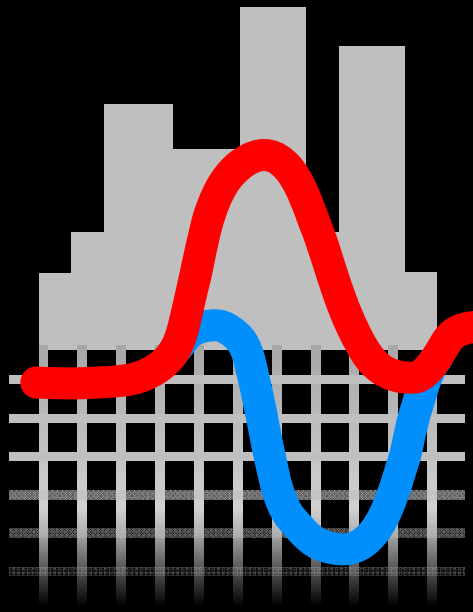

Facility Dynamics
ENGINEERING

Inputs and Outputs – The Field Perspective

Outputs and Actuator Considerations

Presented By:

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Senior Engineer

NAVFAC, San Diego

Proportional Actuators

Electric

- Tristate
  - Two sets of contacts
    - Clockwise rotation
    - Counterclockwise
  - Can be used as two position
- Proportional signal
  - 4-20 milliamp
  - 2-10 vdc
  - 1-5 vdc

Image courtesy Bray Controls; used with permission

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Proportional Actuators

Electric

- Electronic controller boards required to integrate the drive system with the control and power system

Proportional Actuators

Image courtesy Bray Controls; used with permission

Electric

- Frequently powered with low voltage cabling system to minimize cost
  - Power limited circuits mean that the instantaneous power available to move something is limited
  - Small motors are geared to manage the available power
    - Torque may be limited unless high voltage power is provided

Image courtesy Bray Controls; used with permission

Proportional Actuators

Electric

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  - Small motors are geared to manage the available power
    - Torque may be limited unless high voltage power is provided

- Speed is compromised
  - 15 seconds is fast
  - 30-60 seconds is common
  - 90 – 120 seconds is not unheard of in large actautors

Proportional Actuators

Pneumatic

- Power is a function of diaphragm or piston area
- Even with low pressure (20 psi) air you can get a lot of force and torque
- 50-150 psi operation is possible
- Can be used for modulation or two position operation

Image courtesy Bray Controls; used with permission

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Proportional Actuators

Pneumatic

- Relatively simple construction
- Easy to understand and repair
- Actuating speed can be a matter of seconds to go full stroke
  - The air line needs to be sized to provide the volume required for the desired speed
  - Beware of water hammer and air hammer

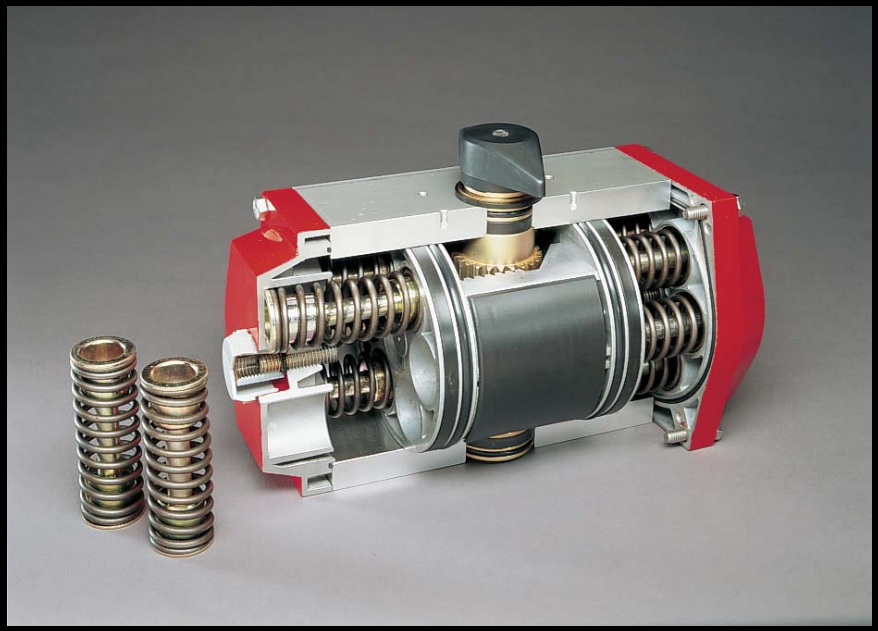

Image courtesy Bray Controls; used with permission

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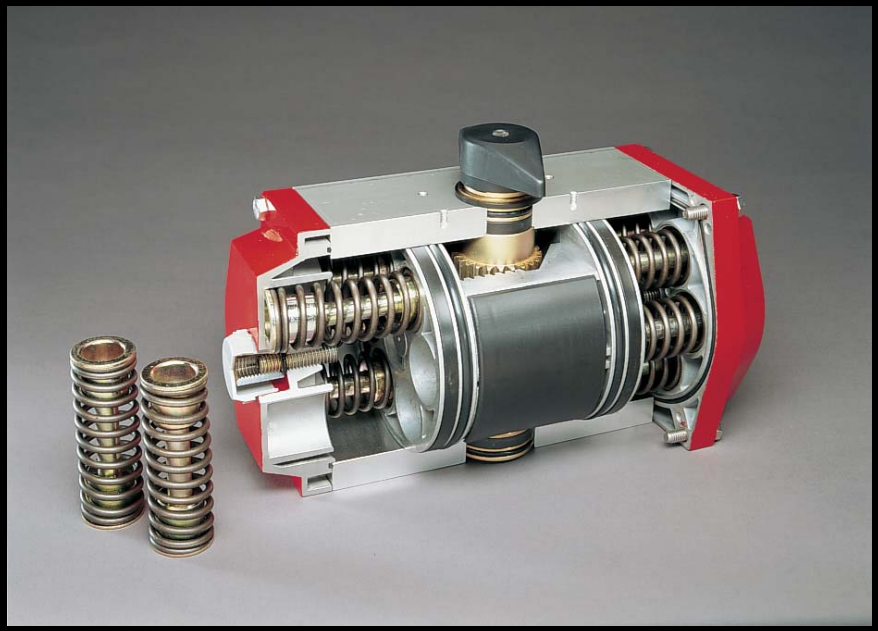


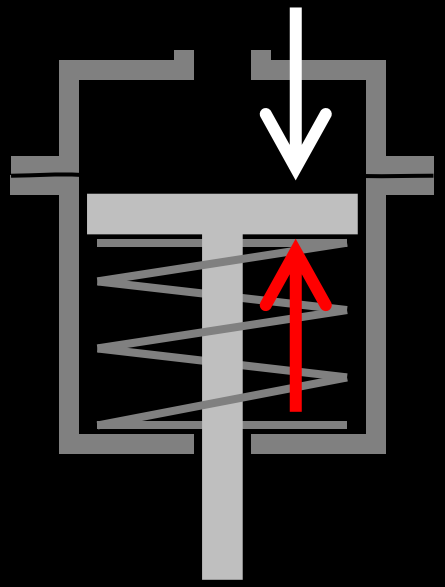
- Double acting cylinders can use air to provide equal power in either direction
  - Accumulators with check valves provide fail safe operation

Proportional Actuators

Pneumatic

- 3-15 psi = standard signal
- Spring ranges allow sequencing
  - HW Coil – 3-5 psi = Full flow to no flow
  - Economizer – 7 – 10 psi = MOA to Maximum OA
  - CHW Coil – 12-15 psi – No flow to full flow

