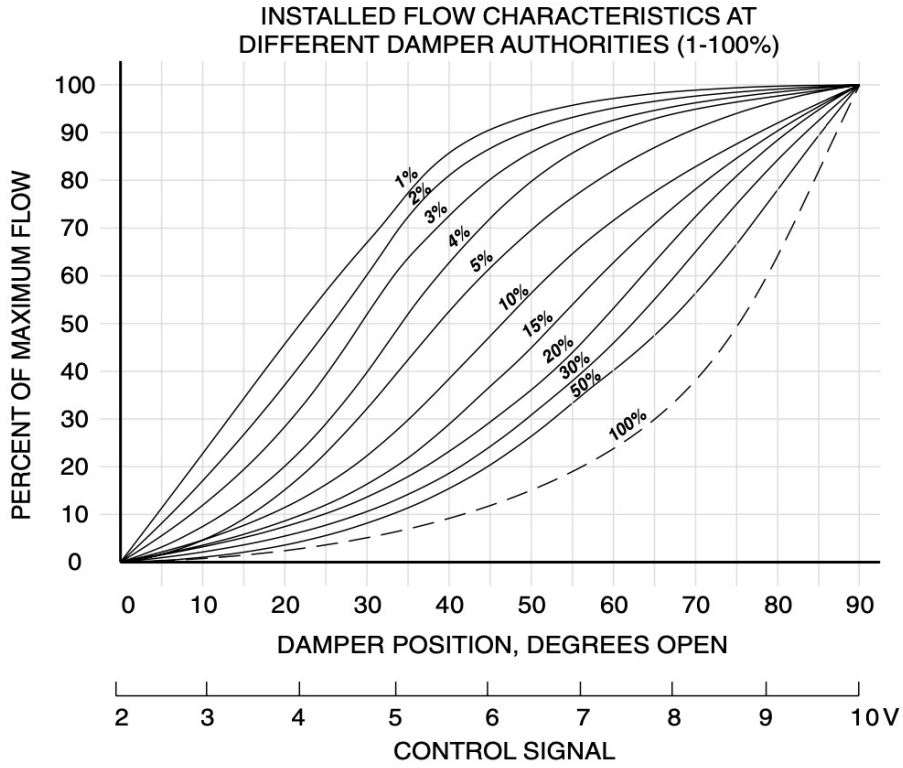



$$Damper\ Authority\ \% = \frac{Open\ Damper\ Pressure\ Drop}{Total\ System\ Pressure\ Drop} \times 100\%$$

# Recap

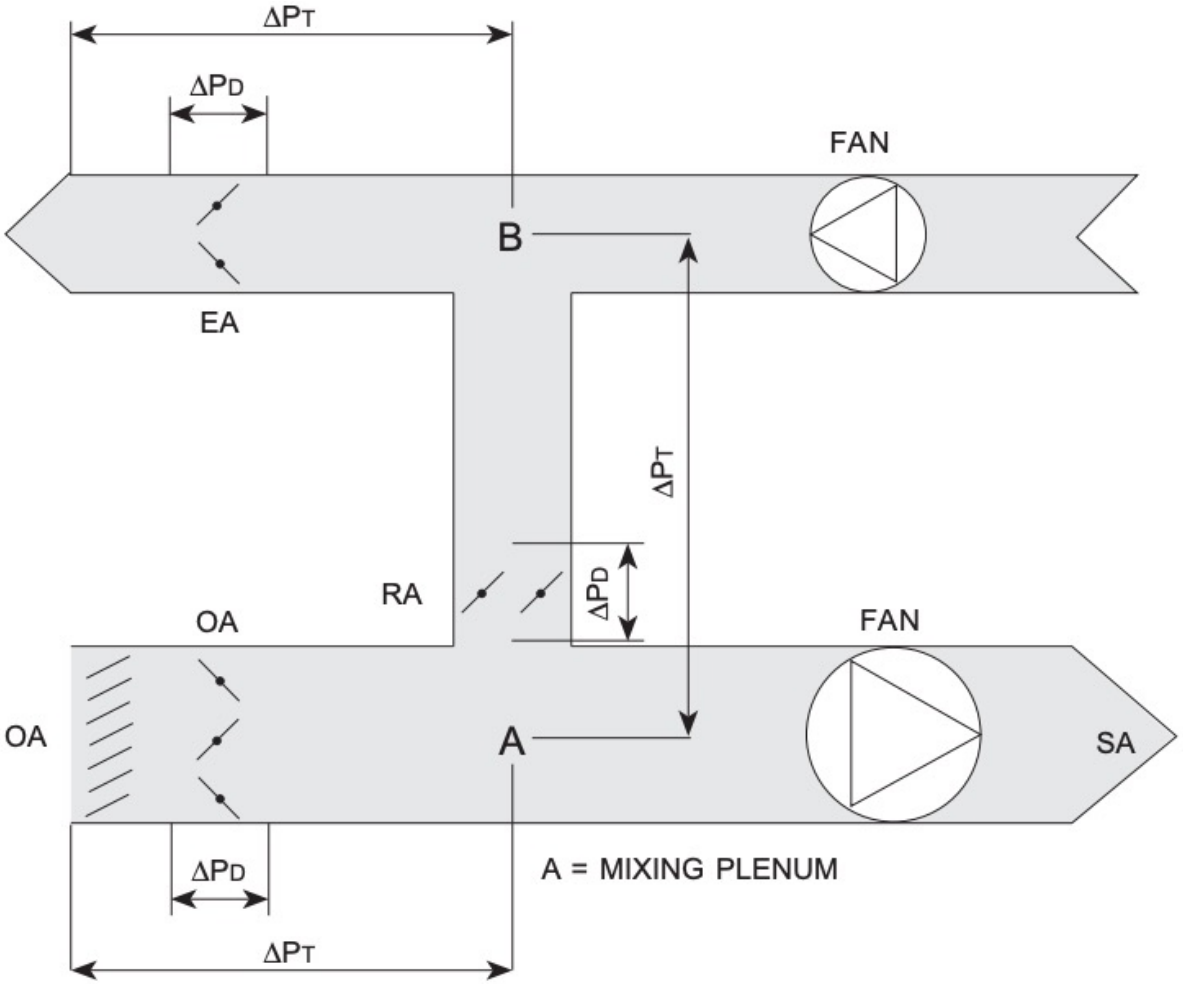
- Consider the two figures for the damper authorities and discuss the pattern?



# Recap

- How to calculate damper authority?




$$\text{Authority} = \frac{\text{Pressure drop over damper}}{\text{Total pressure drop}} = \frac{\Delta P_D}{\Delta P_T} \times 100\%$$



https://www.yorkland.net/downloads/Belimo_DamperApplicationsGuide.pdf

# Recap

- Damper leakage classes are:

**Allowable Air Leakage to Achieve Classification**

| SI | Maximum Allowable Leakage, L/s/m$^2$ | | |
|---|---|---|---|
| Class | at 0.25 kPa[1] | at 1.0 kPa[1] | at *x* kPa[2] |
| 1A | 15.2 | N/A | N/A |
| 1 | 20 | 41 | $2\sqrt{x} \times 20$ |
| 2 | 51 | 102 | $2\sqrt{x} \times 51$ |
| 3 | 203 | 406 | $2\sqrt{x} \times 203$ |

| I-P | Maximum Allowable Leakage, cfm/ft$^2$ | | |
|---|---|---|---|
| Class | at 1 in. wg[1] | at 4 in. wg[1] | at *x* in. wg[2] |
| 1A | 3 | N/A | N/A |
| 1 | 4 | 8 | $\sqrt{x} \times 4$ |
| 2 | 10 | 20 | $\sqrt{x} \times 10$ |
| 3 | 40 | 80 | $\sqrt{x} \times 40$ |

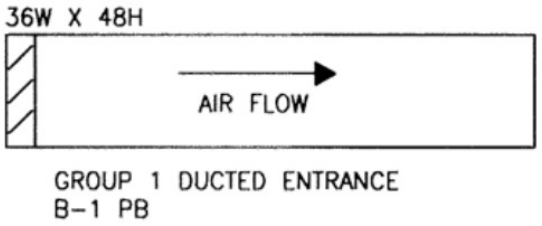
**Notes**:
[1] Required pressures; shall be cataloged
[2] Any other pressure may be cataloged using these formulas

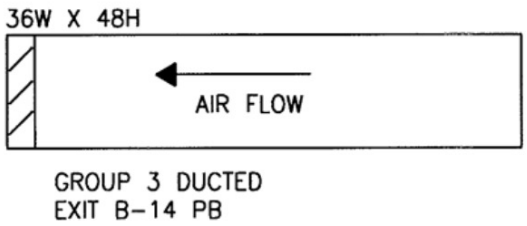


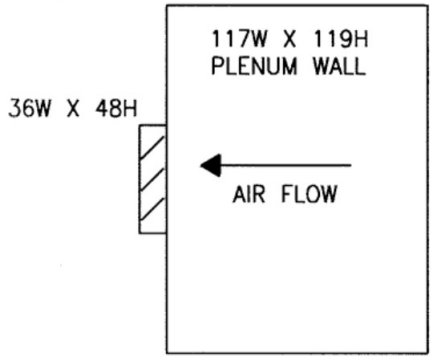
https://www.amca.org/assets/resources/public/userfiles/file/CRP%20Publications/amca_511-13.pdf

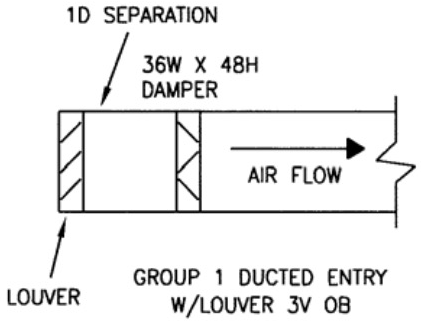
# Recap

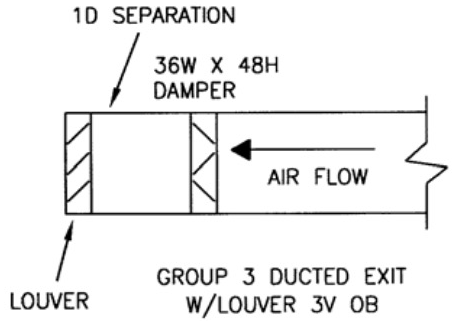
- In sizing dampers, it is important to know the location and application of the damper (e.g., Fully ducted damper, ducted damper exhausting air into an open area, a plenum mounted damper)

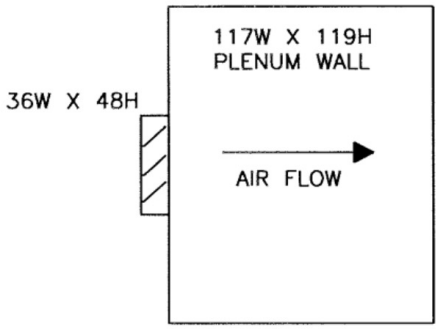


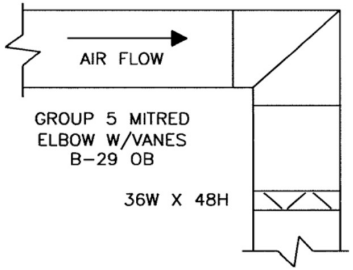



# Recap

- Some sizing links:


https://ecaps.greenheck.com/

RUSKIN
AUTHORITY IN AIR CONTROL

***Ruskin*® Quick Product Selection Tables: Commercial Dampers**

The Quick Product Selection Reference Guide assists in selecting the appropriate *Ruskin*® Product for your application.

Commercial Airfoil Blades

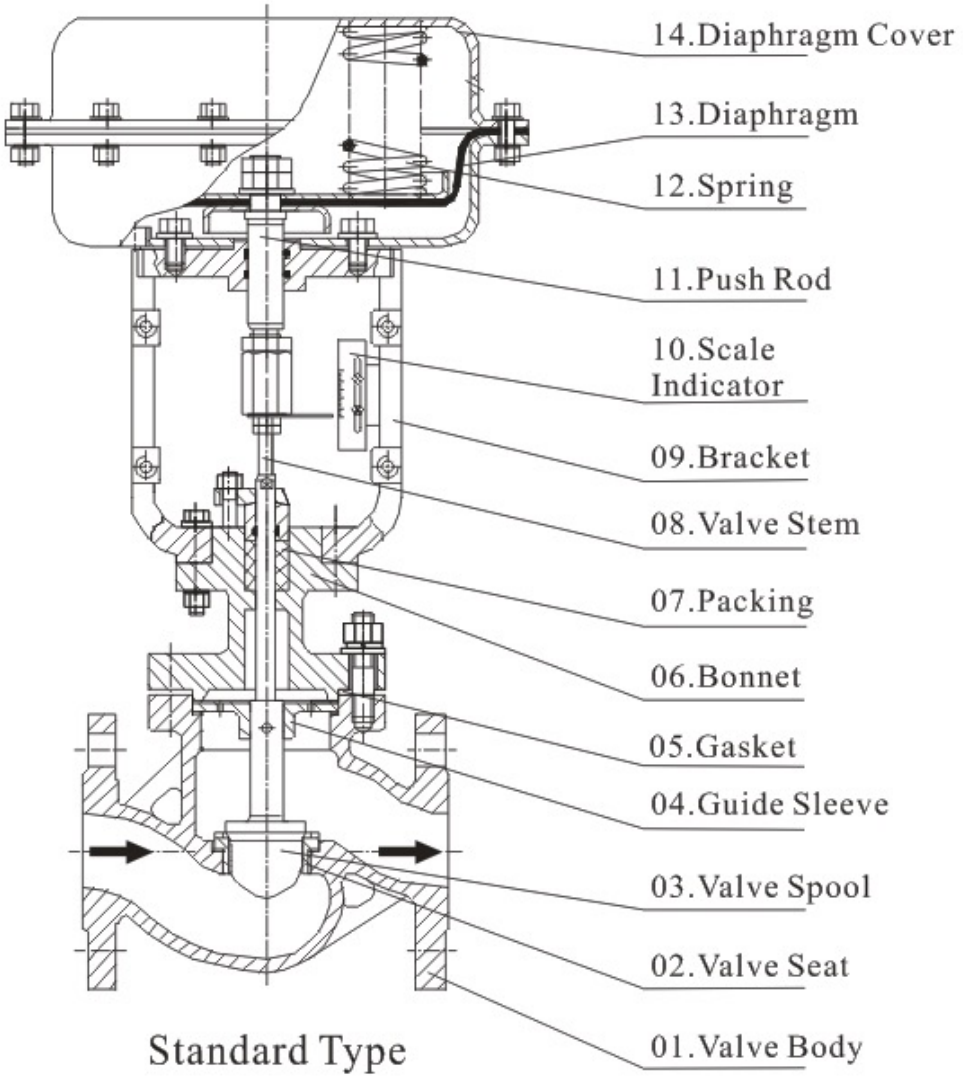
Commercial V Groove Blades

https://www.ruskin.com/doc/Id/6959

# CONTROL VALVES

# Intro to Valves

- Valve includes different components:






https://www.shautovalve.com/pneumatic-control-valve/hts-single-seat-pneumatic-control-valve

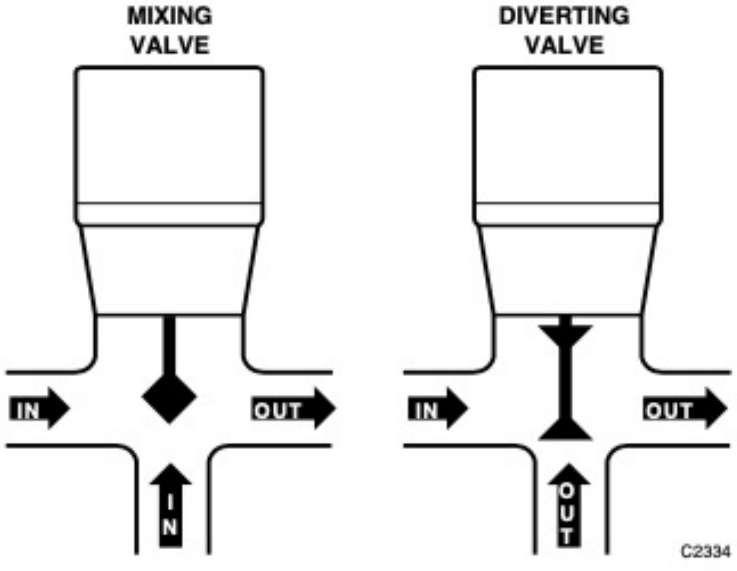
# Intro to Valves

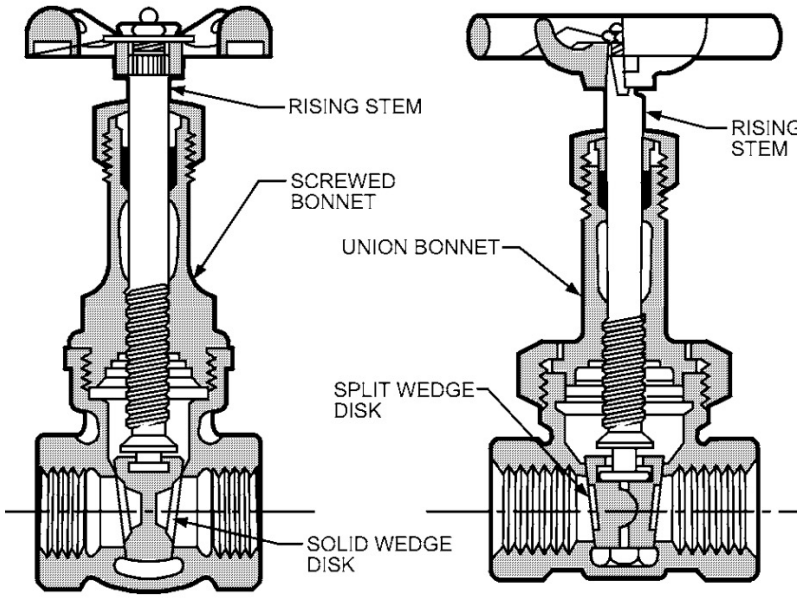
- Valves have different configurations:
  - Single-seated valve
  - Double-seated or balanced valve
  - Three-way mixing valve
  - Three-way diverting valve

