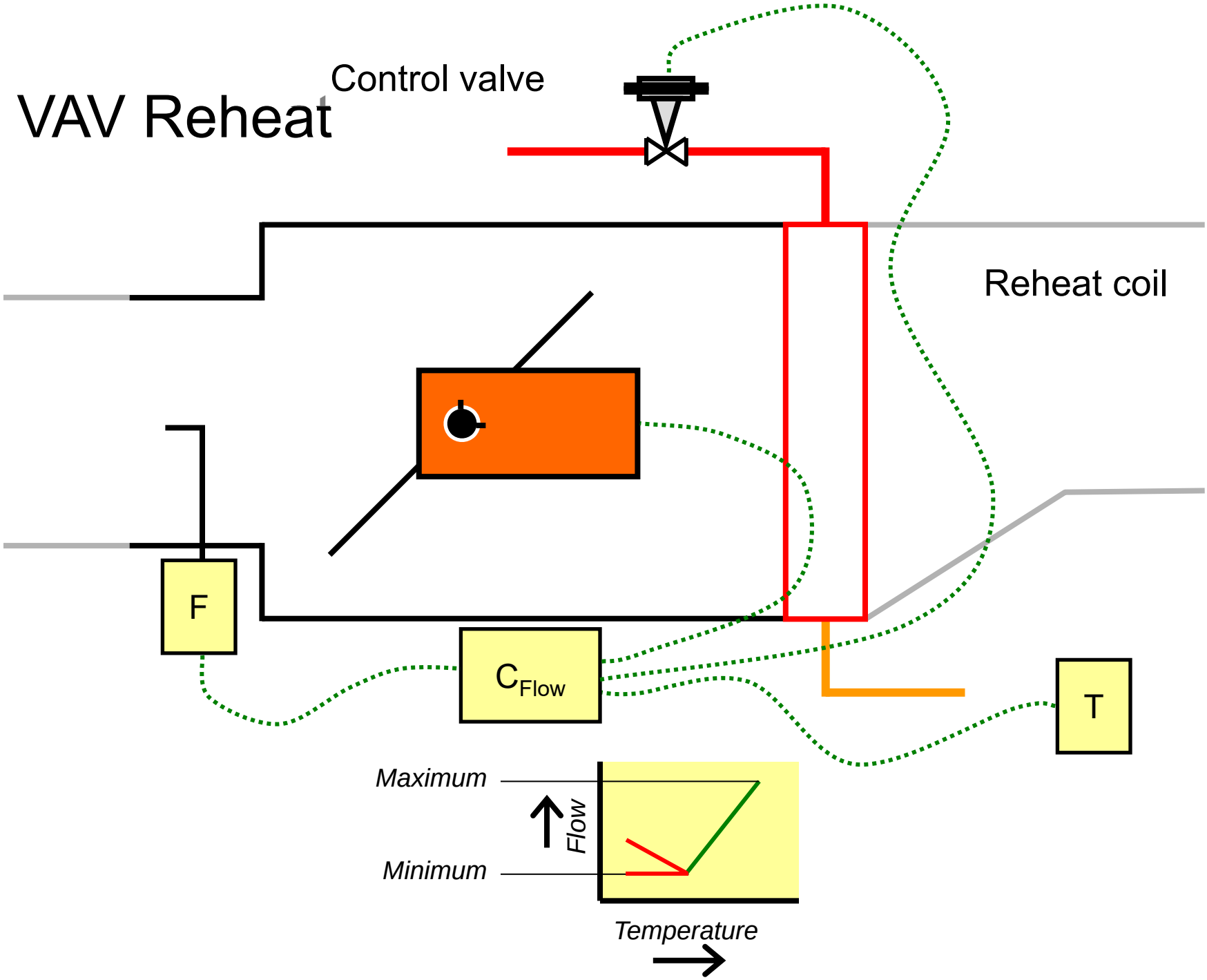
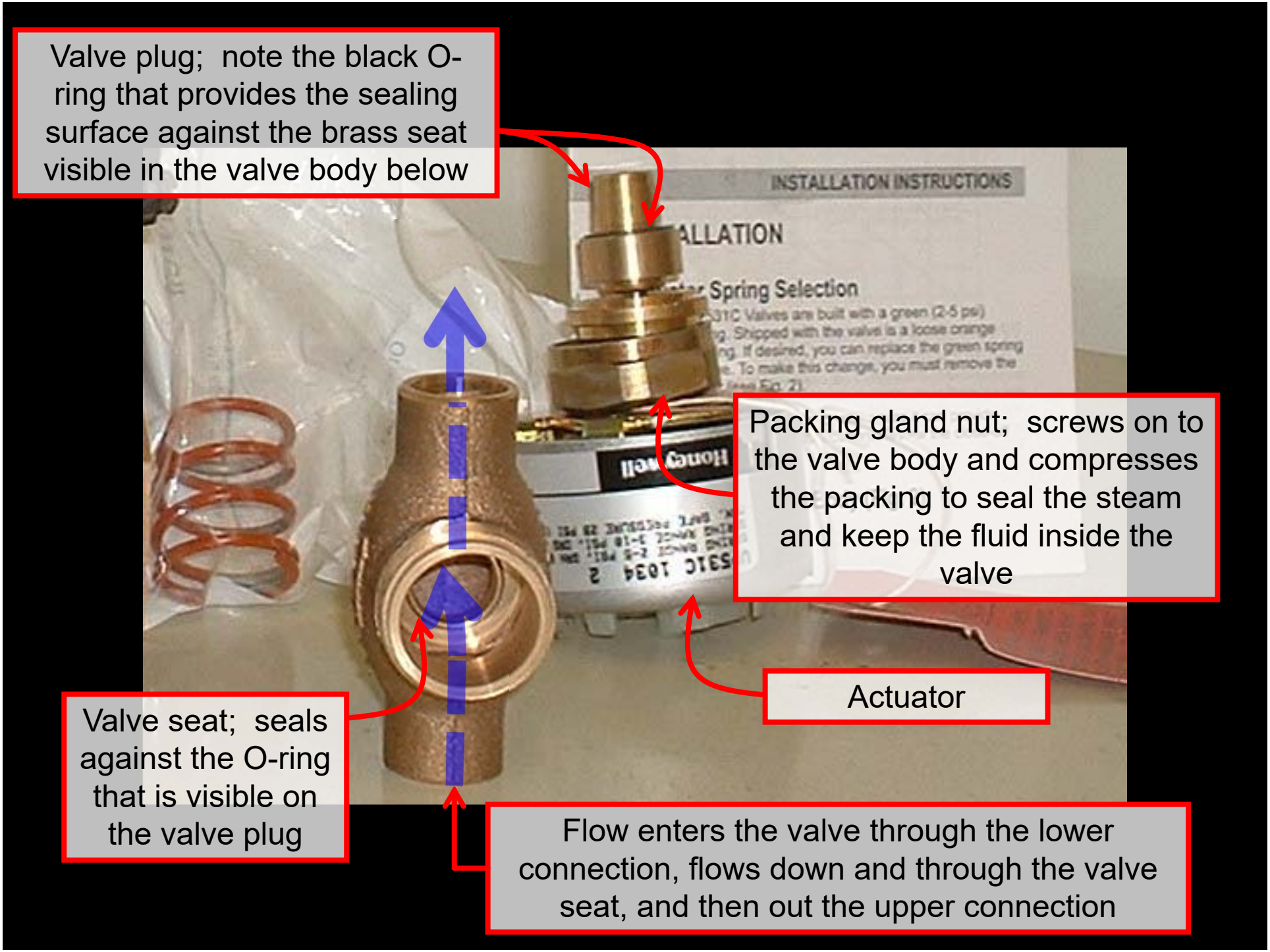
A Field Perspective on Pneumatic Control and Actuation Systems