The Forces Acting on a Valve Actuator as Described in the Literature



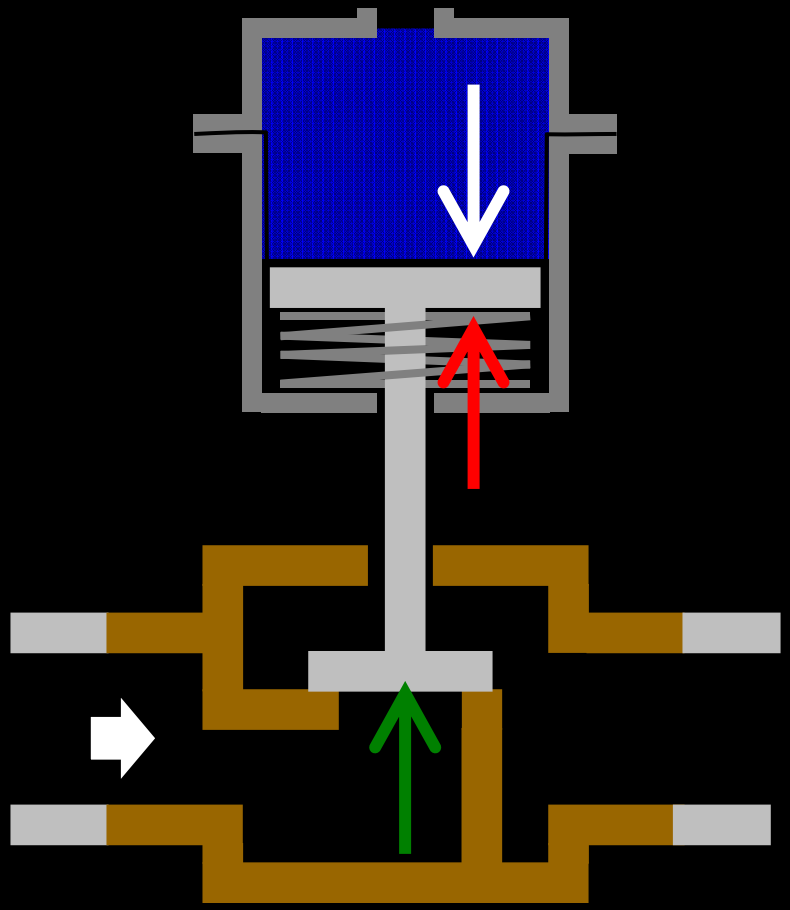
Control Signal

Force = Pressure x Area

Spring

Force = Spring Rate x Deflection

The Forces Acting on a Valve Actuator in the Field



Control Signal

Force = Pressure x Area

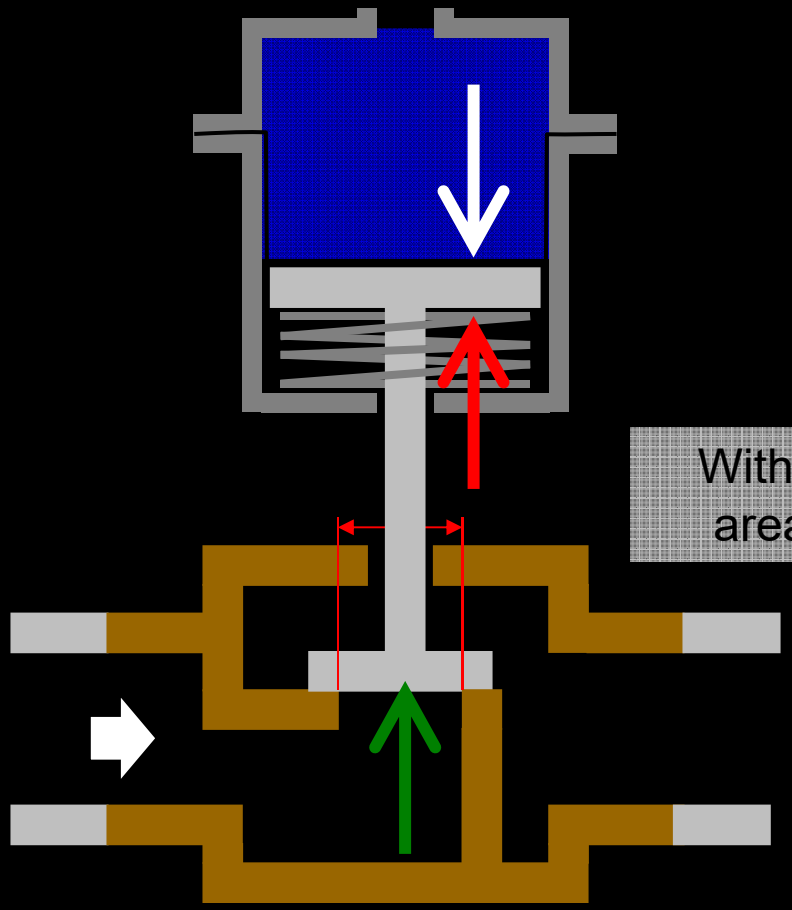
Spring

Force = Spring Rate x Deflection

Valve Plug Differential Pressure

Force = Effective Area x ΔP