# VALVE CHARACTERISTICS

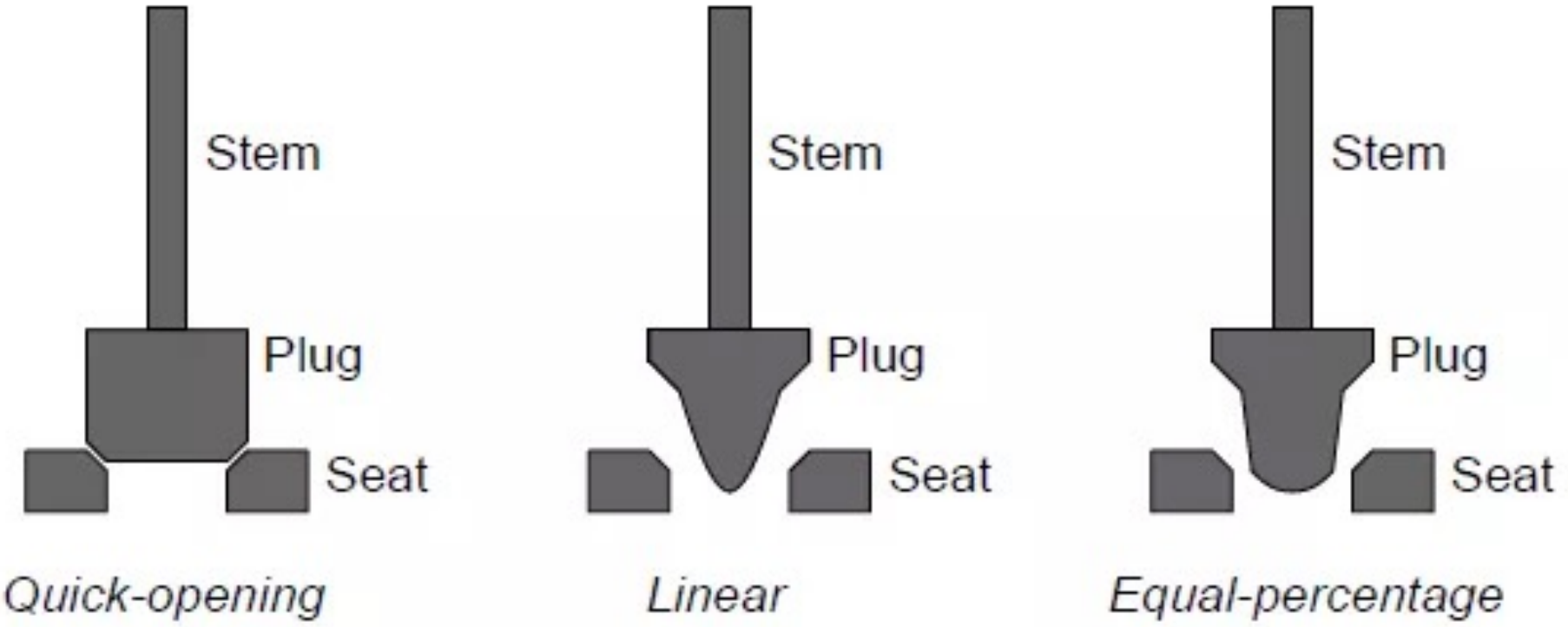
# Valve Characteristics

- Different valve types exist



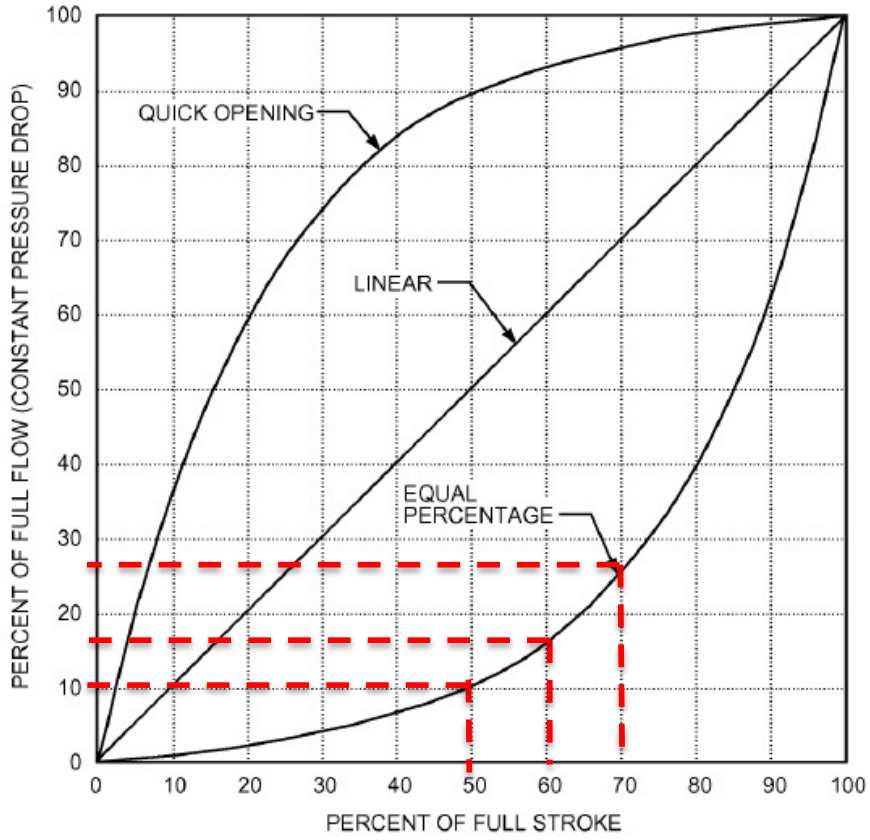
# Valve Characteristics



# Valve Characteristics

- Valve performance is expressed in terms of its flow characteristics. Common characteristics are:

  - **Equal Percentage:** Each equal increment of opening increases flow by an equal percentage over the previous value
  - **Quick Opening:** Maximum flow is approached as valve begins to open
  - **Linear:** Opening and flow are related in direct proportion



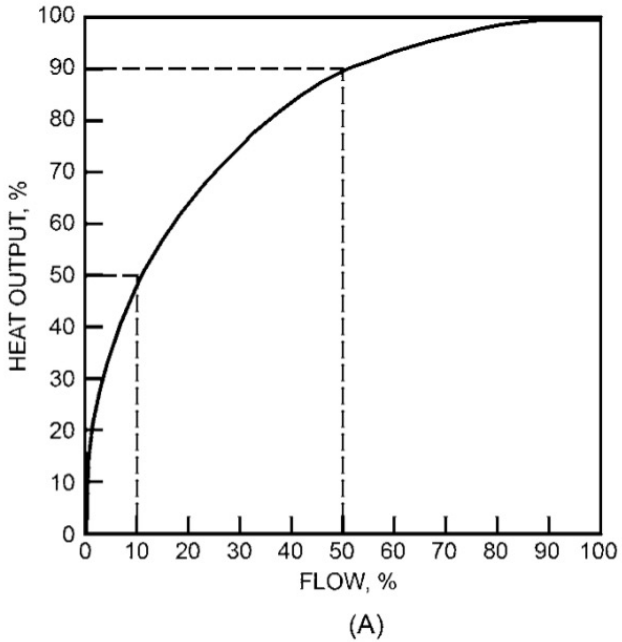
# Valve Characteristics

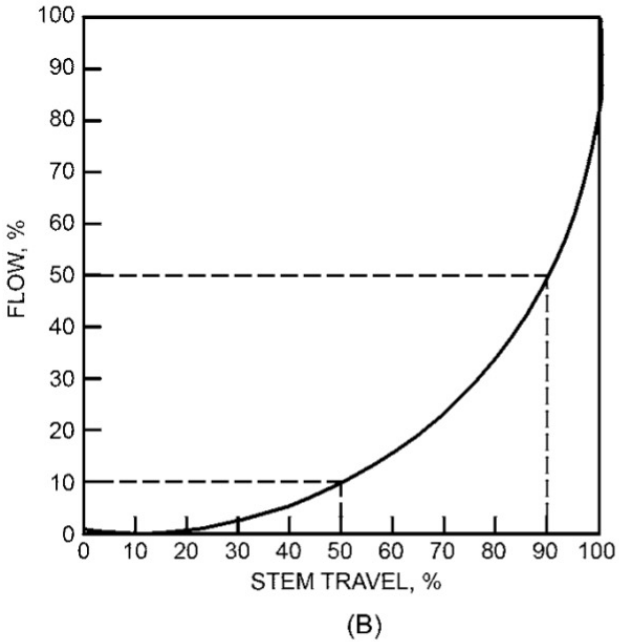
- Where do we use the valve characteristics?

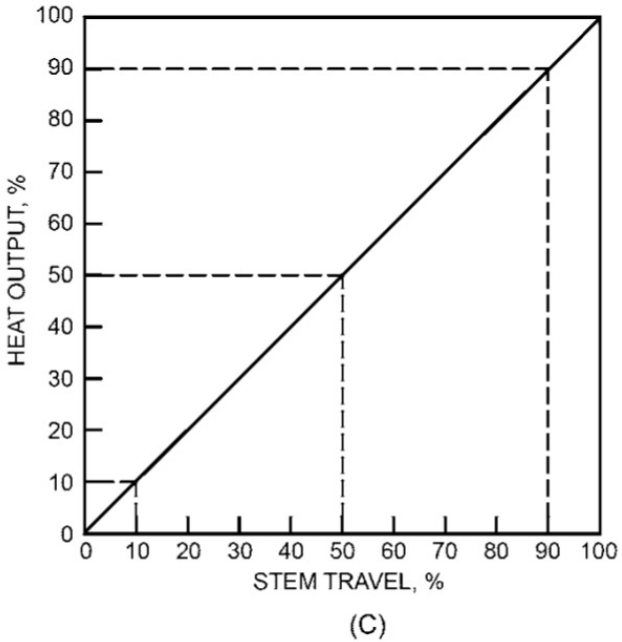
| Valve Characteristics | Application |
|---|---|
| Equal Percentage | ❑ Primarily used in water applications<br>❑ High pressure drops<br>❑ Small changes are allowed<br>❑ Control temperature and pressure |
| Linear | ❑ Primarily used in steam applications<br>❑ In steady state systems<br>❑ Valve accounts for the major pressure drop |
| Quick opening | ❑ Primarily used in on/off application<br>❑ An instant large flow is required |

# Valve Characteristics

- In a valve assembly, other components are also important in the decision-making. Why?



# Valve Characteristics

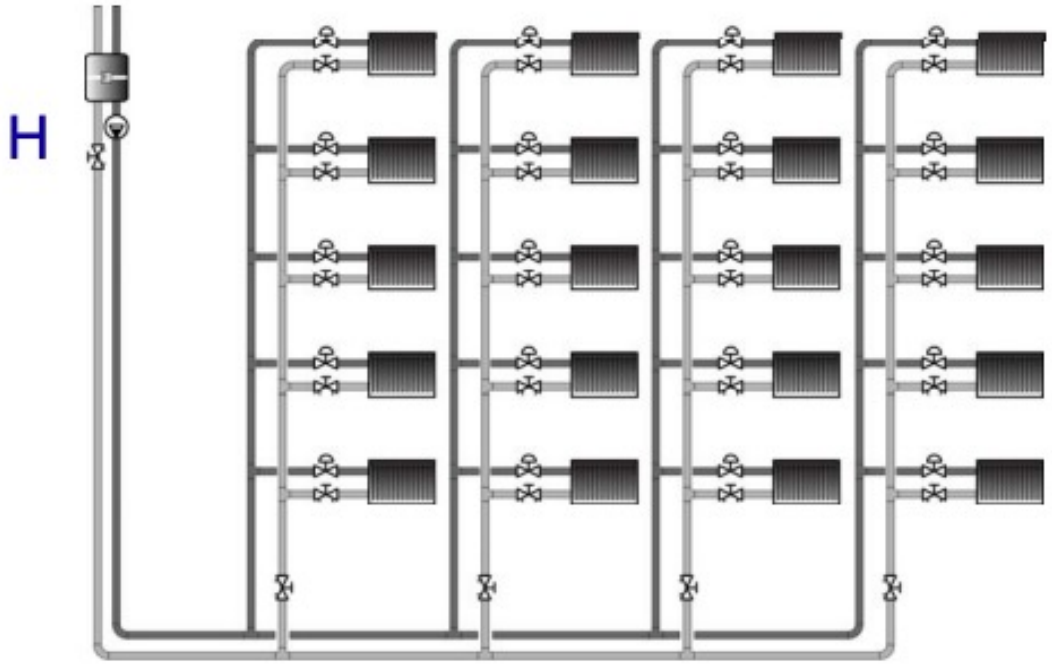
- Valve authority is the ratio of pressure drop across control valve at maximum flow (100%) to the total total pressure drop of all components in the controlled branch as follow:

$$Valve\ Authority\ \% = \frac{Open\ Valve\ Pressure\ Drop}{Total\ System\ Pressure\ Drop} \times 100\%$$

- Try to keep it to 25% to 50%

# Valve Characteristics

- Valve authority changes throughout the operation:




**Authority in design conditions:**

$\beta \approx 5/(5+7) =$ **0.42**

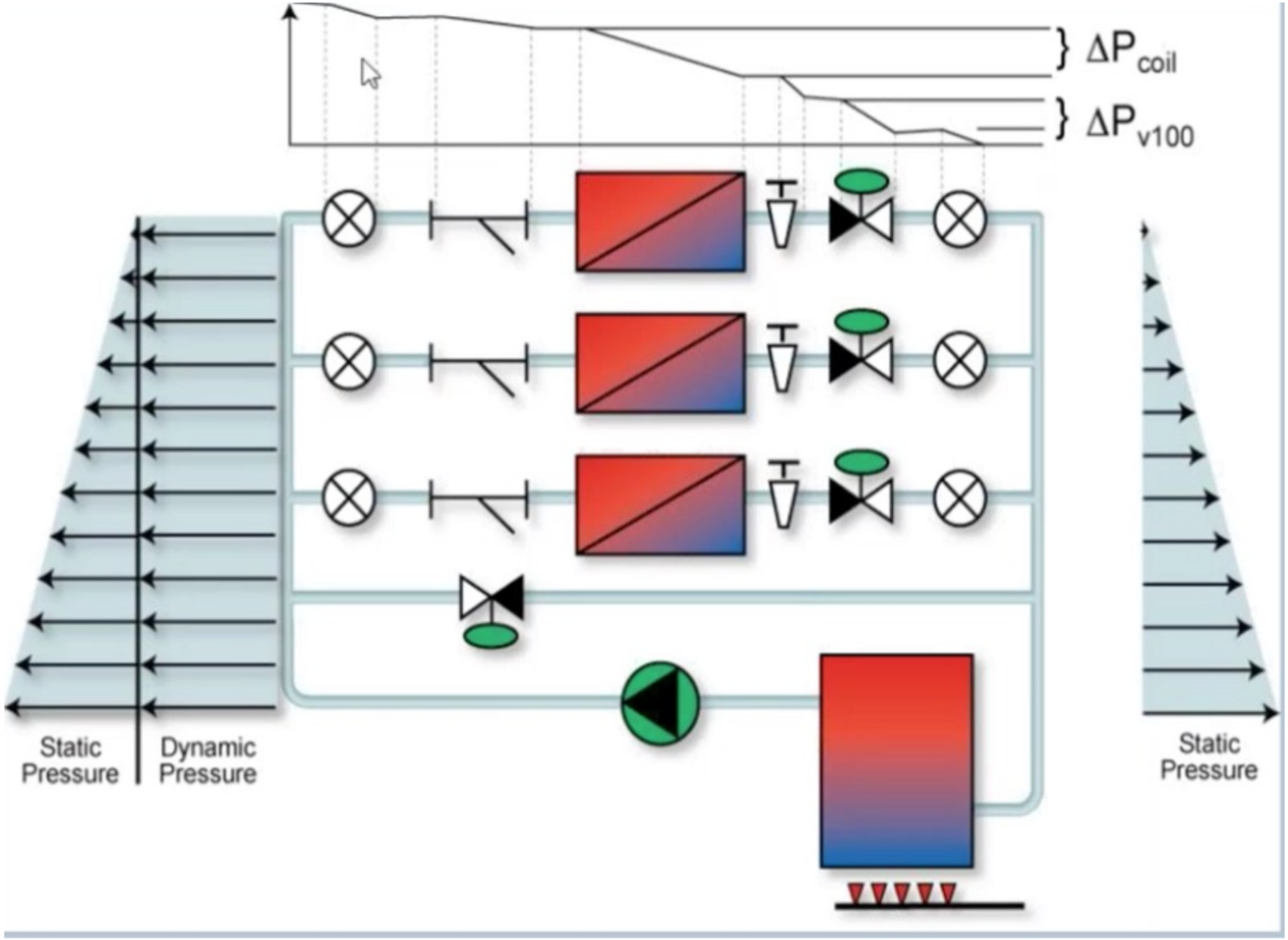
**Authority at half-load:**

$\beta = 5/(5+7+0.96*21) =$ **0.15 !**



https://rockymtnashrae.com/downloads/2013_Technical_Conference/2013_tech_conf_control_valve_pressure_indep.pdf

# Valve Characteristics






*Credit: Siemens*

# Valve Characteristics

- The flow coefficient is calculated as:

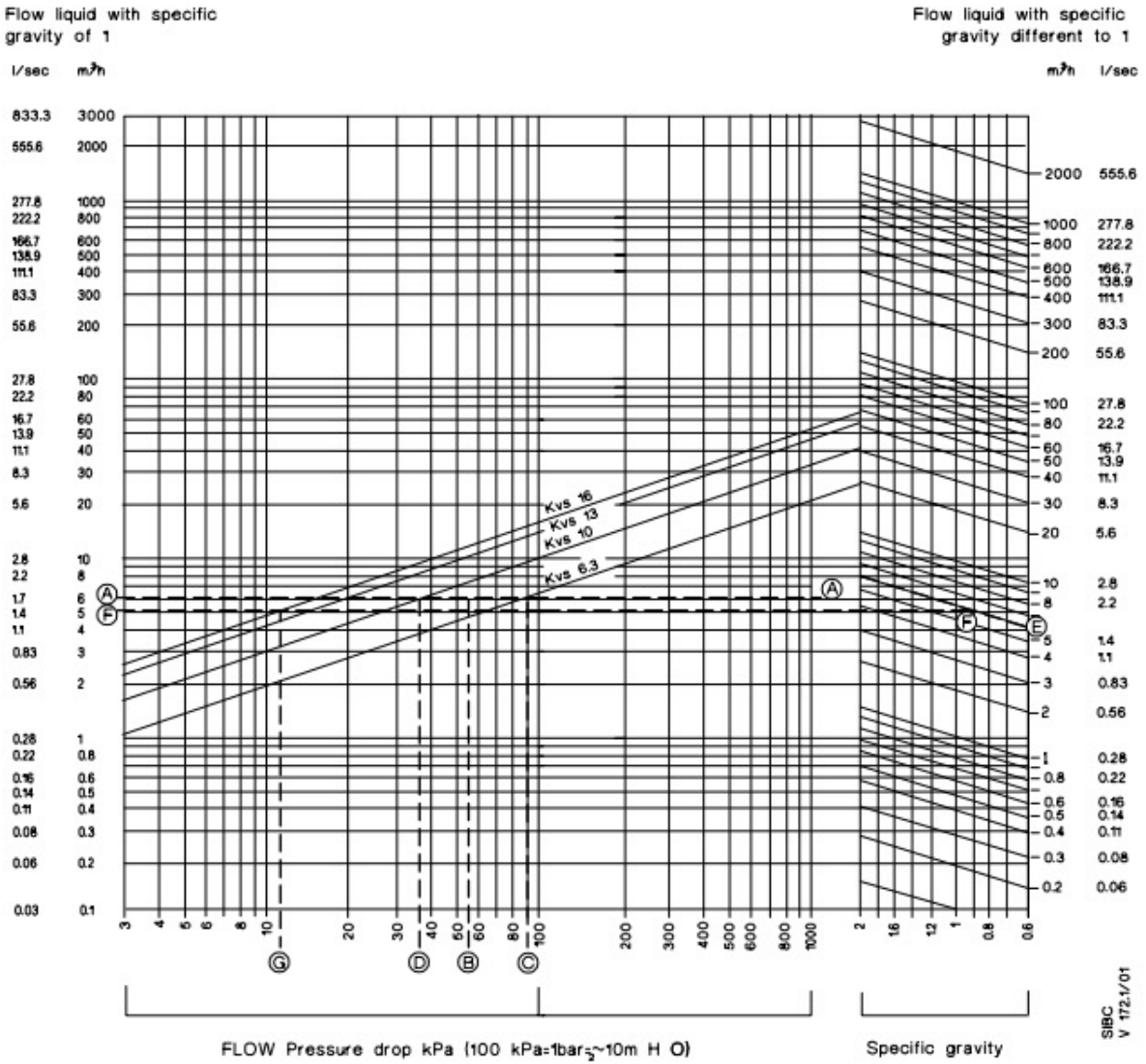
$$C_v = Q\sqrt{\frac{SG}{\Delta P}}$$

  - $SG$: Specific gravity
  - $C_v$: Flow coefficient
  - $Q$: Volumetric flow rate in gpm when valve is fully open
  - $\Delta P$: Differential pressure in psi when the valve is fully open

*Why specific gravity?*

# Valve Characteristics

- Control valve sizing charts:






https://www.luckinslive.com/data/fbfd8c4e-b8cb-409e-8077-39afff976318/4e9680d3-c541-4a99-8614-71d2b4d5fd02.PDF

# Valve Characteristics

- Valves are usually sized based on the flow capacity (or flow coefficient) which varies under different coefficients

- The coefficient is:
  - $C_v$ in IP unit
  - kvs in metric unit

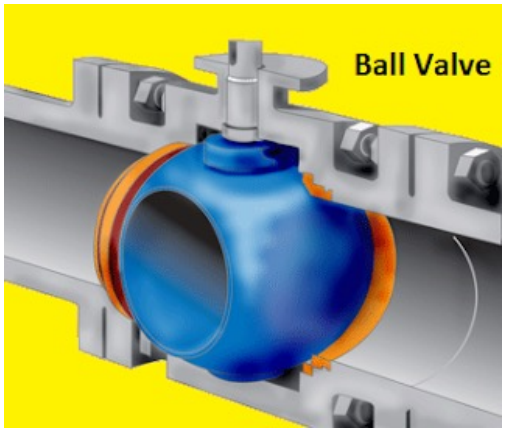
# Valve Characteristics

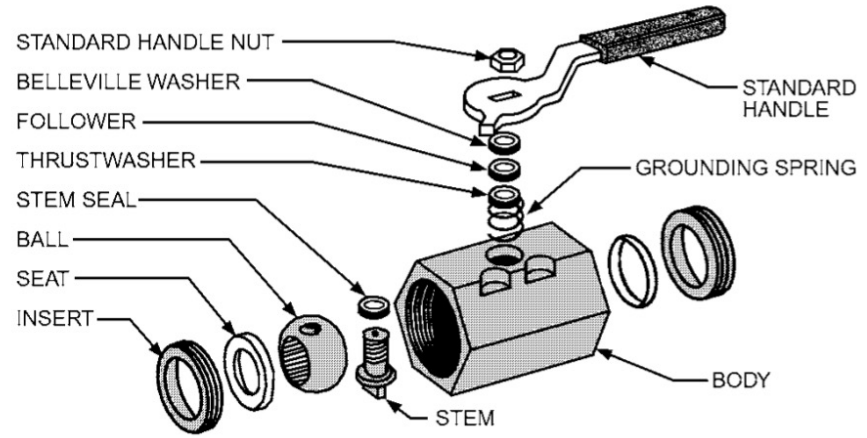
- $C_v$ is a key factor in sizing:
  - With a too small value (undersized), the required flow rate will not be achieved even when the valve is fully opened
  - With a too large value (a high control valve), it will not provide the desired control and may cause the system

# VALVE TYPES

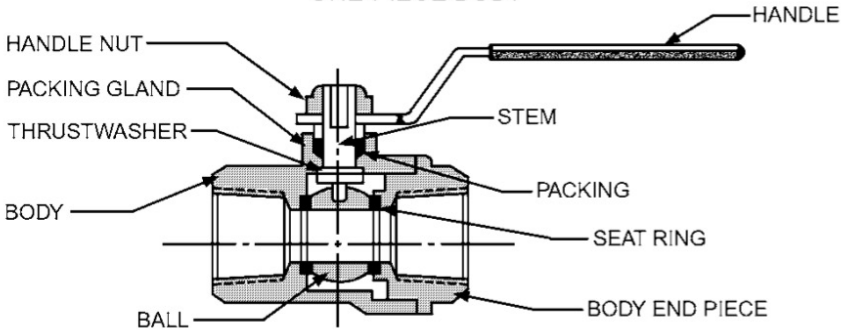
# Valve Types

- Ball valves
  - ❑ There is a precision ball held between two circular seats or seals
  - ❑ It can be used for modulating applications or when full on/off is required

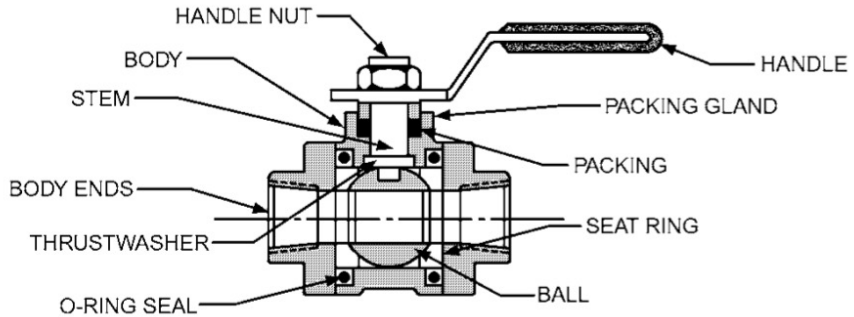



ONE-PIECE BODY




TWO-PIECE BODY




THREE-PIECE BODY



http://hvac-system-basics.blogspot.com/2012/10/ball-valve-how-it-works.html#.X2DGN5NKik4

# Valve Types

- Ball valves:
  - ❑ The best control is the equal percentage
  - ❑ Offer various advantages:
    - ❖ Relatively low cost
    - ❖ High full capacity
    - ❖ Tight sealing with low torque
    - ❖ High close off pressure

  - ❑ The main disadvantage is the inherent dead bands



*Credit: Siemens*

# Valve Types

- Butterfly valves
  - ❑ Consist of a cylindrical, flanged-end
  - ❑ The best control is linear or equal percentage
  - ❑ Mostly used for the open/closed applications
  - ❑ Throttling applications
  - ❑ Small pressure drop applications

*Credit: Siemens*

# Valve Types

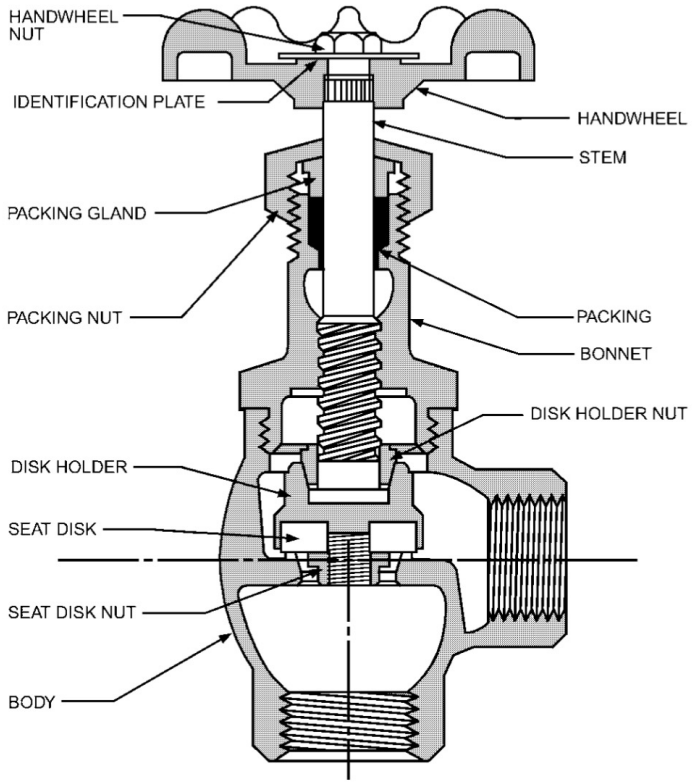
- Butterfly valves
  - Offer various advantages:
    - Relatively low cost
    - High full capacity
    - Low pressure drop
  - They have different disadvantages:
    - High torque requirements for control



*Credit: Siemens*

# Valve Types

- Globe valves
  - Flow is controlled by a circular disk forced against or withdrawing form an angular ring
  - Direction of the disk movement is parallel to the flow direction
  - Mostly used in smaller pipes (up to 12”)
  - They have pressure drop when they 100% open
  - They are good for flow control not to shutoff



# Valve Types

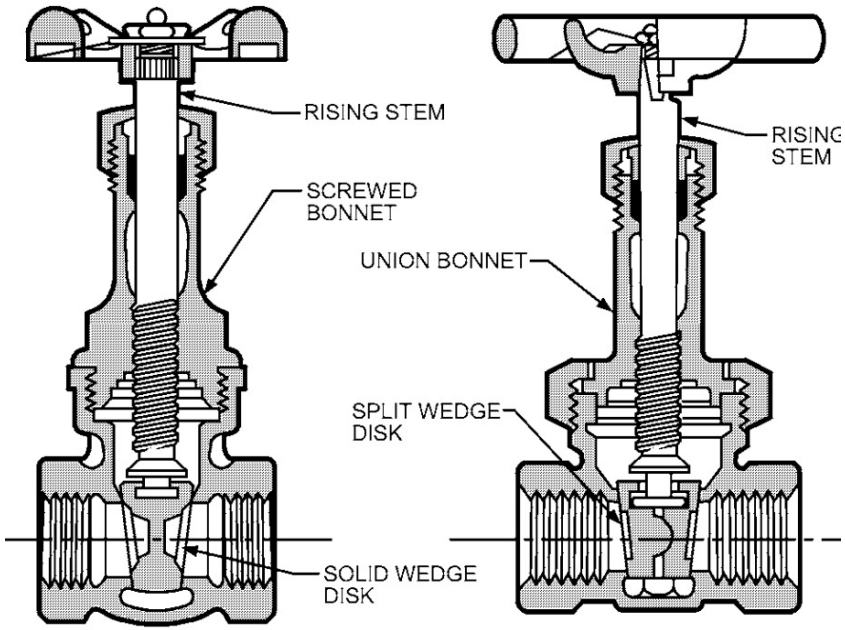
- Globe valves
  - ❑ The best control is the equal percentage or linear
  - ❑ Offer various advantages:
    - ❖ Suited for water and steam applications
    - ❖ Efficient and precise throttling
    - ❖ High accurate flow control
  - ❑ They have different disadvantages:
    - ❖ They have low flow coefficients
    - ❖ Relatively higher costs than other valves



https://www.piping-world.com/globe-valve-introduction

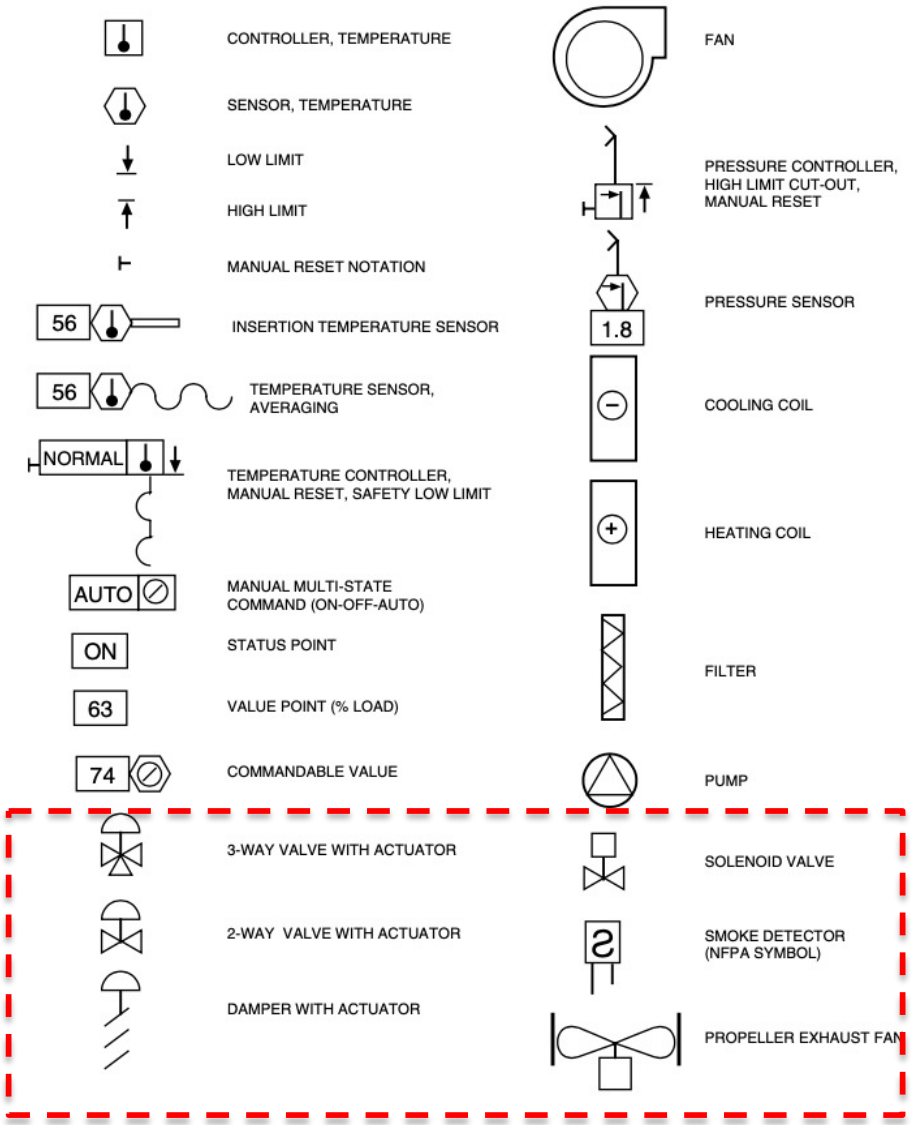
# Valve Types

- Gate valves
  - Flow is controlled by a wedge disk fitting against machined seating faces
  - Direction of the disk movement is perpendicular to the flow direction
  - They are either fully open or fully closed
  - They are not suitable for controlling flow



# Drawings

- Pay attention to the symbols






*Engineering manual of automatic control*

# CLASS ACTIVITY

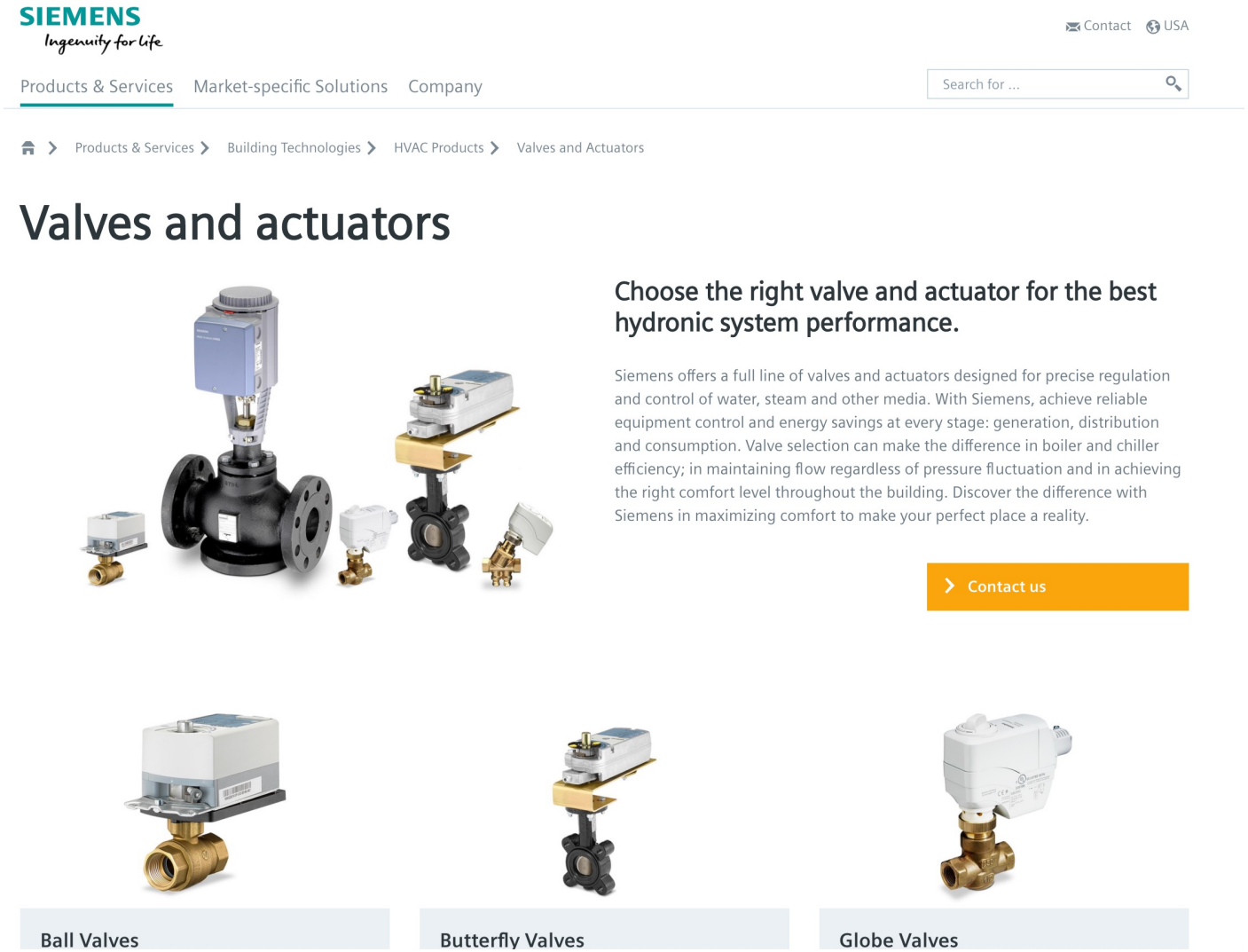
# Class Activity

- Form your groups
- Fill in the spreadsheet (at 3 different vendors, let's consider each valve type

https://docs.google.com/spreadsheets/d/1duxKfuy1kpYNJxXT6e9bHjVBBqUXnwBSBuR8Dkz4f7c/edit#gid=1540160475

# Class Activity

- Let's look at some manufacturers




https://new.siemens.com/us/en/products/buildingtechnologies/hvac/valves-actuators.html

# Class Activity

- Let's look at some manufacturers

## VALVES AND ACTUATORS

Our HVAC Control Valves and Actuators are critical components in an end-to-end system, and their efficiency is an important factor in overall system efficiency. Choose from thousands of valve and actuator combinations that are built to deliver efficient, dependable, long-lasting and leak-proof performance. Our consistent designs and convenient built-in operating features provide outstanding control – without the need for field add-ons.

VIEW OUR FULL PRODUCT CATALOG | CONTACT US TO LEARN MORE


### Greater efficiency and comfort begin with the control valve

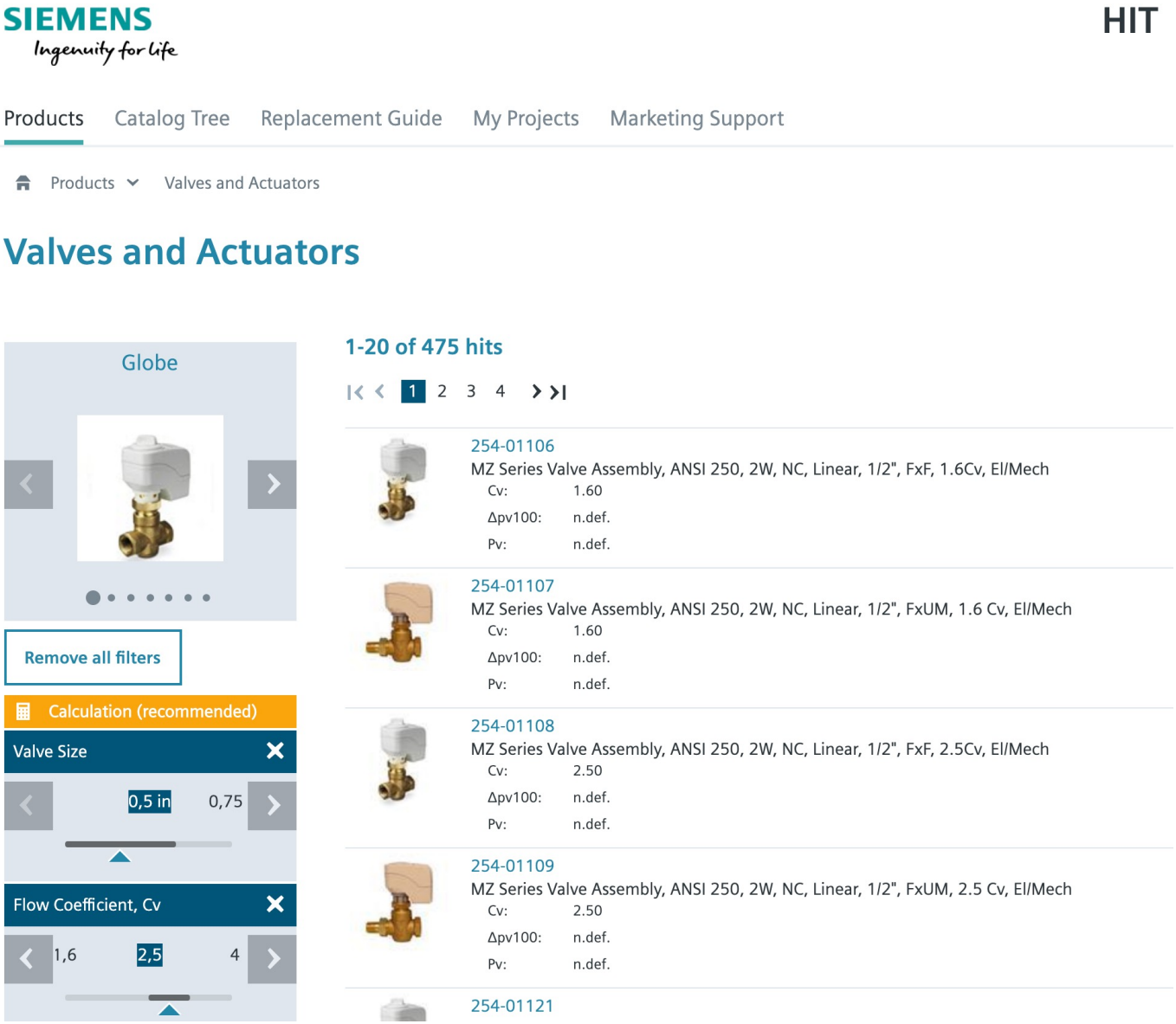
Deliver a stable flow, regardless of pressure fluctuations, with the new VP140 Series of Pressure Independent Control Valves (PICVs). By combining a pressure regulator, a regulating valve and a control valve, it increases occupant comfort and system efficiency without the need for balancing valves. The VP140 Rotary (Ball) Valve is ideal for applications that require enhanced flexibility for seasonal commissioning and different room layouts, and the VP140 Compact Axial (Globe) Valve is designed for applications where a compact valve and actuator footprint is needed. All models deliver reduced installation, commissioning and operational costs.

DOWNLOAD THE VP140 BROCHURE | WATCH RECORDED WEBINAR

https://www.johnsoncontrols.com/building-automation-and-controls/hvac-controls/valves-and-actuators

# Class Activity

- Let's look at some manufacturers



# Class Activity

- Let's look at some manufacturers

Honeywell | Building Controls

NEWS | VIDEOS | CONTACT

Search

CONTRACTOR LOCATOR | PRODUCTS | CASE STUDIES | ENGINEERING SPECS

Home > Dampers, Actuators & Valves > Valves & Valve Actuators

## Globe Valve Linkage

**No Valve Disassembly Required**

- Used with 2-way and 3-way globe valves in modulating or two-position service.
- Quick and simple installation with no disassembly required.
- Heavy-duty steel rack and pinion construction and aluminum die-cast housing.
- Maintenance-free construction.
- Flexible actuator mounting orientation.
- Adjustable manual override lever and valve position indicator.
- Available for 1/2 in. through 6 in. globe valves made by most manufacturers.
- Used with Honeywell MS and MN Spring and Non-Spring Actuators.
- Globe Valve Linkage
- Simplify quoting this product with CPQ Select

## Pressure Independent Control Valves

**Deliver high efficency in less time**

- Pressure independent control valves balance the system at every point over the range of the control valve within 5% accuracy
- Control flow exactly at all load conditions, not just at design conditions
- High Turn-Down Ratio/Equal Percentage Flow results in linear heat transfer for optimal control. The characterized insert is integral to the ball, resulting in longer service life and higher differential pressure capabilities.
- Less torque is needed, so you can use lower-cost, low-torque actuators on larger pipe sizes
- No Cv calculation required - just pick the valve that matches the flow requirements - Flow range of 1 to 95 gpm
- Field serviceable stem allows valve to be serviced in the field rather than cut from the pipe
- Optional test ports facilitate system set-up for balancing report
- Manual override to control valve during installation or in the event of power failure
- Full range of sizes from 1/2" to 6"

## Control Ball Valves

**Cover every application with one control valve brand**

- VBN/VBF Control ball valves control hot and chilled water in HVAC systems to provide two-position, floating, or modulating functions.
- Order them with or without factory-mounted non-spring return or spring return direct-coupled actuators.
- Flanged control ball valve offering available (VBF)
- Accurate flow control
- Simplified actuator selection with a large range of Cvs
- Built for safety and endurance with a blowout-proof stem to withstand high pressure and optional NEMA 3R enclosure for weatherproofing
- Field replaceable stem allows valve to be serviced and replaced on the pipe
- Threaded 2-Way models up to 3" and 3-Way models up to 2-1/2"
- Parabolic flow insert constructed into the ball provides high quality seals and precise control
- Multi-actuator mounting bracket allows the same bracket to be utilized on all valves
- Product Resources for Control Ball Valves

https://buildingcontrols.honeywell.com/subcategory/Dampers-Actuators-Valves/Valve-Actuators

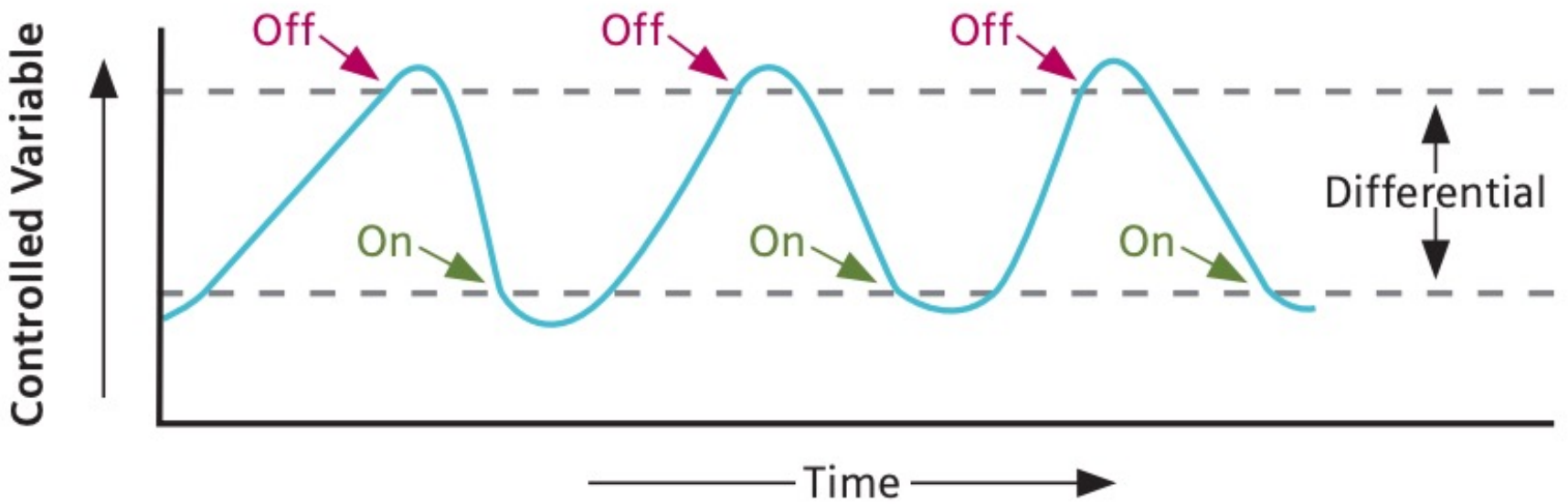
# CONTROL ACTION

# Control Action

- There are different control action strategies:
  - Two position (e.g., on / off)
  - Floating (e.g., three position on / stop / off)
  - Proportional
  - Modulating a continuous range (e.g., 0 to 100% open)

# Control Action

- Two position (e.g., on / off):
  - ❑ Actuator is able to drive a valve (or a damper) to full clockwise position or full counter-clockwise position (same for a spring actuator)



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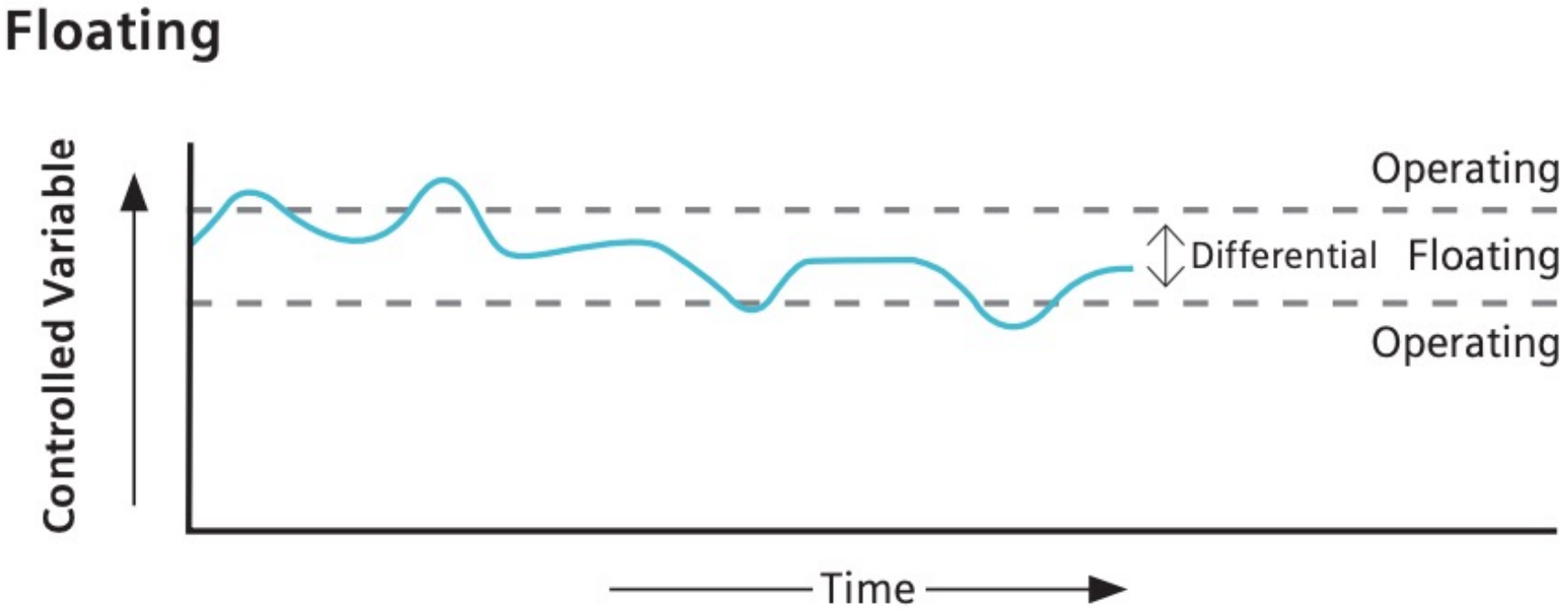
# Control Action

- Floating (3-point)
  - ❑ Similar to the on/off, it has a two-position feature. If no signal exists, the actuator stays in its last position