The Forces Acting on a Valve Actuator in the Field

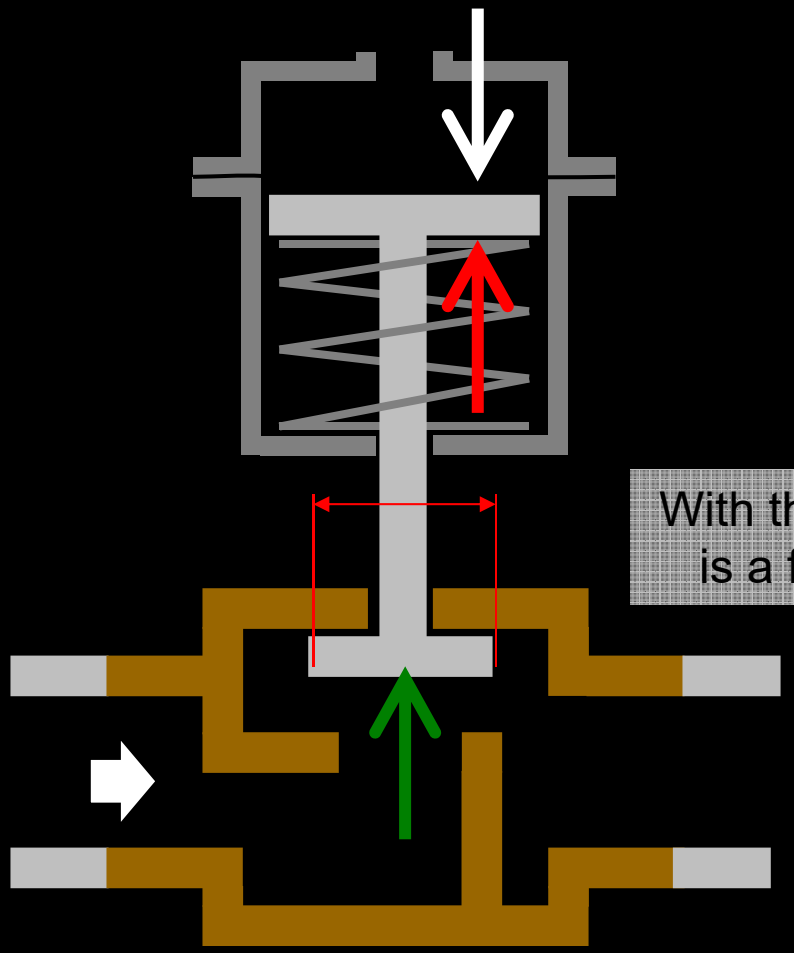


With the valve closed, the effective area is a function of this diameter

Plug force will vary as the result of a number of operating variables

- Effective area can change

The Forces Acting on a Valve Actuator in the Field

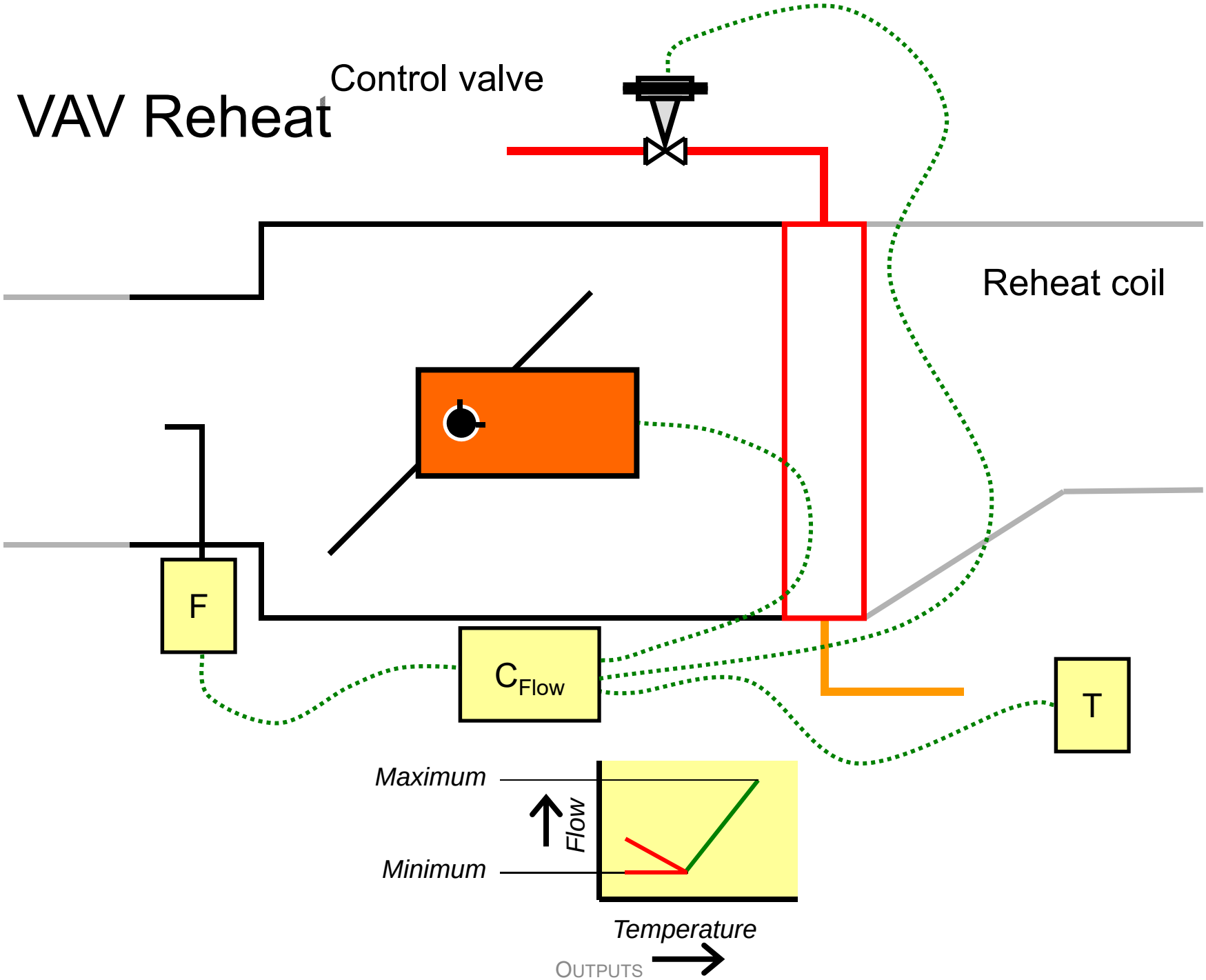


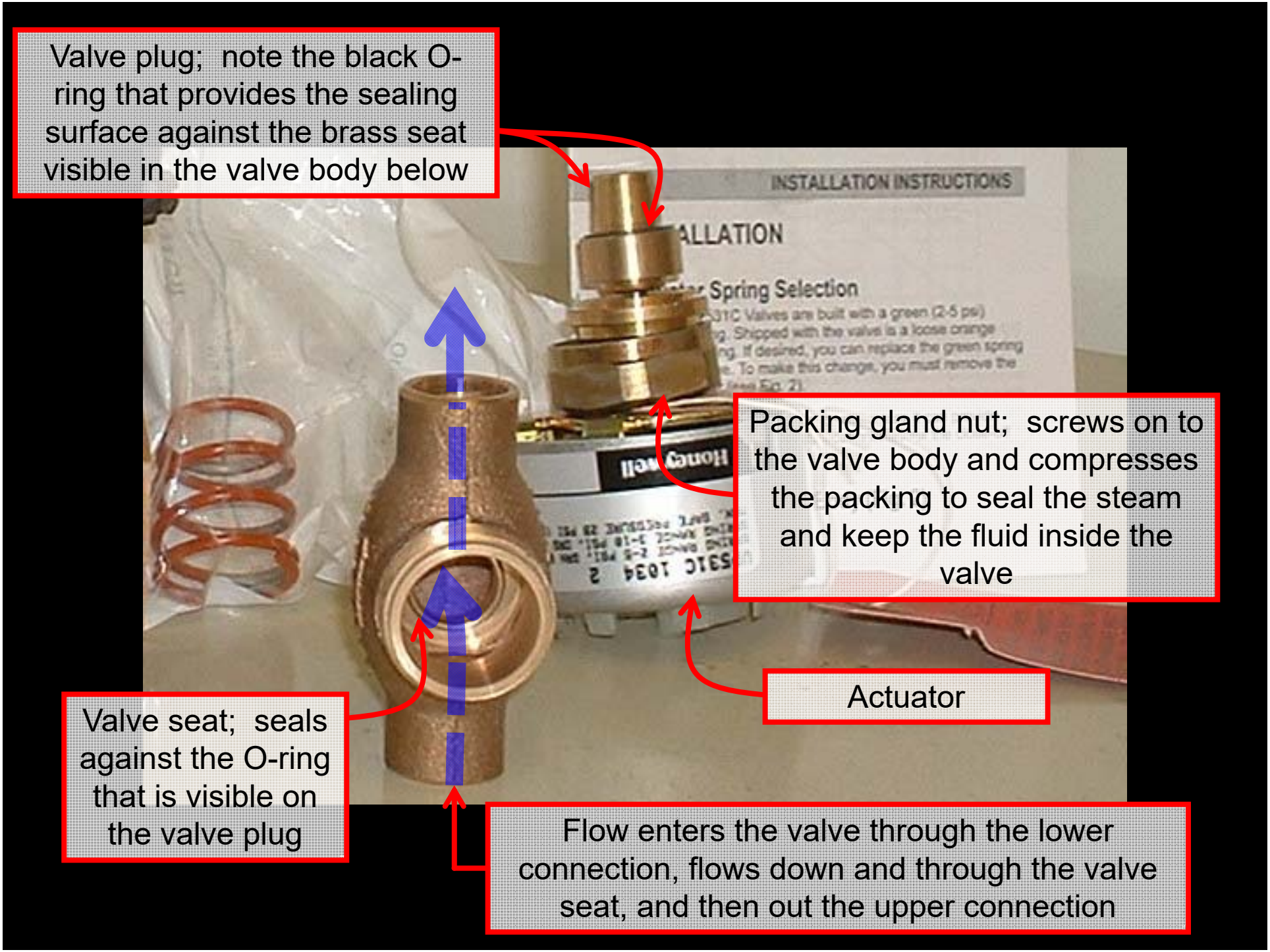
Plug force will vary as the result of a number of operating variables

- Effective area can change

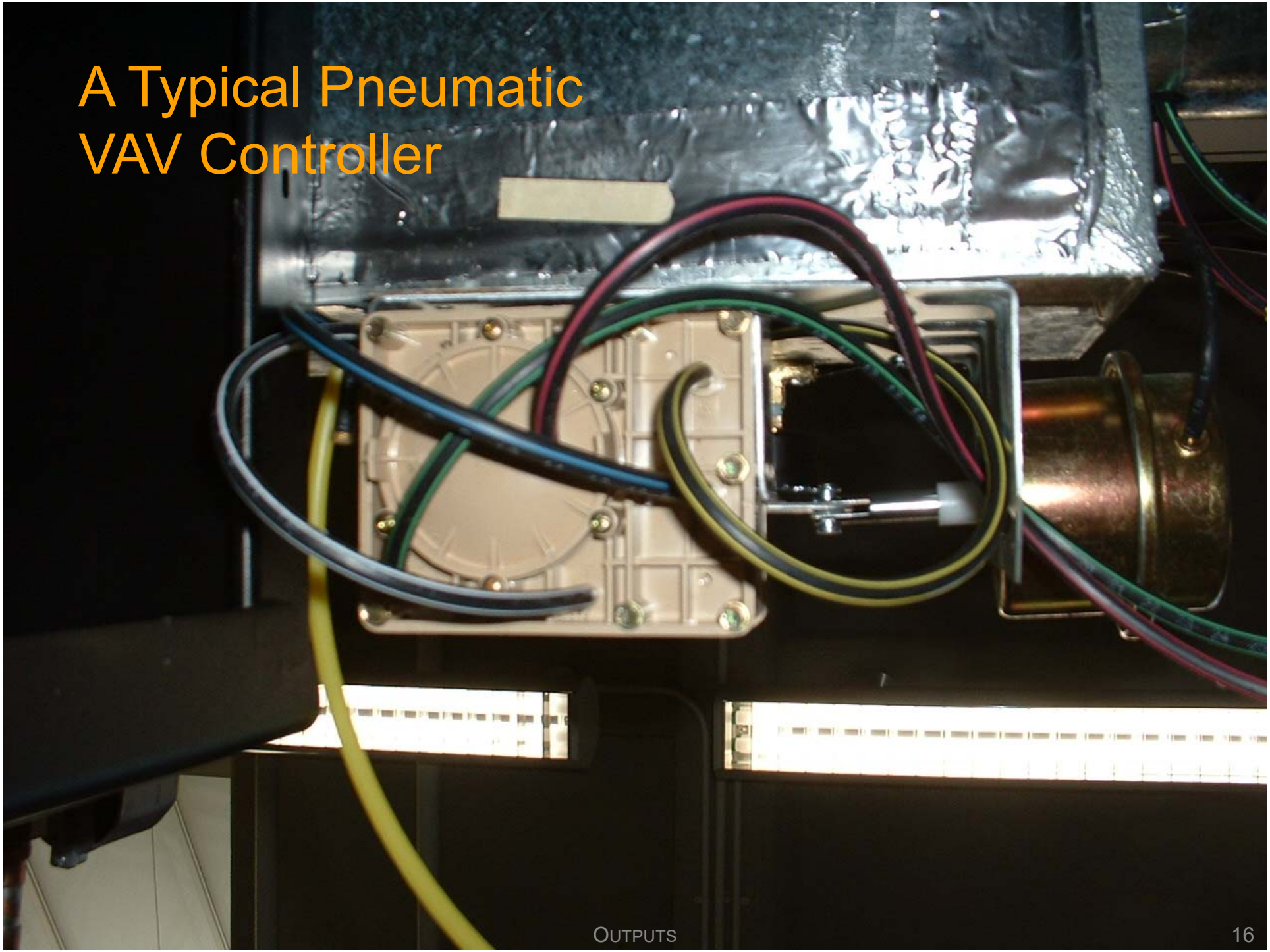
With the valve open, the effective area is a function of a different diameter