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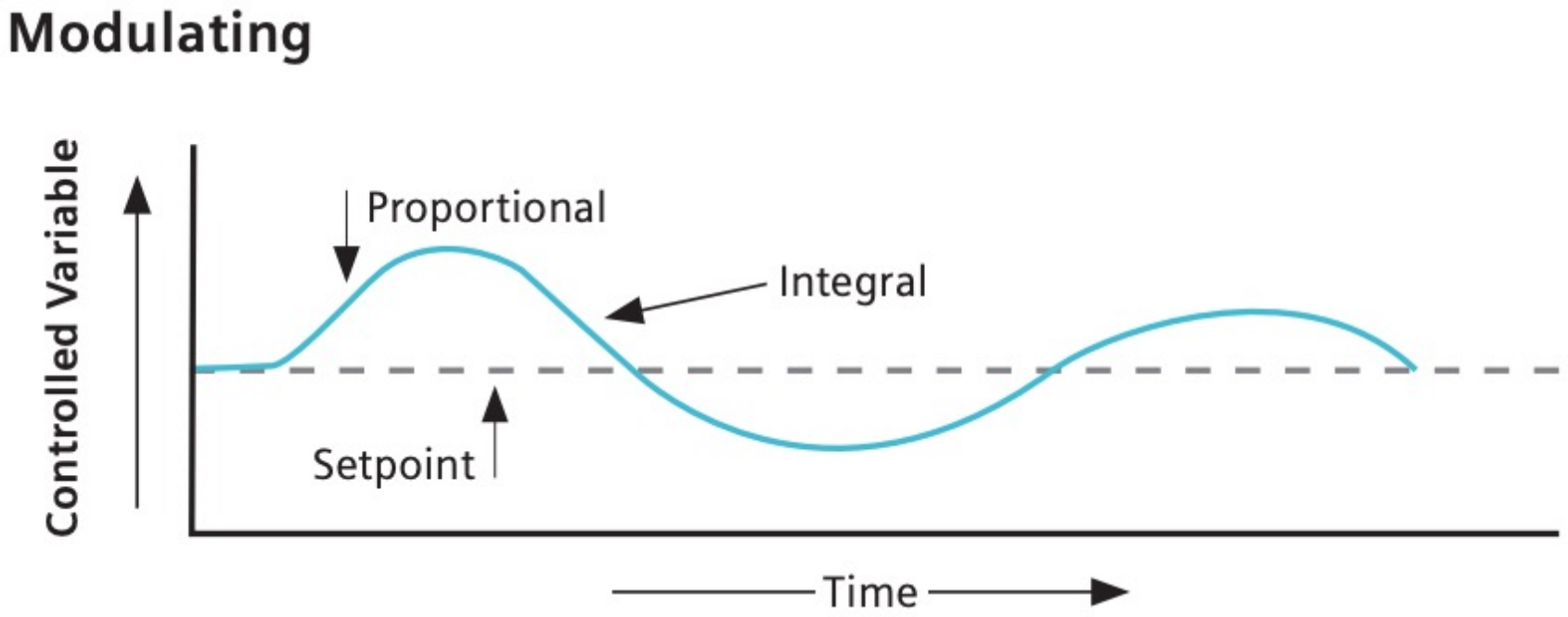
# Control Action

- Modulating (or proportional)
  - ❑ The actuator moves proportional to its control input and modulates throughout its angle of rotation




*What's are control signals that we consider?*



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# ACTUATORS

# Actuators

- An actuator is a device that converts electric or pneumatic energy into a rotary or linear action
  - ❑ Pneumatic
  - ❑ Electric
  - ❑ Electronic
  - ❑ Microprocessor

# Actuators

Manual
Quadrant

Electric
External Mount

Electric
Internal Mount

Pneumatic



https://content.greenheck.com/public/DAMProd/Original/10002/ControlDampers_catalog.pdf

# Actuators

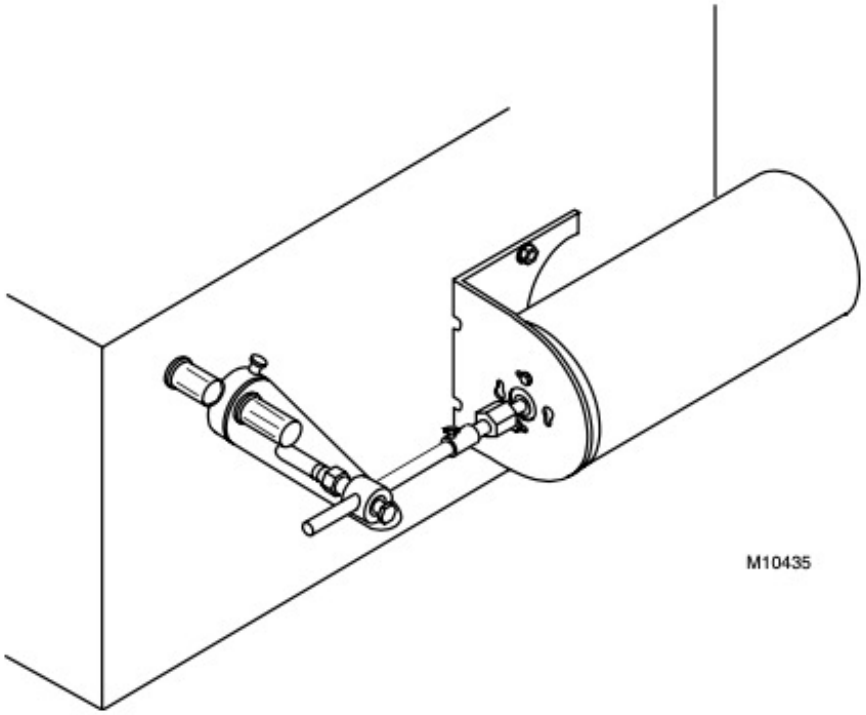
- Pneumatic actuators:

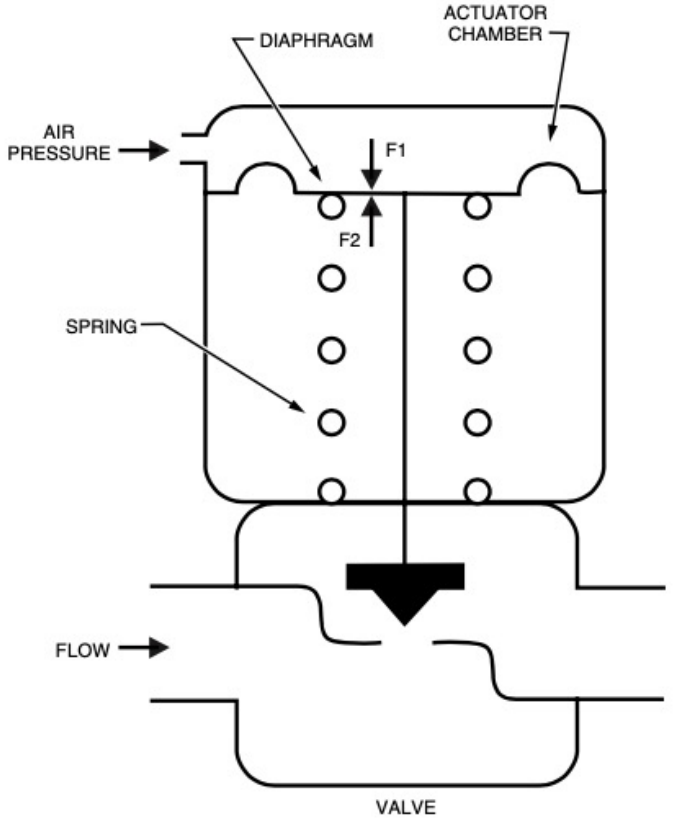



https://content.greenheck.com/public/DAMProd/Original/10002/ControlDampers_catalog.pdf

# Actuators

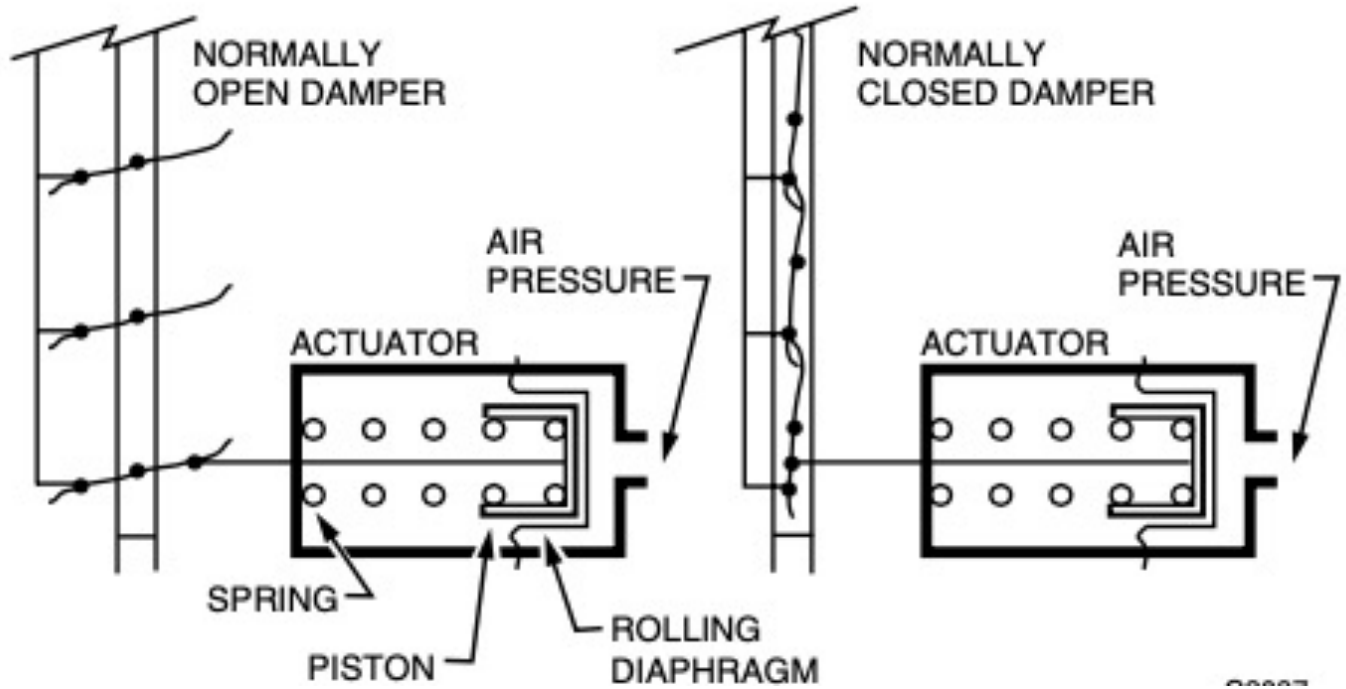
- An example for a typical pneumatic valve actuator is:



# Actuators

- An example for a typical pneumatic damper actuator is:

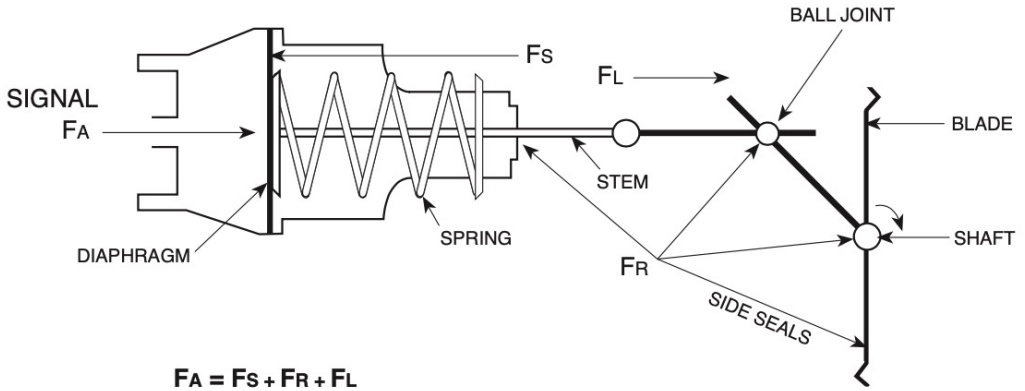





*Engineering manual of automatic control*

# Application of Actuators

- Pneumatic actuators:
  - Power supply (20 psi)
  - Operation
    - Spring Return (spring will drive damper to original starting point)
  - Fail Direction (for spring return only)
  - Control Signal (3 to 15 psi)



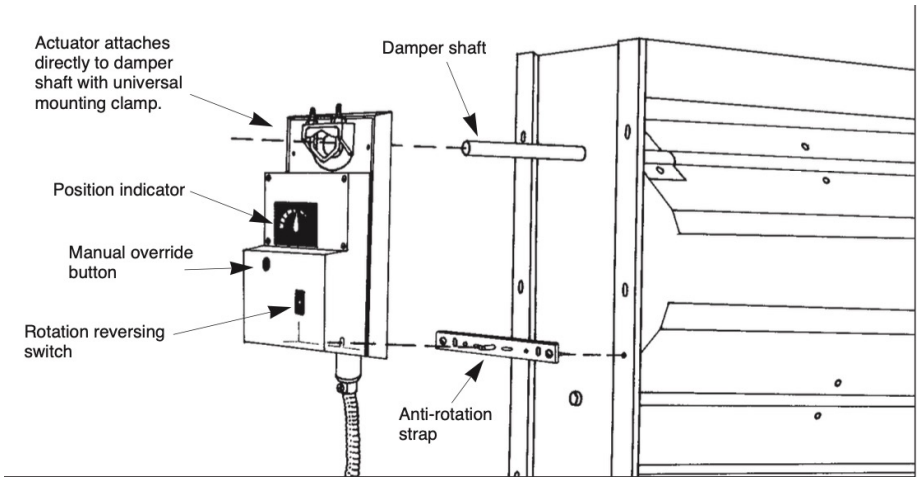

$F_A = F_S + F_R + F_L$

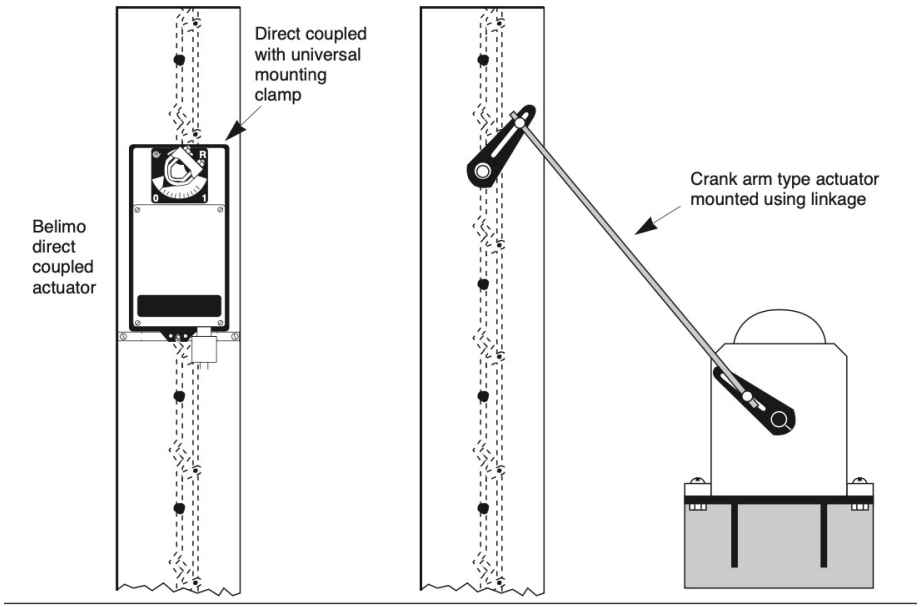
| | |
|---|---|
| $F_A$ = Air Signal (Power) | Positive |
| $F_S$ = Spring | Positive |
| $F_R$ = Resistance and Friction | Always Resists Change |
| $F_L$ = Damper Load | Negative and/or Positive |

For any value of $F_A$ (Signal) the actuator takes a position dependent on the forces acting on it. Repeatability is low. The hysteresis is high. With age, $F_R$ increases. 1.5 PSI hysteresis is normal over a 5 PSI span.

# Actuators

- Electric actuators
  - ❑ Power supply
  - ❑ Operation
    - ❖ Spring Return (spring will drive damper to original starting point)
    - ❖ Power Open or Power Closed
  - ❑ Fail Direction (for spring return only)
  - ❑ Control Signal



# Actuators

- Summary of the characteristics and attributes of control methods:

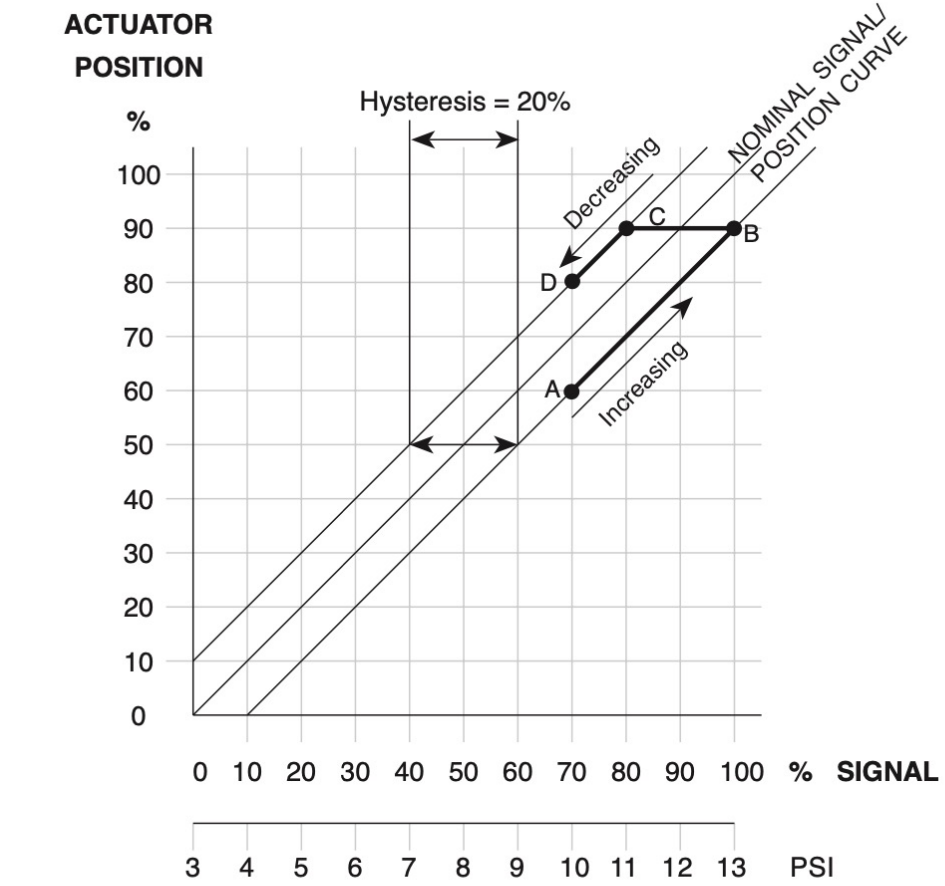
| Pneumatic | Electric | Electronic | Microprocessor |
|---|---|---|---|
| Naturally proportional | Most common for simple on-off control | Precise control | Precise control |
| Requires clean dry air | Integral sensor/ controller | Solid state repeatability and reliability | Inherent energy management |
| Air lines may cause trouble below freezing | Simple sequence of control | Sensor may be up to 300 feet from controller | Inherent high order (proportional plus integral) control, no undesirable offset |
| Explosion proof | Broad environmental limits | Simple, remote, rotary knob setpoint | Compatible with building management system. Inherent database for remote monitoring, adjusting, and alarming. |
| Simple, powerful, low cost, and reliable actuators for large valves and dampers | Complex modulating actuators, especially when spring-return | High per-loop cost | Easily performs a complex sequence of control |
| Simplest modulating control | | Complex actuators and controllers | Global (inter-loop), hierarchial control via communications bus (e.g., optimize chillers based upon demand of connected systems) |
| | | | Simple remote setpoint and display (absolute number, e.g., 74.4) |
| | | | Can use pneumatic actuators |