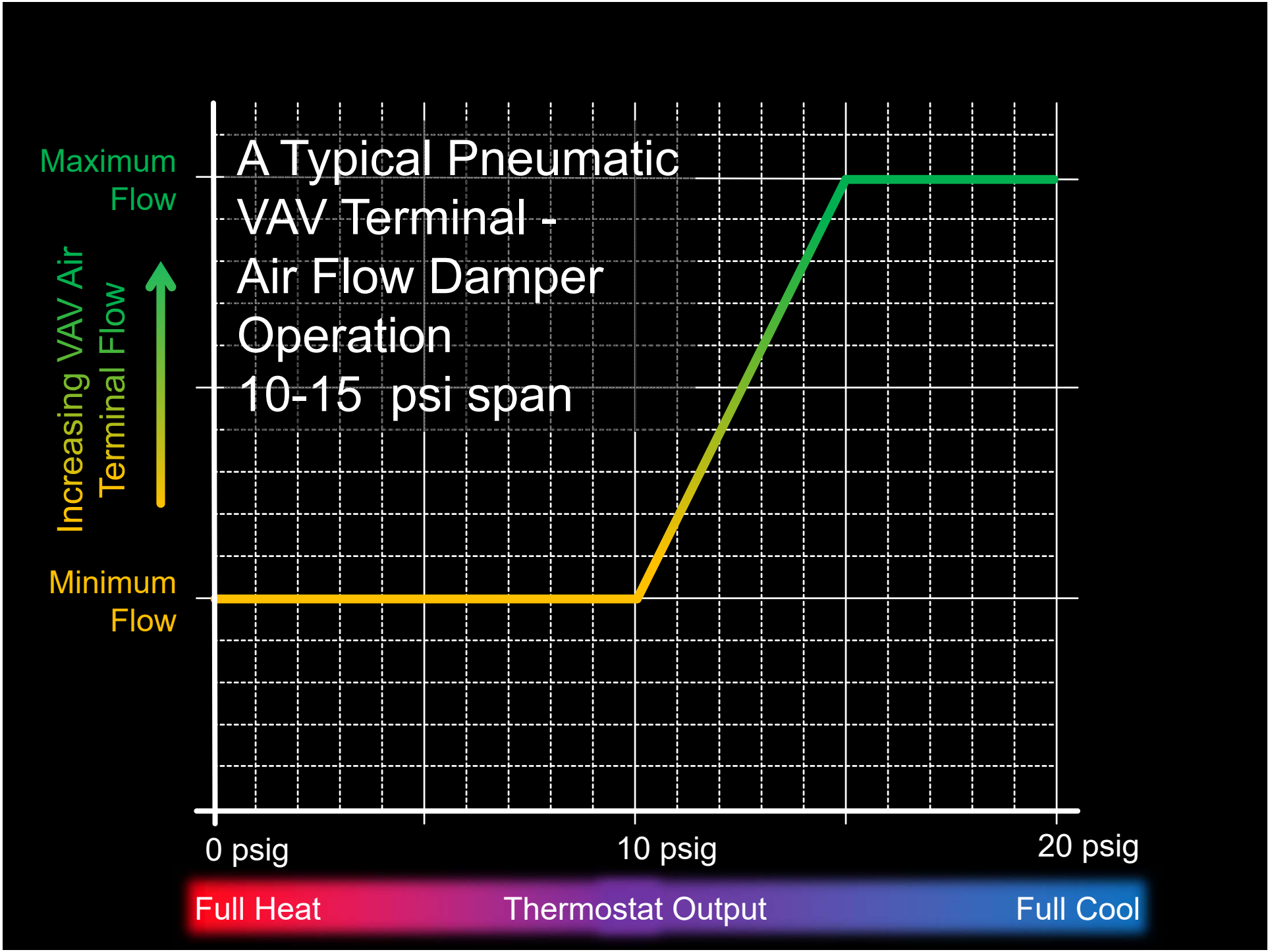
VAV Reheat

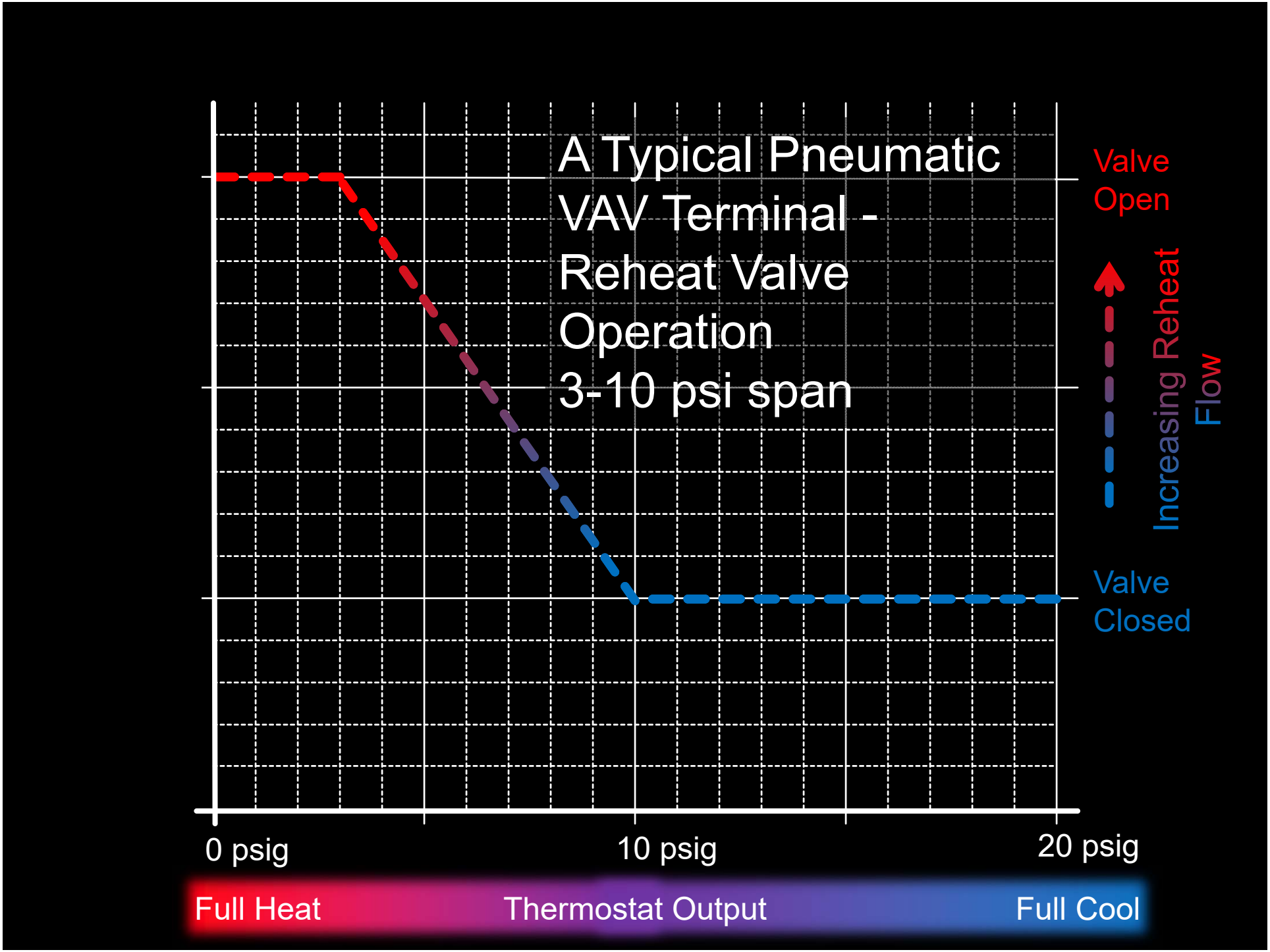

Control valve
Reheat coil
F
C_{Flow}
T
Maximum
Minimum
Flow
Temperature
OUTPUTS

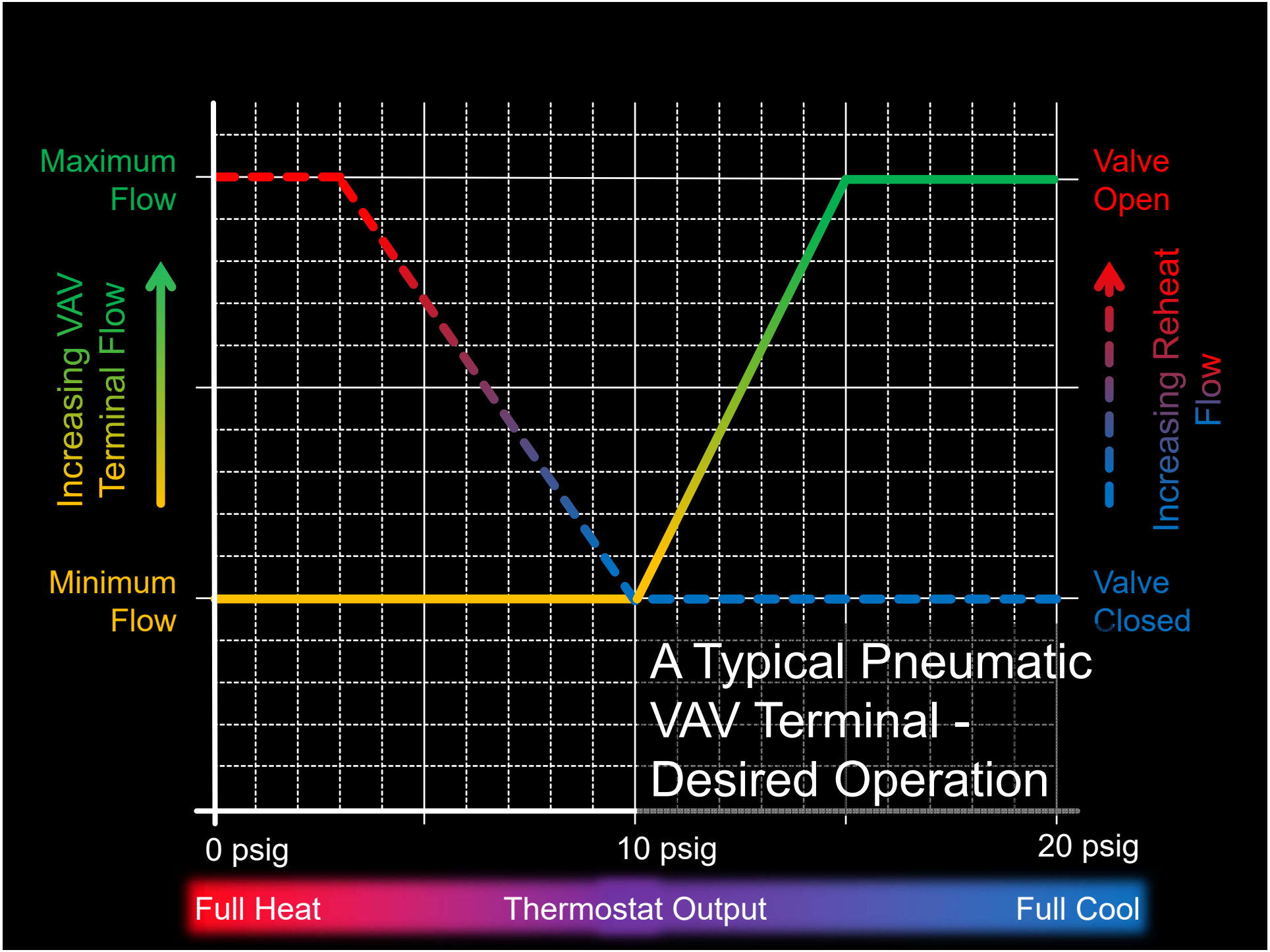

Valve plug; note the black O-ring that provides the sealing surface against the brass seat visible in the valve body below
INSTALLATION INSTRUCTIONS
Spring Selection
Packing gland nut; screws on to the valve body and compresses the packing to seal the steam and keep the fluid inside the valve
Actuator
Valve seat; seals against the O-ring that is visible on the valve plug
Flow enters the valve through the lower connection, flows down and through the valve seat, and then out the upper connection

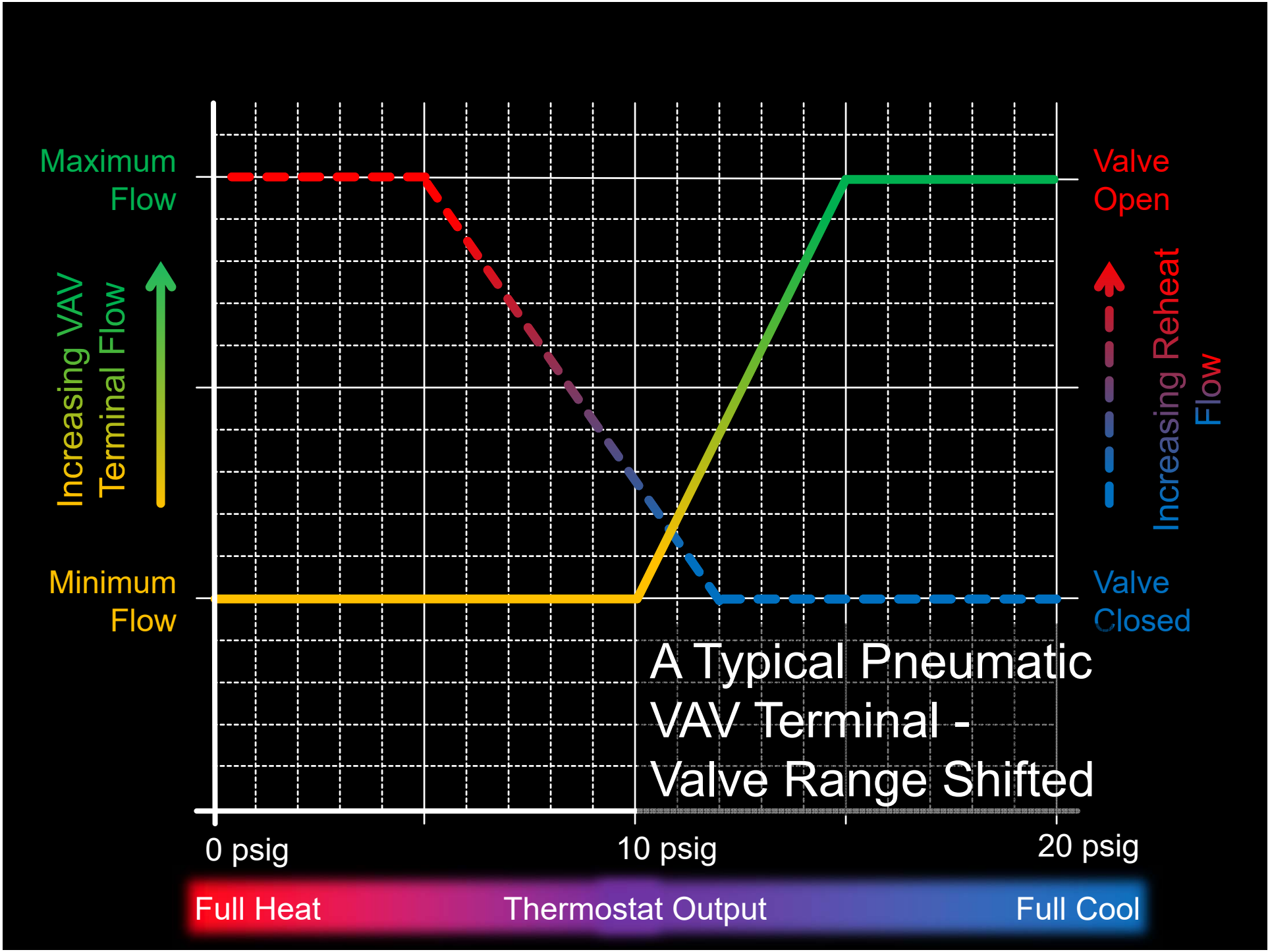
A Typical Pneumatic VAV Controller

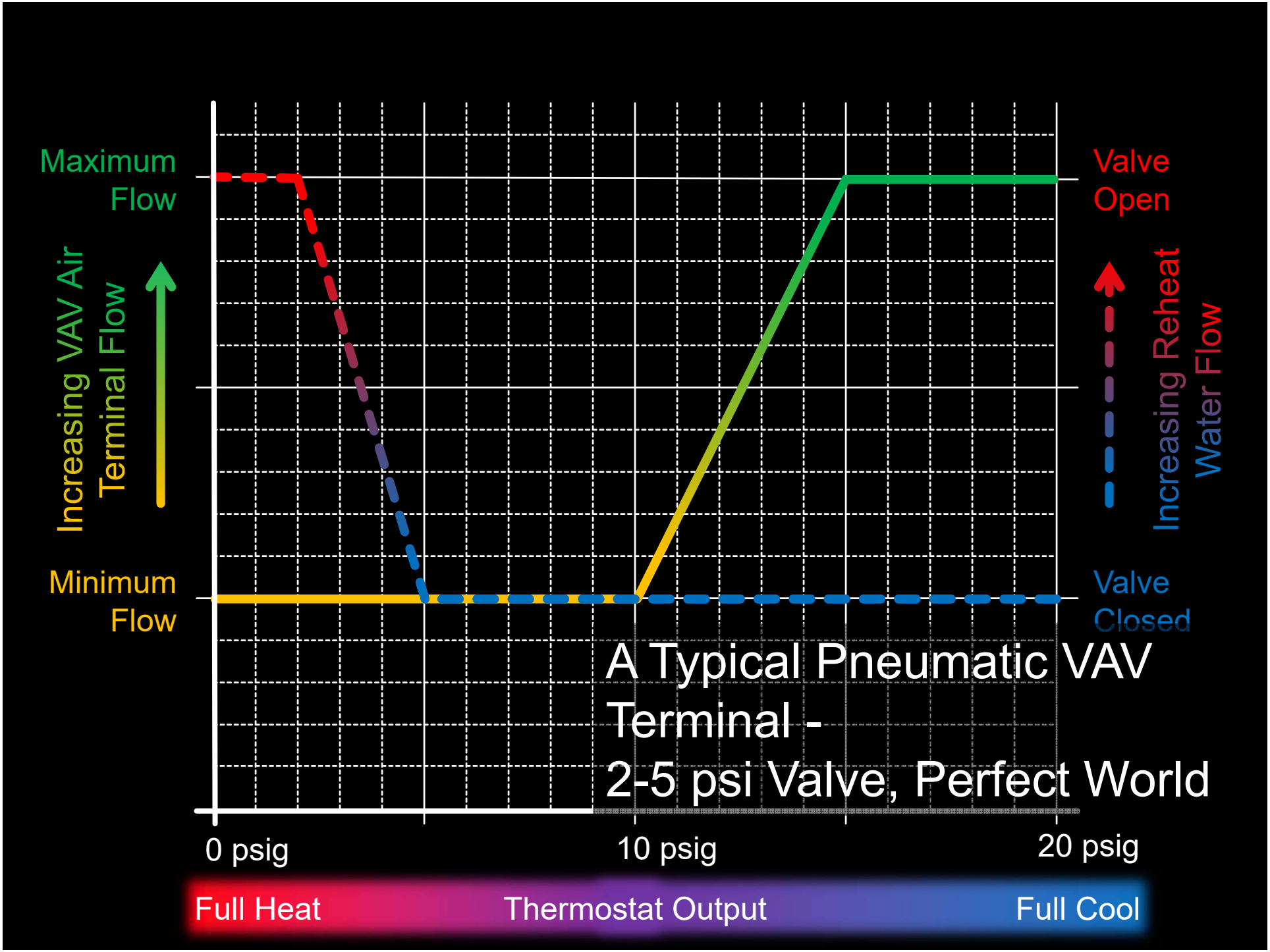


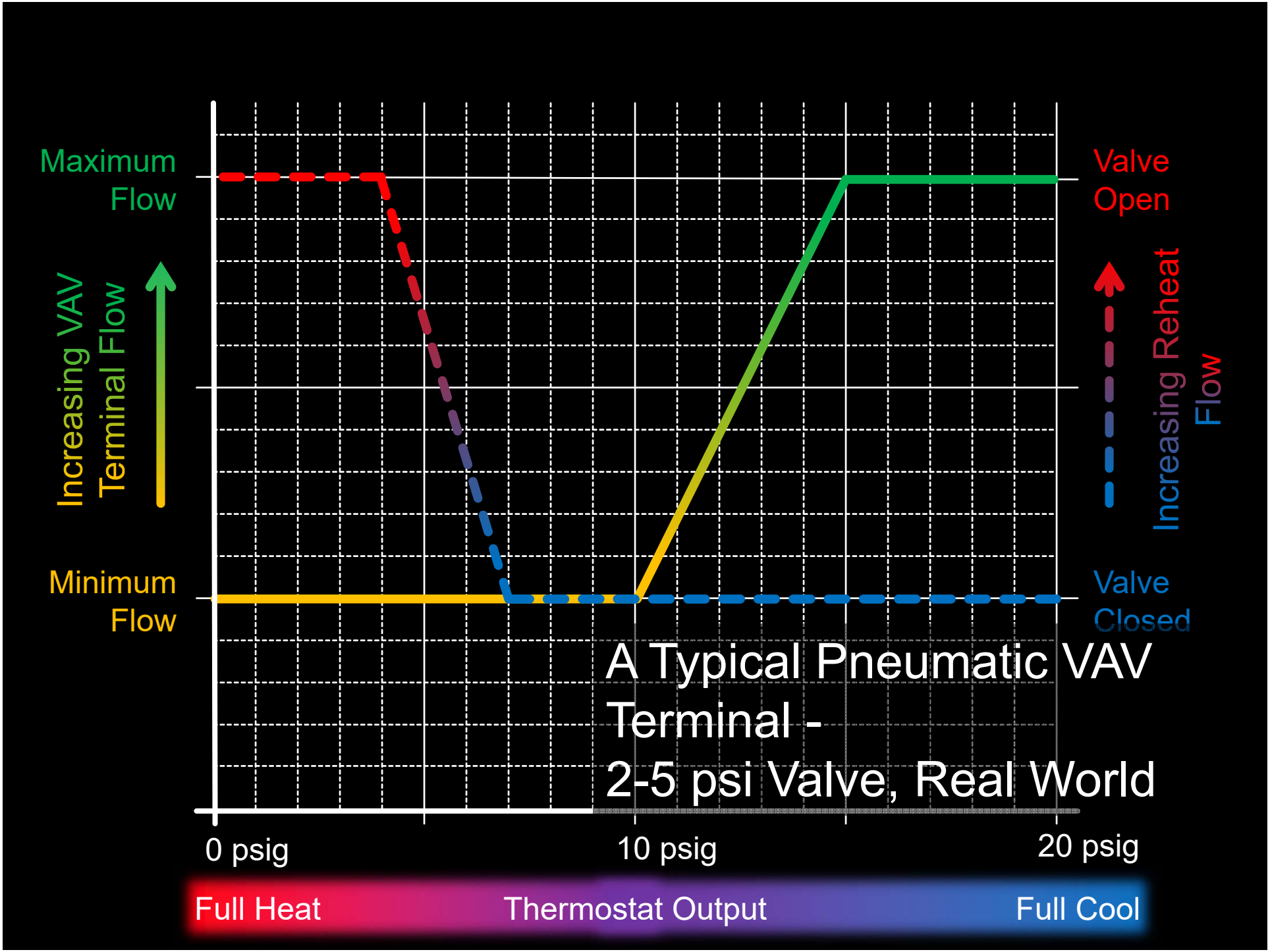

A Typical Pneumatic VAV Terminal - Air Flow Damper Operation
10-15 psi span
Maximum Flow
Minimum Flow
Increasing VAV Air Terminal Flow
0 psig
10 psig
20 psig
Full Heat
Thermostat Output
Full Cool


A Typical Pneumatic VAV Terminal - Reheat Valve Operation 3-10 psi span
Valve Open
Increasing Reheat Flow
Valve Closed
0 psig
10 psig
20 psig
Full Heat
Thermostat Output
Full Cool


Maximum Flow
Minimum Flow
Increasing VAV Terminal Flow
Valve Open
Valve Closed
Increasing Reheat Flow
A Typical Pneumatic VAV Terminal - Desired Operation
0 psig
10 psig
20 psig
Full Heat
Thermostat Output
Full Cool


Maximum Flow
Minimum Flow
Increasing VAV Terminal Flow
Valve Open
Valve Closed
Increasing Reheat Flow
A Typical Pneumatic VAV Terminal - Valve Range Shifted
0 psig
10 psig
20 psig
Full Heat
Thermostat Output