*Engineering manual of automatic control*

# Actuators

- Actuators tend to have hysteresis meaning:
  - ❑ “There is one position/signal curve for increasing signals, and a slightly different curve for decreasing signals”




**EXAMPLE:**

| | |
|---|---|
| Point A | The signal is 70%, and the position is 60%. |
| Point B | The signal is increased to 100%, the position is 90%. |
| Point C | The signal is decreased to 80%, the position remains at 90%. |
| Point D | The signal is decreased to 70%, the position will be 80%. |

*What are the main issues?*

# Actuators

- Spring return vs. non-spring-return:
  - ❑ If the power supply is lost, the actuator will either fail in its current position, or the mechanical spring takes over and forces the actuator back to its original starting position
  - ❑ In certain cases when power is lost and the application requires protection to the internal components, the damper should be forced to its original starting position (fail-safe spring return actuators)
  - ❑ Spring Return actuators utilize an internal spring that drives the actuator open or closed on loss of power to avoid damage to other components (e.g., motor, fan)



https://assets.new.siemens.com/siemens/assets/api/uuid:58cb9df1-0c4b-4951-a5d5-356c5946560c/damper-actuator-selection-for-hvac-systems-appliction-guide.pdf

# Actuators

- Fail-safe vs non fail-safe:
  - Electronic Fail-safe actuators utilize super capacitors that discharge stored energy to the motor and the actuator is driven open or closed on a loss of power. Non-Spring return actuators stay in their current position on loss of power

# TORQUE

- Damper leakage classes are:

**Allowable Air Leakage to Achieve Classification**

| SI | Maximum Allowable Leakage, L/s/m$^2$ | | |
|---|---|---|---|
| Class | at 0.25 kPa[1] | at 1.0 kPa[1] | at *x* kPa[2] |
| 1A | 15.2 | N/A | N/A |
| 1 | 20 | 41 | $2\sqrt{x} \times 20$ |
| 2 | 51 | 102 | $2\sqrt{x} \times 51$ |
| 3 | 203 | 406 | $2\sqrt{x} \times 203$ |

| I-P | Maximum Allowable Leakage, cfm/ft$^2$ | | |
|---|---|---|---|
| Class | at 1 in. wg[1] | at 4 in. wg[1] | at *x* in. wg[2] |
| 1A | 3 | N/A | N/A |
| 1 | 4 | 8 | $\sqrt{x} \times 4$ |
| 2 | 10 | 20 | $\sqrt{x} \times 10$ |
| 3 | 40 | 80 | $\sqrt{x} \times 40$ |

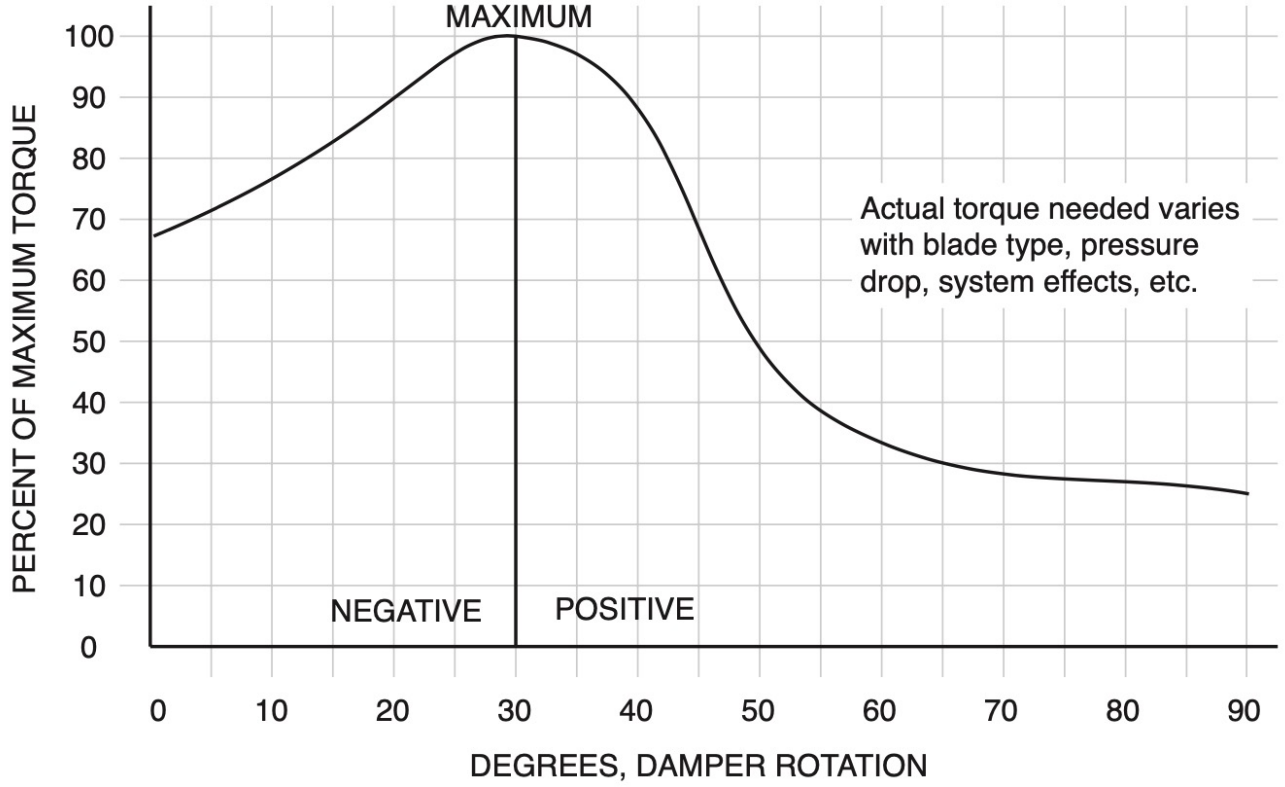
**Notes**:
[1] Required pressures; shall be cataloged
[2] Any other pressure may be cataloged using these formulas



https://www.amca.org/assets/resources/public/userfiles/file/CRP%20Publications/amca_511-13.pdf

# Actuators

- Torque is an important factor since:
  - ❑ It is required to operate a damper
  - ❑ It depends on the size, type, quality, and condition of the damper, differential pressure and airflow



# Torque

- How to calculate the actuator's torque
  - ❑ Rely on the manufacturer's datasheets
  - ❑ Calculate it similar to the following steps
    - ❖ Calculate the damper area $A = \frac{h \times W}{144}\ (ft^2)$
    - ❖ Multiply the rated torque loading of a damper by the damper area

| | | Torque Loading in-lb/ft² | | |
|---|---|---|---|---|
| | | < 1000 FPM | 1000-2500 FPM | 2500-3500 FPM |
| SQUARE | **Damper Blade** | 2 inch water column (WG) | | |
| | Parallel blade/edge seals | 7 (Typical) | 10.5 | 14 |
| | Opposed blade/edge seals | 5 (Typical) | 7.5 | 10 |
| | Parallel blade/no edge seals | 4 | 6 | 8 |
| | Opposed blade/no edge seals | 3 | 4.5 | 6 |
| | Round | 10 | 14 | 20 |

# Torque

- How to calculate the actuator's torque

| Torque Vector Table | | | |
|---|---|---|---|
| Air Velocity (Ft/Min) | Torque Factor (Lb. In/Ft²) | | |
| | < 1200 | < 2500 | < 3000 |
| **Damper Blade Style** | | | |
| Opposed Blade No Seals | 3 | 4.5 | 6 |
| Opposed Blade with Seals | 6 | 7.5 | 10 |
| Parallel Blade No Seals | 4 | 6 | 8 |
| Parallel Blade with Seals | 8.5 | 10.5 | 14 |



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# Torque

- How to calculate the actuator's torque
  - ❑ For dampers when the data does not exist. Use the following table (for less than 1000 fpm face velocity):

| Damper Type | Torque Loading |
|---|---|
| Opposed blade, without edge seals, for non-tight close-off applications | 3 in-lb/sq. ft. |
| Parallel blade, without edge seals, for non-tight close-off applications | 4 in-lb/sq. ft. |
| Opposed blade, with edge seals, for tight close-off applications | 5 in-lb/sq. ft. |
| Parallel blade, with edge seals, for tight close-off applications | 7 in-lb/sq. ft. |

  - ❑ Multiply these numbers by 1.5 for face velocity of 2000 fpm and 2 for face velocity up to 3000 fpm



https://www.belimo.us/mam/americas/technical_documents/Installation_instructions/AFB_AFX_Installation.pdf

# Torque

- How to calculate the actuator's torque
  - ❑ An example is:

| APPLICATION REQUIREMENTS | SQUARE DAMPER | ROUND DAMPER |
|---|---|---|
| Damper Length | 24" | |
| Damper Width | 12" | |
| Damper (Round) | | 12" |
| Blade Type | Opposed | Round |
| Edge Seals | Edge Seals | |
| Design CFM | 1800 CFM | 700 CFM |
| Fail-Safe | Yes | Yes |
| Supply Voltage | 24 Volt | 24 Volt |
| Control Signal | 2-10 VDC | 2-10 VDC |
| **CALCULATIONS** | | |
| Damper Area (sq inches) | 24" x 12" = 288 $in^2$ | $\pi r^2$ =113.04 $in^2$ |
| Damper Area (sq feet)* | 288 $in^2$ x 1ft/12 in x 1ft/12 in = 2 $ft^2$ | 113.04 $in^2$ / 1ft/12in x 1ft/12in= 0.785 $ft^2$ |
| Velocity | 1800 $ft^3$/min / 2 $ft^2$ = 900 ft/min | 700 $ft^3$/min / .785 $ft^2$ = 892 ft/min |
| | See chart under <1000 FPM (ft/min) | See chart under <1000 FPM (ft/min) |
| Rated Torque Loading (in-lbs/$ft^2$)** | Select 5 in-lbs/$ft^2$ for Opposed Blade/Edge Seals | Select 10 in-lbs/$ft^2$ for Round Damper |
| **EXAMPLE EQUATION** | ***Damper Area (sq ft) x **Rated Torque Loading of Damper (in-lbs/$ft^2$) = Total in-lbs Required** | |
| | 2 $ft^2$ x 5 in-lbs/$ft^2$ = 10 in-lbs<br>Belimo LF24-SR US @ 35 in-lbs | 0.785 $ft^2$ x 10 in-lbs/$ft^2$ = 7.85 in-lbs<br>Belimo LF24-SR US @ 35 in-lbs |

# APPLICATION OF ACTUATORS

# Application of Actuators

- The following table summarizes valve and damper actuator selection guide when actuator positioning desired on system shutdown and loss of motive force

| Actuator Application | Pneumatic Actuators | | Electric Actuators | |
|---|---|---|---|---|
| | System Shutdown | Loss of Air | System Shutdown | Loss of Electricity |
| **Dampers** | | | | |
| Outdoor air | Closes | Closes | Closes | Closes |
| Relief air (to outdoor) | | | | |
| Return air | Opens | Opens | Opens | Opens [1] |
| VAV fan inlet vanes | Closes | Closes | Closes | Closes |
| VAV box | Owner Perference | Opens | Owner Perference | Owner Perference |
| Multizone hot deck, cold areas | Opens | | Opens | Opens |
| Multizone hot deck, hot areas | Closes | Closes | Closes | Closes |
| **Valves** | | | | |
| AHU chilled water | Closes | Opens | Closes | Stays same |
| Terminal reheat | | | | |
| Preheat in OA below 35F | Opens [2] | | Opens [2] | Opens |
| Preheat in OA above 35F | Closes | | Closes | |
| Other hot water | Closes [2] | | Closes [2] | Stays same |
| AHU steam heating | | Closes | | Closes |
| Steam humidifier | Closes | | Closes | |

# Application of Actuators

- Fast acting (quick responding) actuators are designed to respond fast within matter of seconds (e.g., 2 seconds)
- Shaft adapter concentrically holds shaft with no slipping or call backs for fast installation
- Examples are
  - ❑ Supply/exhaust air
  - ❑ Fume hoods




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# Application of Actuators

- Fire and smoke actuators:
  - ❑ Make sure to meet the UL requirements
  - ❑ Range of torque



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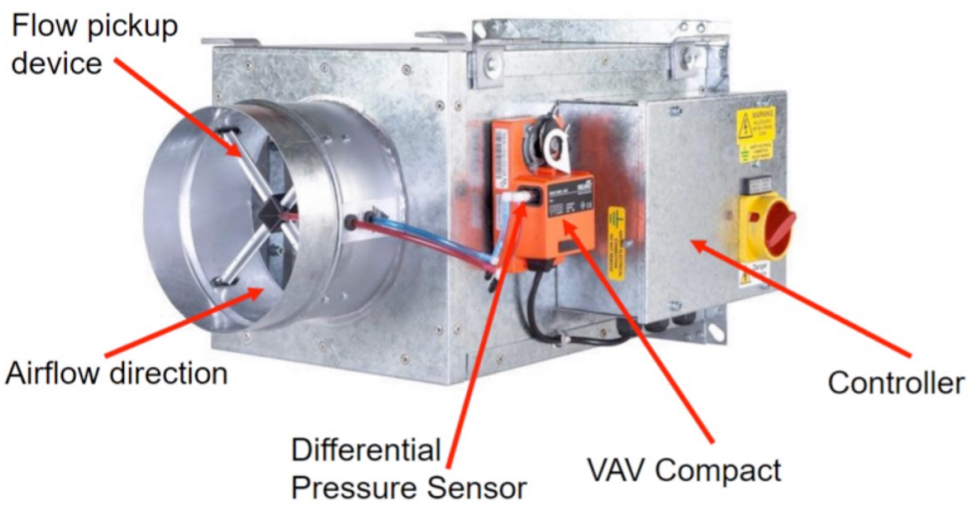
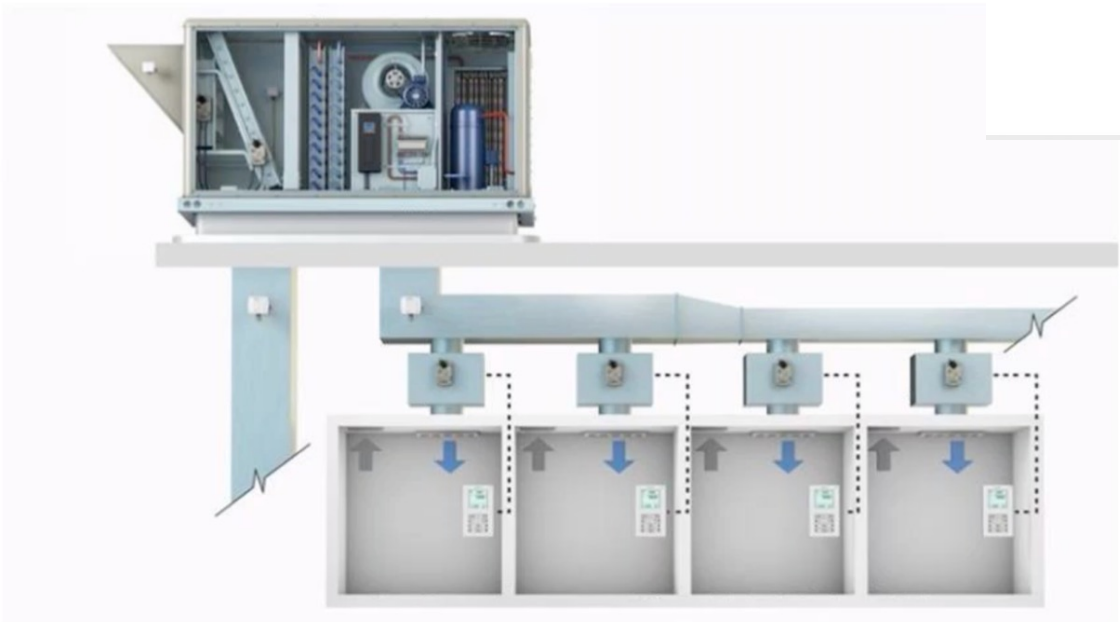
# Application of Actuators