Full Cool


Maximum Flow
Minimum Flow
Increasing VAV Air Terminal Flow
Valve Open
Valve Closed
Increasing Reheat Water Flow
A Typical Pneumatic VAV Terminal -
2-5 psi Valve, Perfect World
0 psig
10 psig
20 psig
Full Heat
Thermostat Output
Full Cool


Maximum Flow
Minimum Flow
Increasing VAV Terminal Flow
Valve Open
Valve Closed
Increasing Reheat Flow
A Typical Pneumatic VAV Terminal -
2-5 psi Valve, Real World
0 psig
10 psig
20 psig
Full Heat
Thermostat Output
Full Cool

Dampers Can See Similar Variation in Power Required vs. Stroke

- Aerodynamic loads can vary with stroke
- Jamb seal loads can increase as the blades become aligned with the frame
- Blade seals require a very specific torque applied to the damper shaft to compress them and achieve rated leakage

Positioners

Pneumatic and Electric

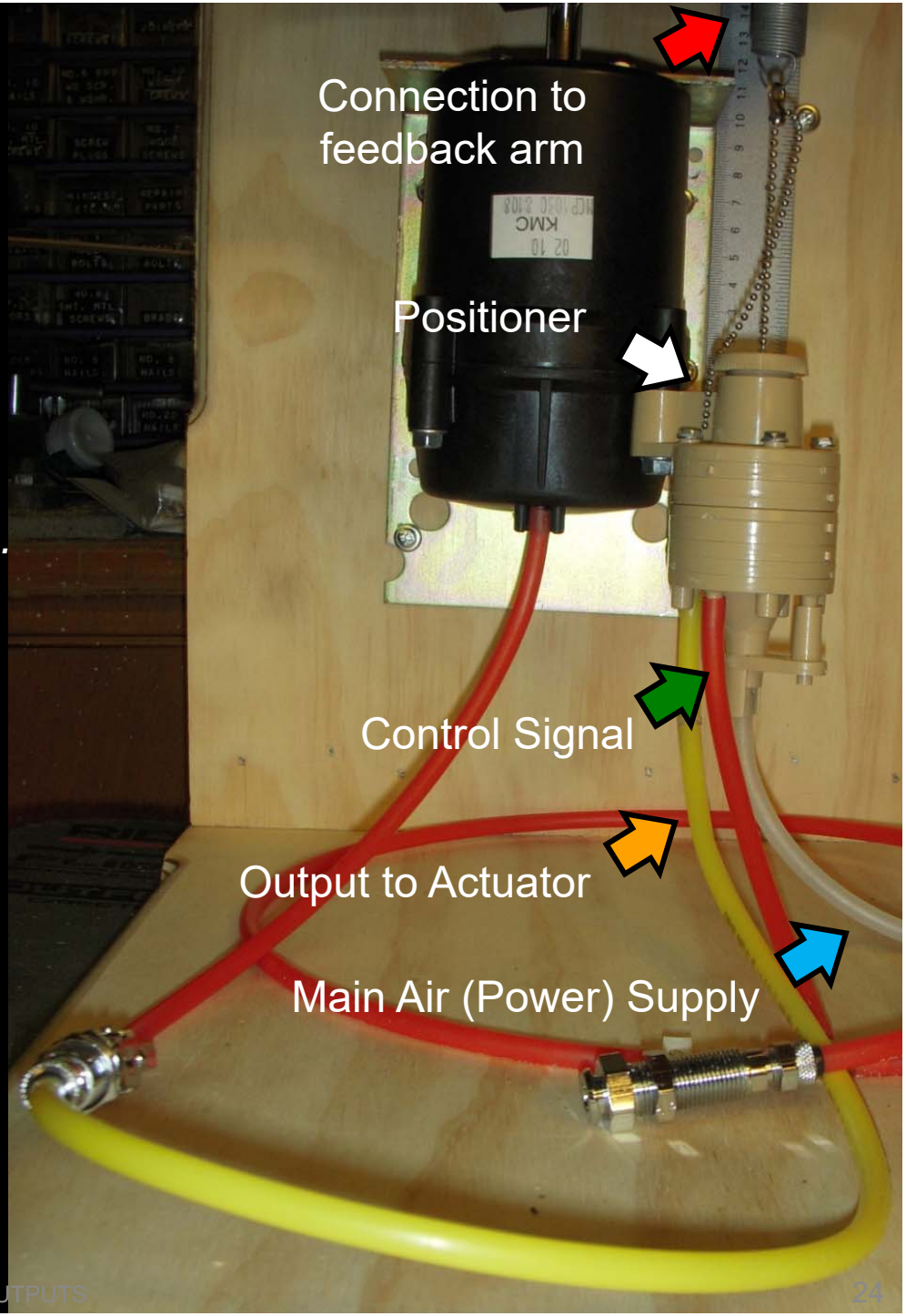
- Positive positioning relays … *a.k.a "Positive positioners" a.k.a. "Positioning relay" a.k.a. "Positioners" …*