- VAV boxes
  - ❑ Pneumatic
  - ❑ Electric



# DAMPER ACTUATOR SELECTION

# Damper Actuator Selection

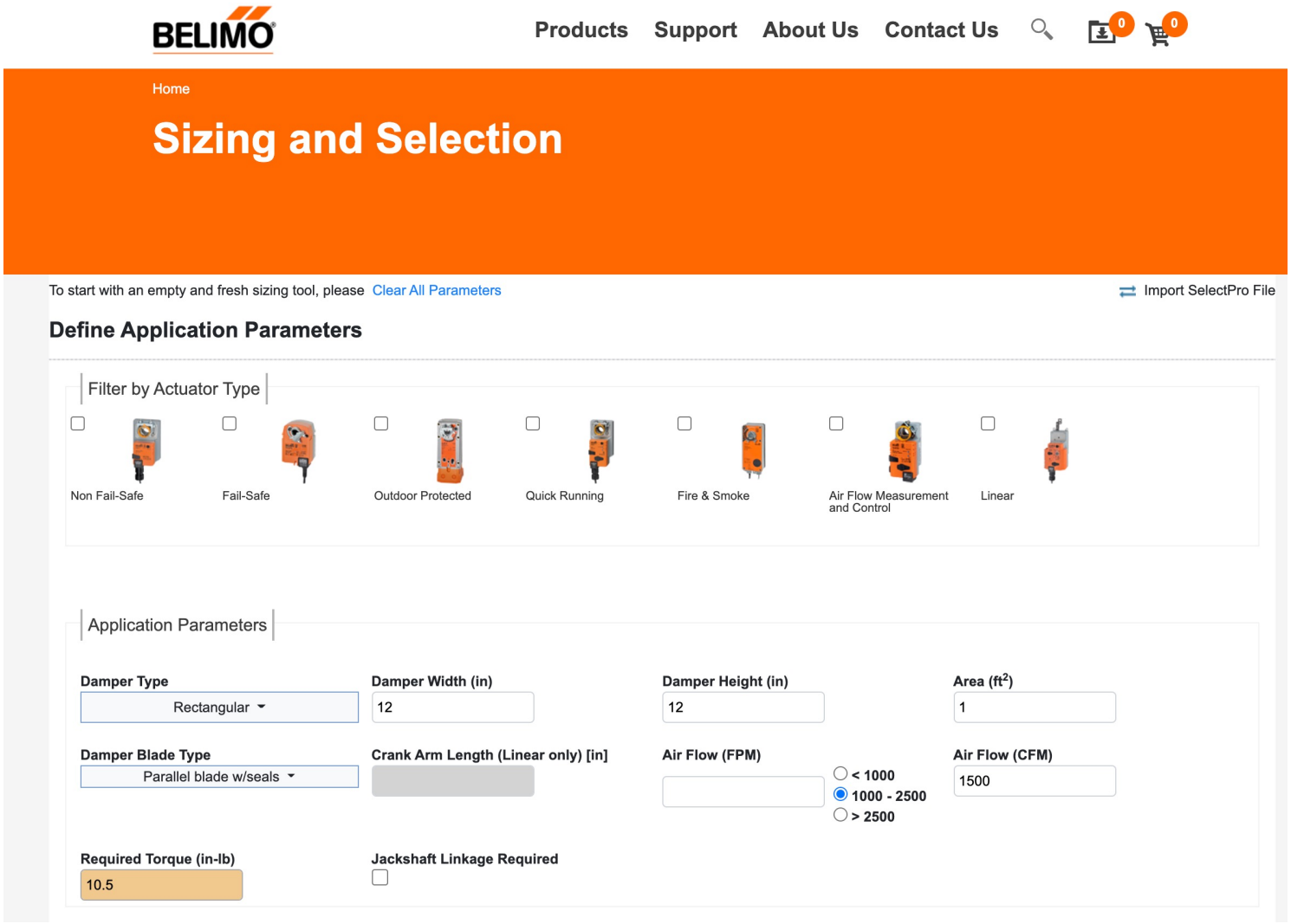
- For dampers:
  - ❑ Assess damper's physical properties such as:
    - ❖ Area
    - ❖ Required Torque
    - ❖ Max Pressure Ratings
    - ❖ Damper Part Number
    - ❖ Max Air Velocity or CFM
    - ❖ Temp. Ratings
    - ❖ Seal Type
    - ❖ Blade Type/Length
    - ❖ Blade Action

# Damper Actuator Selection

- For dampers:
  - ❑ Identify or calculate the torque requirements
    - ❖ Use recommended values
  - ❑ Understand the applications
    - ❖ Actuator application (on/off, modulating, …)
    - ❖ Fail safe
    - ❖ Spring return
    - ❖ Power requirement
    - ❖ Control signal

# Damper Actuator Selection

- Let's look at some manufacturers




https://www.belimo.com/us/shop/en_US/actuator-sizing-and-selection

# Damper Actuator Selection

- Let's look at some manufacturers

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## Actuators

Belimo damper actuators are designed for use in a wide variety of HVAC applications ensuring performance, reliability and lower power consumption. With a comprehensive torque range (18 to 1400 in-lbs) suited for damper sizes as small as 6 inch round allowing the ability to direct mount on standard damper shafts or jackshafts. Actuators are suited for control dampers, air handlers, economizer units, VAV terminal units, fan coil units, fan shutters, and unit ventilators.


Versatile in Performance and Function

### Non Fail-Safe

18 to 1400 in-lbs

Shop Now
Learn More


Performance with Low Power Consumption

### Fail-Safe

22 to 1400 in-lbs

Shop Now
Learn More


NEMA 4/4X Rated

### Outdoor Protected

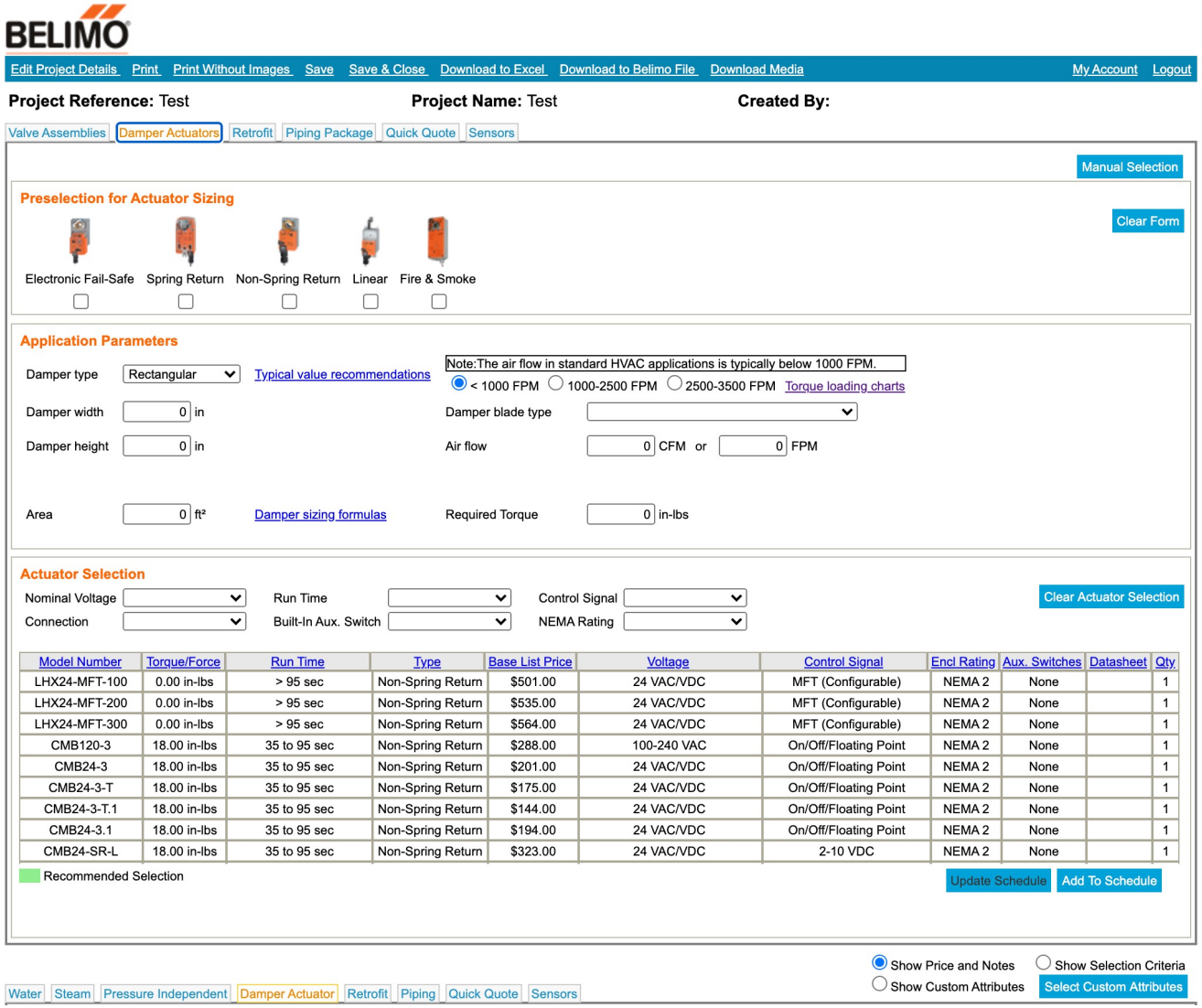
90 to 1400 in-lbs

Shop Now
Learn More

https://www.belimo.us/en_US/products/actuators.html

# Damper Actuator Selection

- Let's look at some manufacturers




https://www.belimo.us/shop/en_US/login

# Class Activity

- Form 3-4 breakout groups
- Fill in the spreadsheet:

*https://docs.google.com/spreadsheets/d/1duxKfuy1kpYNJxXT6e9bHjVBBqUXnwBSBuR8Dkz4f7c/edit#gid=1102666624*

- Select two dampers from your previous list, and select actuators (e.g., spring return, non-spring return non fail-safe, fail-safe, and quick opening)

# VALVE WITH ACTUATOR ASSEMBLY SELECTION

# Valve Selection

- The following steps are recommended for sizing valves
  1. Calculate the pressure drop across the valve (Note use rule of thumbs or coil pressure drop)
  2. Use the $C_v$ equation
  3. Determine the number of ports (2-way or 3-way)
  4. Determine the required ANSI pressure class rating (125 or 250)
  5. Determine the flow characteristics (i.e., Equal Percentage, ..)
  6. Determine the trim requirements (Bronze/Brass or Stainless steel)
  7. Recognize the flow temperature and packing (Standard or high temperature)
  8. Determine the mechanical connections (Flanged, Sweat, NPT, FxUM)

# Actuator and Assembly Selection

- The following steps are recommended for selecting actuators:
  1. Determine the actuator normal position and failsafe
     - ❑ NO – Normally Open
     - ❑ NC – Normally Closed
     - ❑ SR – Spring Return or failsafe
     - ❑ NSR – Non-Spring Return or Fail-in-Place
  2. Determine type of actuator and control signal (2 position, 3 position, 0-10 vdc)
  3. Determine if manual override is required
  4. Check close of pressure
  5. Check the actual pressure drop using the formula
  6. Confirm the valve authority is between 25% to 50%

# CLASS ACTIVITY

# Class Activity

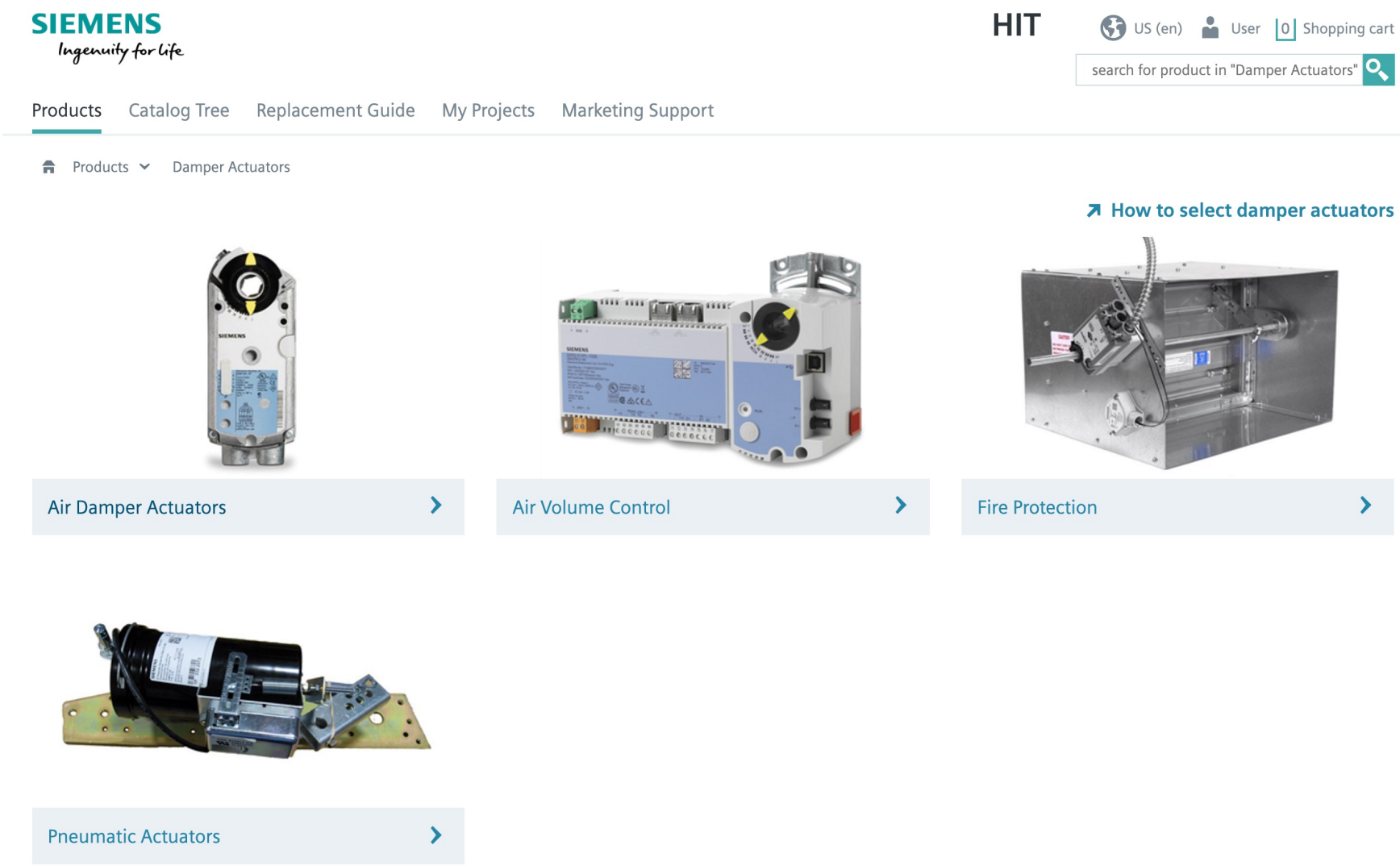
- Form 3-4 breakout groups
- Fill in the spreadsheet:

https://docs.google.com/spreadsheets/d/1duxKfuy1kpYNJxXT6e9bHjVBBqUXnwBSBuR8Dkz4f7c/edit#gid=1102666624

- Select two valves from your previous list, and select actuators (e.g., spring return, non-spring retrun non fail-safe, fail-safe, and quick opening)

# Class Activity

- Let's look at some manufacturers

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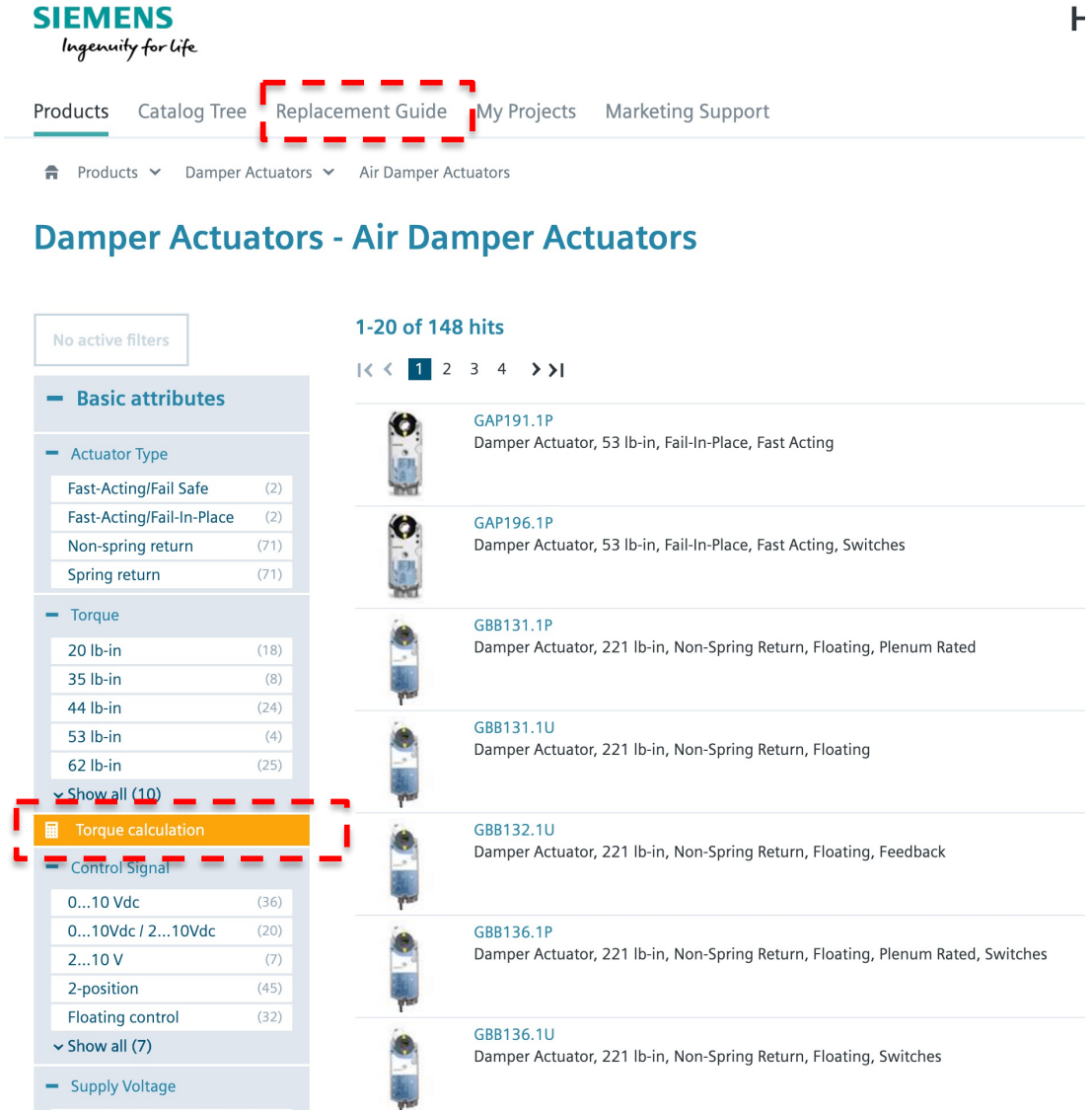
# Class Activity

- Let's look at some manufacturers






https://hit.sbt.siemens.com/RWD/app.aspx?RC=US&lang=en&MODULE=Product&ACTION=ShowGroup&KEY=HIT_Prod_Grp_50255

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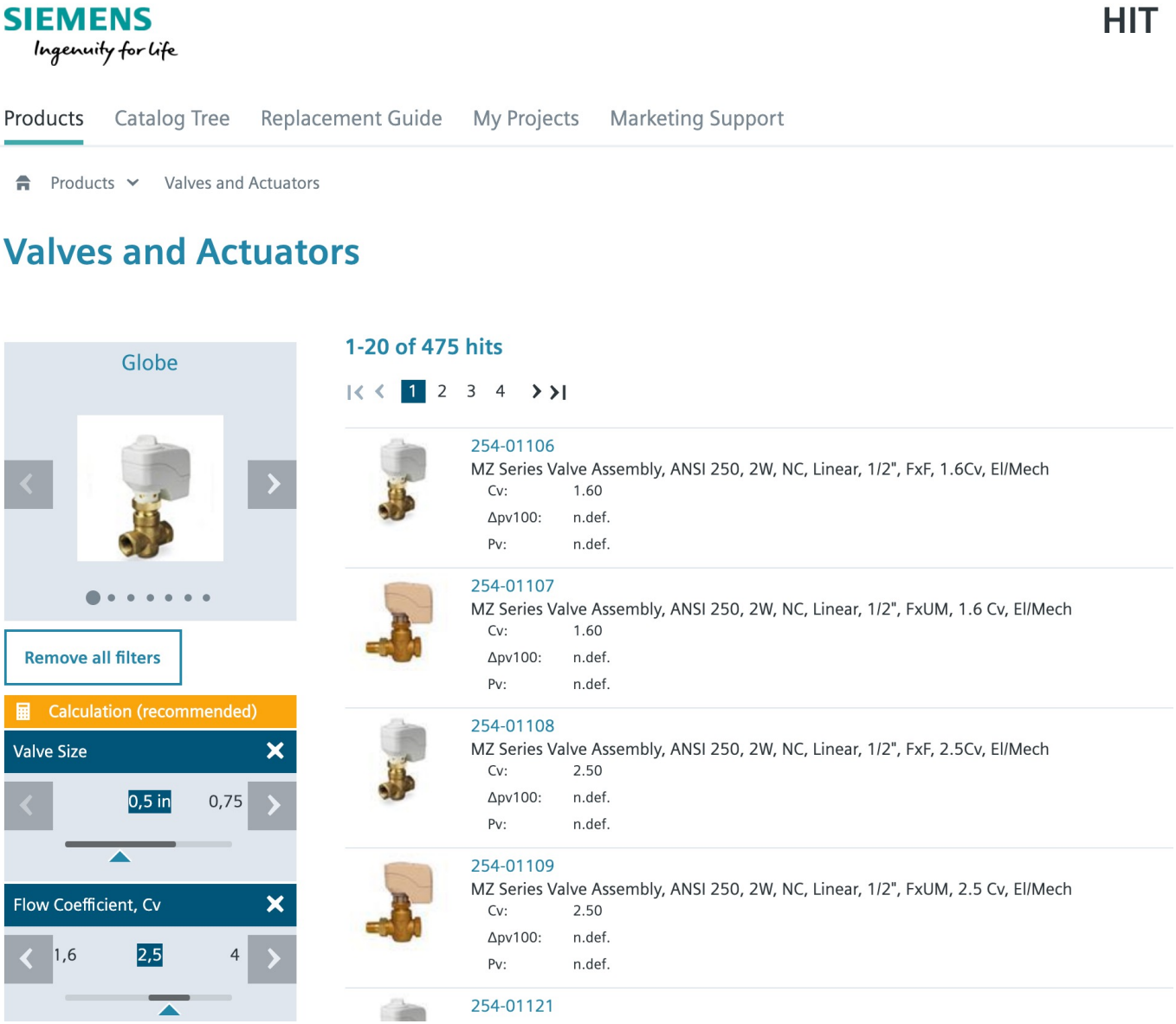

# Actuator and Assembly Selection

- How to read specifications:

| Sample: | B | 2 | 02 | F | C |
|---|---|---|---|---|---|

Valve Type:
Butterfly

Action:
2 = 2-Way
3 = 3-Way

Valve Size:
02=2", 25=2.5", 03=3", 04=4",
05=5", 06=6", 08=8" 10=10",
12=12", 14=14", 16=16", 18=18",
20=20", 24=24"

Disc Type:
F = Full Cut
U = Under Cut

Valve Configuration:
3-Way - A, B, C, D
2-Way
O = Normally Open
C = Normally Closed
M = Valve assembly with manual operator

| Sample: | A | 1 | 2 | 6 | . | 600 |
|---|---|---|---|---|---|---|

Actuator:
A = Industrial Actuator
GCA = Siemens SR Commercial Actuator
GIB = Siemens NSR Commercial Actuator

Voltage:
1 = 24V
2 = 120V

Control Signal:
2 = 2-Position
3 = Floating (Commercial Actuators only)
6 = Modulating (0-10V)

End Switches:
1 = No switches
6 = Switches

Separator

Industrial Actuator Torque (lb-in):
600=600, 1K=1200, 2K=2000, 3K=3000, 5K=5000, 6K=6500,
13K=13000, 18K=18000, 21K=21300, 41K=40680, 3U = Shaft adapter with 3 foot cable (Commercial Actuators only)

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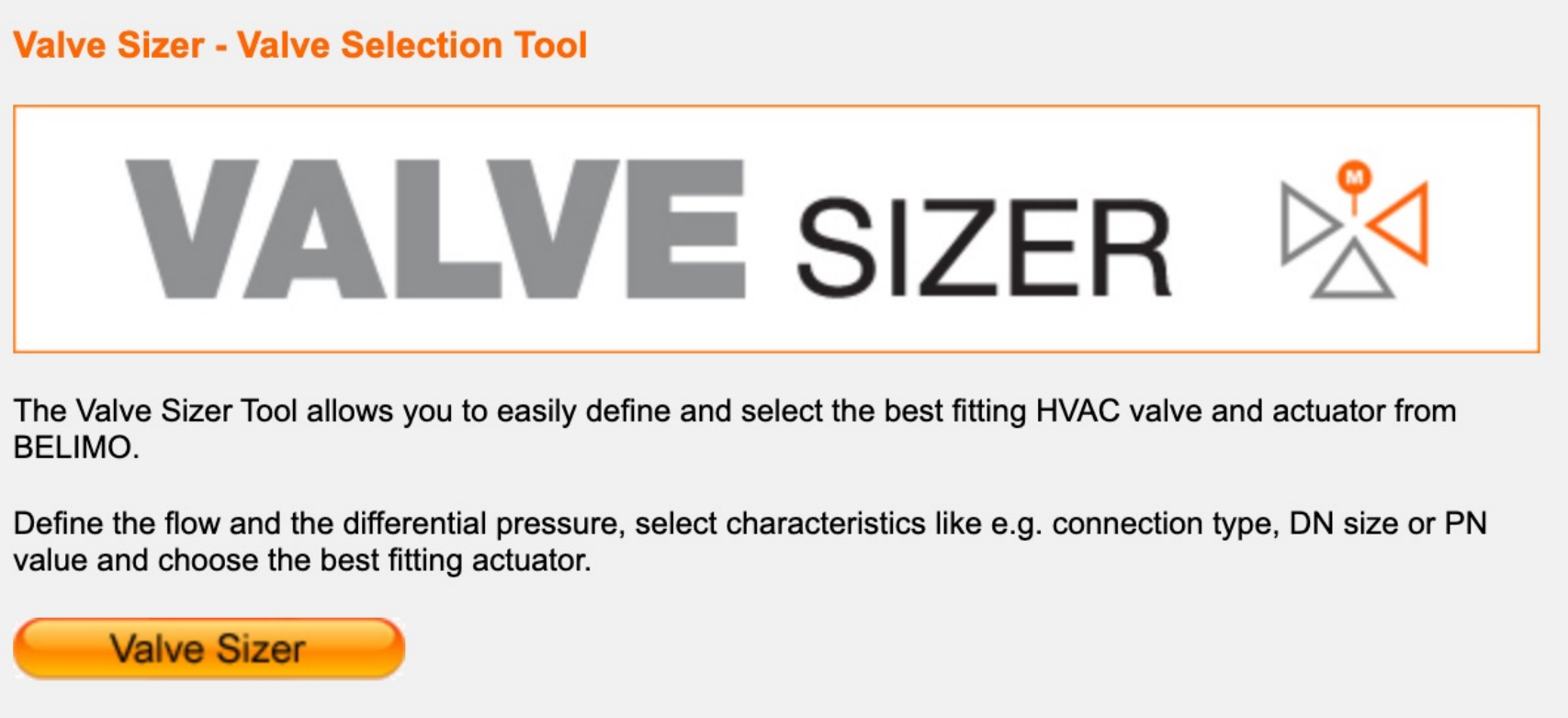


https://www.belimo.eu/ch/en/product/Water/ValveSizer.cfm

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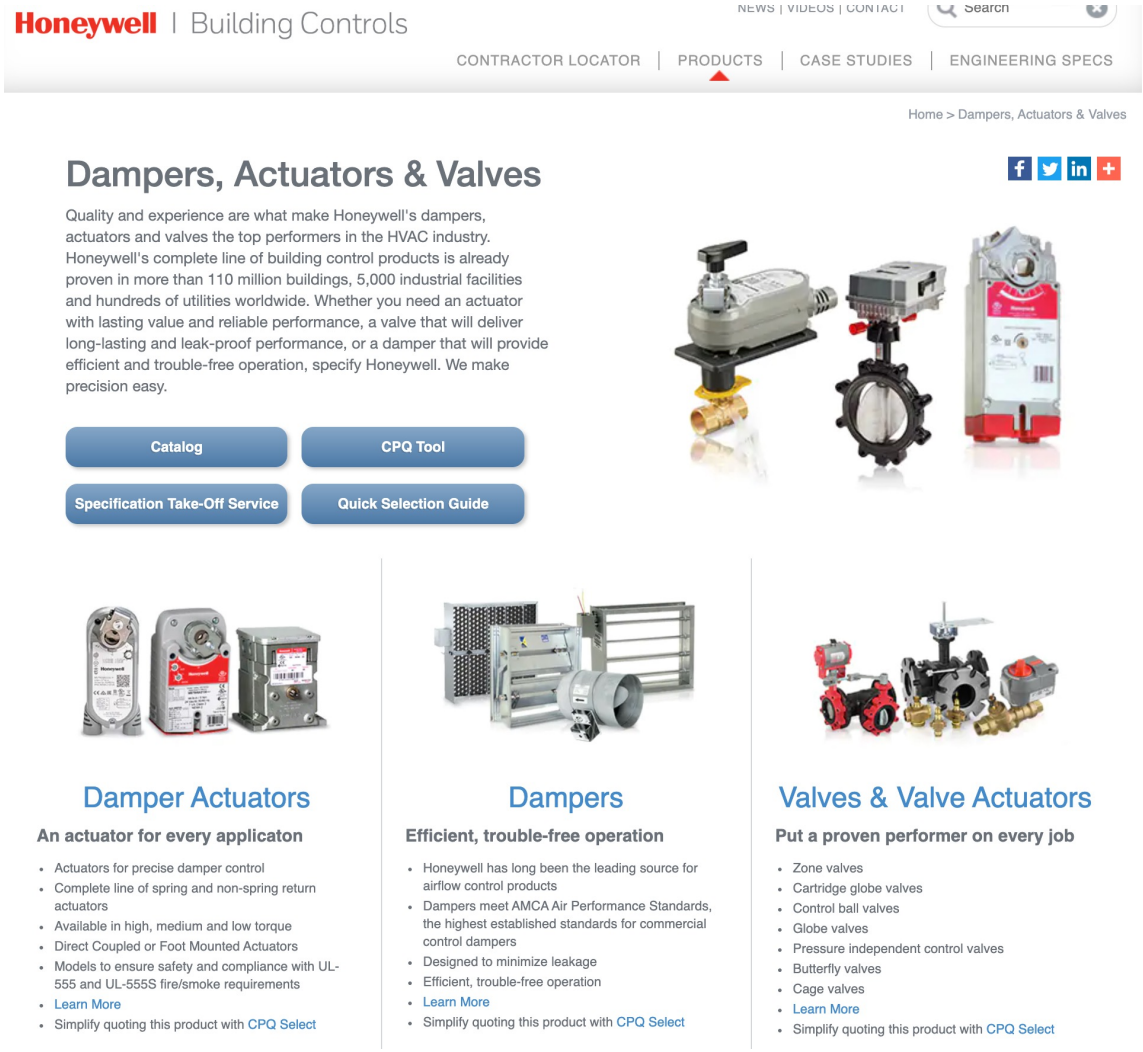


https://buildingcontrols.honeywell.com/subcategory/Dampers-Actuators-Valves

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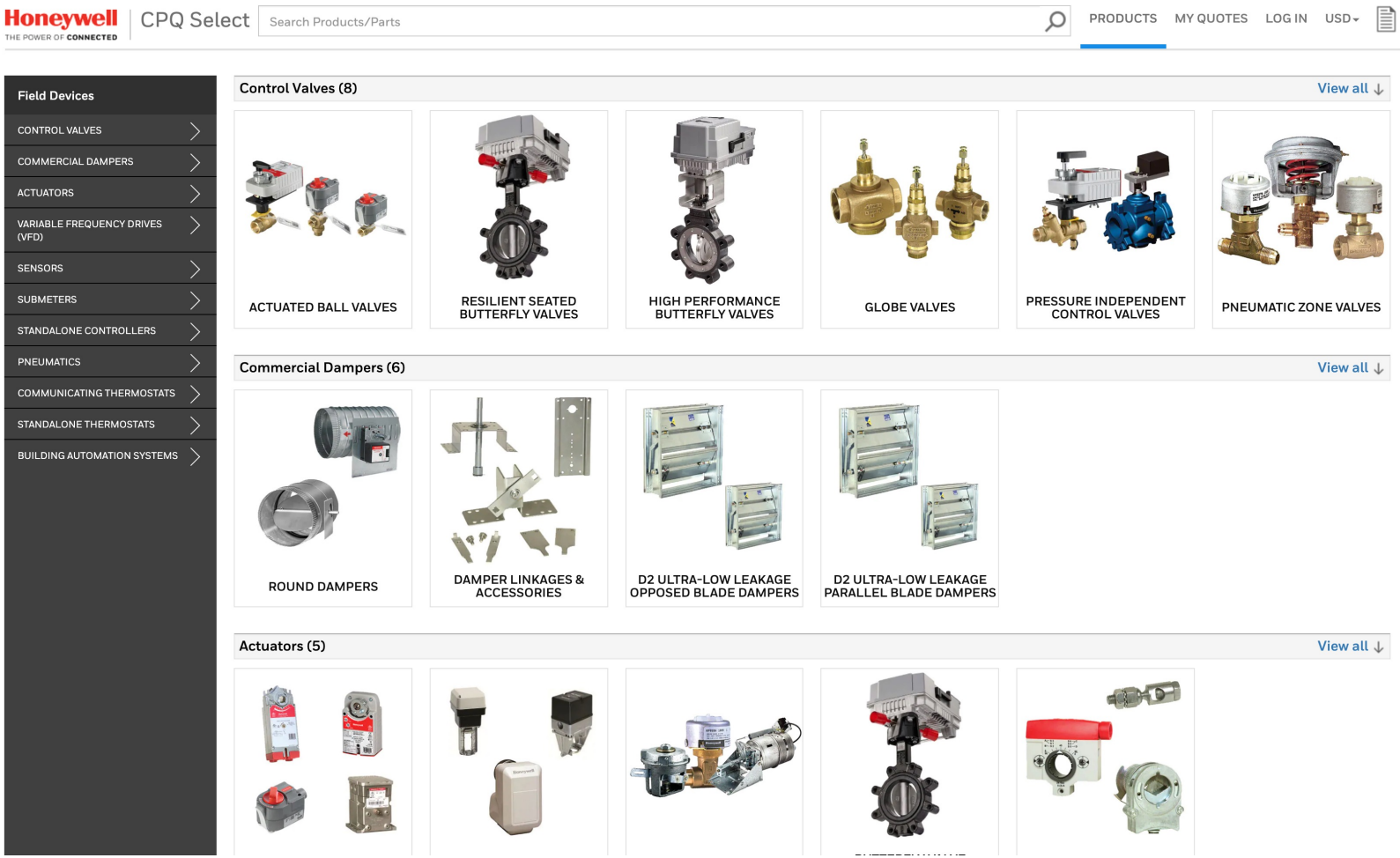


https://www.cpq.honeywell.com/eCommerce#/

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Our HVAC Control Valves and Actuators are critical components in an end-to-end system, and their efficiency is an important factor in overall system efficiency. Choose from thousands of valve and actuator combinations that are built to deliver efficient, dependable, long-lasting and leak-proof performance. Our consistent designs and convenient built-in operating features provide outstanding control – without the need for field add-ons.

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Deliver a stable flow, regardless of pressure fluctuations, with the new VP140 Series of Pressure Independent Control Valves (PICVs). By combining a pressure regulator, a regulating valve and a control valve, it increases occupant comfort and system efficiency without the need for balancing valves. The VP140 Rotary (Ball) Valve is ideal for applications that require enhanced flexibility for seasonal commissioning and different room layouts, and the VP140 Compact Axial (Globe) Valve is designed for applications where a compact valve and actuator footprint is needed. All models deliver reduced installation, commissioning and operational costs.

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https://www.johnsoncontrols.com/building-automation-and-controls/hvac-controls/valves-and-actuators