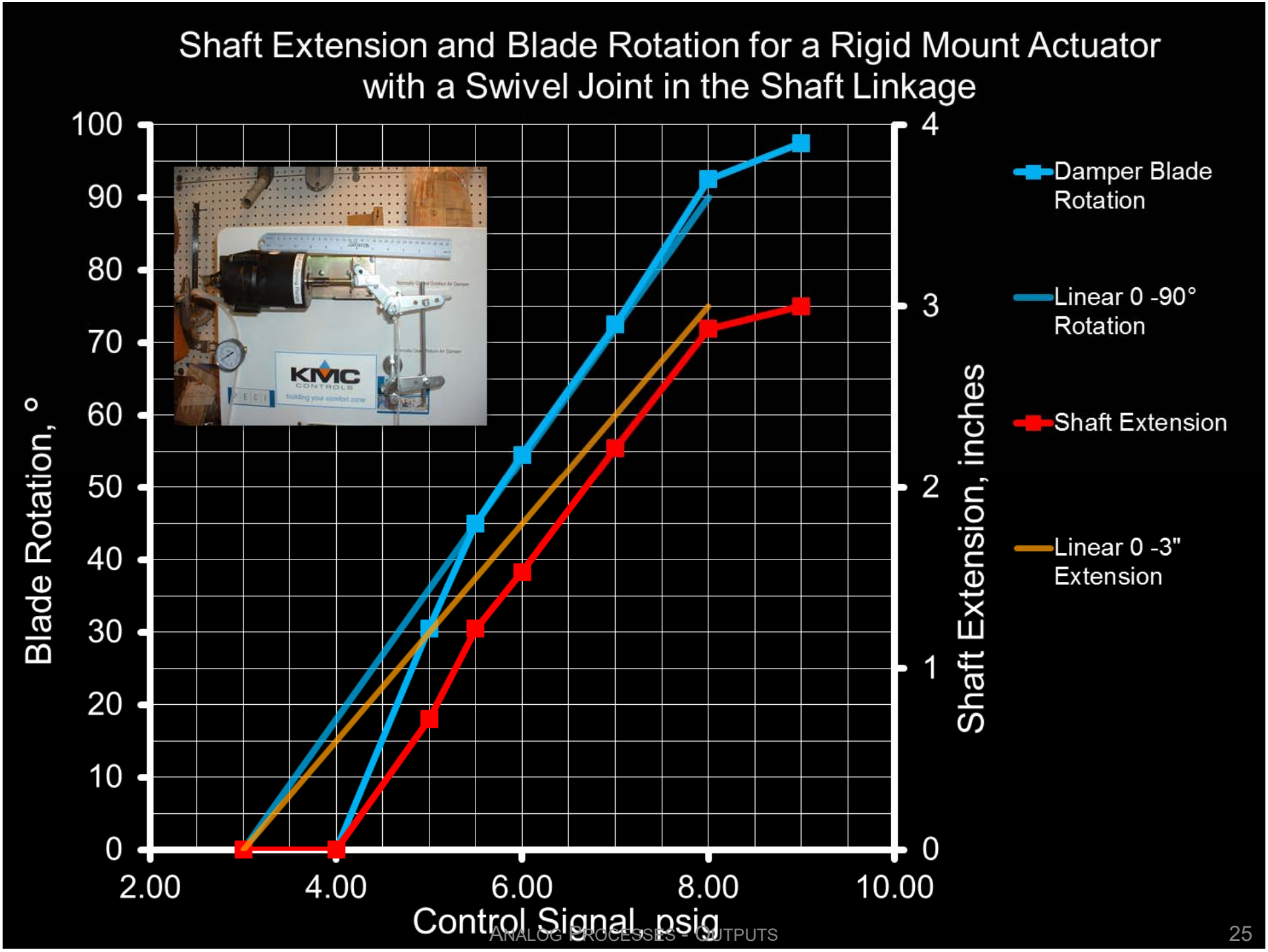
  monitor actuator motion …

  … and compare it to the desired actuator position ….

  … and "do what ever it takes" to get the actuator to move an amount that corresponds to the input change

- An independent energy source provides the power to do this




Shaft Extension and Blade Rotation for a Rigid Mount Actuator with a Swivel Joint in the Shaft Linkage
Blade Rotation, °
Shaft Extension, inches
Control Signal, psig
100
90
80
70
60
50
40
30
20
10
0
4
3
2
1
0
2.00
4.00
6.00
8.00
10.00
Damper Blade Rotation
Linear 0 -90° Rotation
Shaft Extension
Linear 0 -3" Extension
KMC CONTROLS
building your comfort zone

Fortunately, Centerline Drive Actuators Solve the Linkage Linearity Problems


Fortunately, Centerline Drive Actuators
Solve the Linkage Linearity Problems;
BELIMO
NF24-SR US
BELIMO

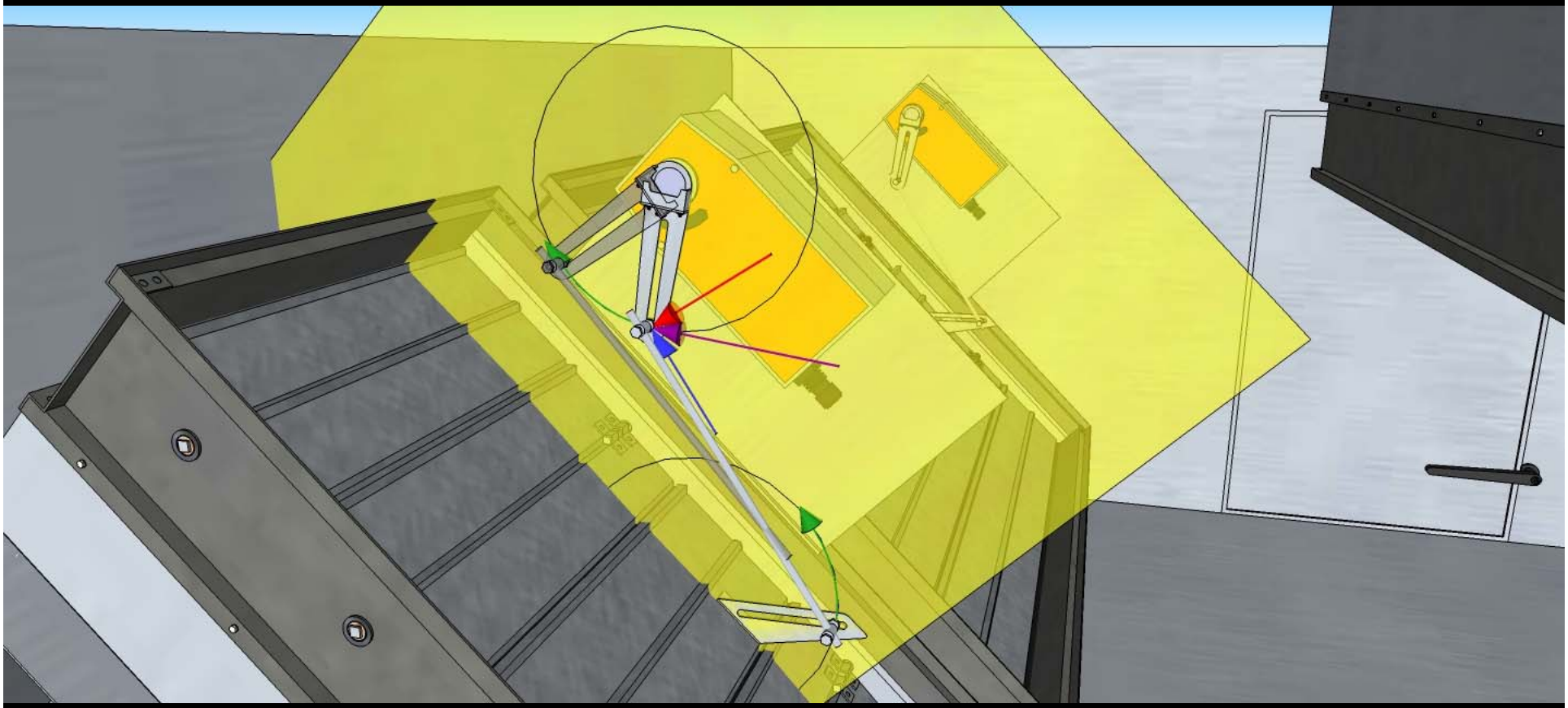
Fortunately, Centerline Drive Actuators Solve the Linkage Linearity Problems;


Fortunately, Centerline Drive Actuators
Solve the Linkage Linearity Problems;

Kinematics

The Physics of Motion

Kinematics can play a huge role in terms of actuator to damper linearity and actuator torque available vs. useful force at the damper blade



Actuators Actuate Final Control Elements

- Examples
  - Valves
  - Dampers
  - Variable Speed Drives
  - Centrifugal Machines
- Final control elements need to be properly applied
- Valves and dampers must be properly sized