Pneumatic VAV Reset Controllers

Presented By:
David Sellers
Senior Engineer, Facility Dynamics Engineering


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

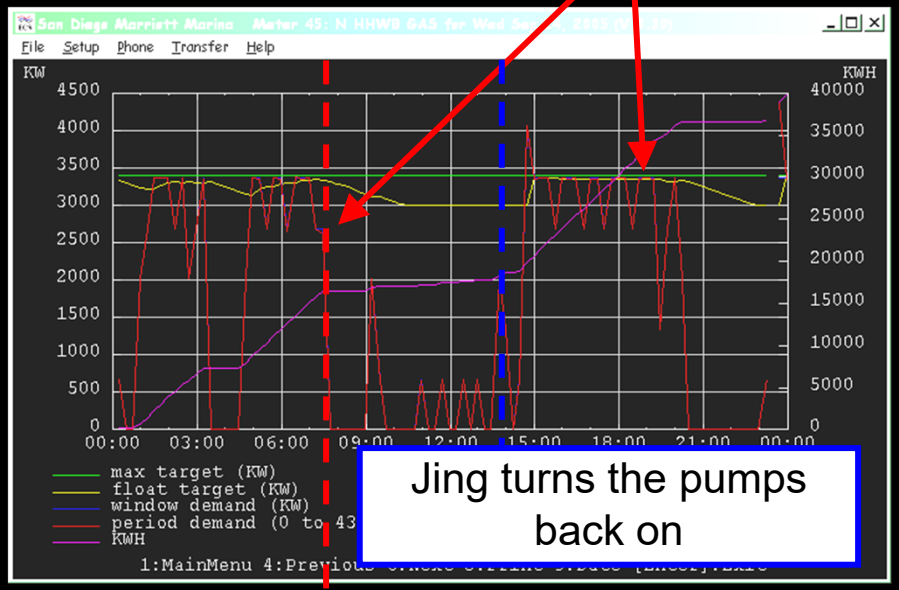

Valve plug; note the black O-ring that provides the sealing surface against the brass seat visible in the valve body below
INSTALLATION INSTRUCTIONS
Packing gland nut; screws on to the valve body and compresses the packing to seal the steam and keep the fluid inside the valve
Actuator
Valve seat; seals 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

Typical Symptons

Investigation Confirms Analysis

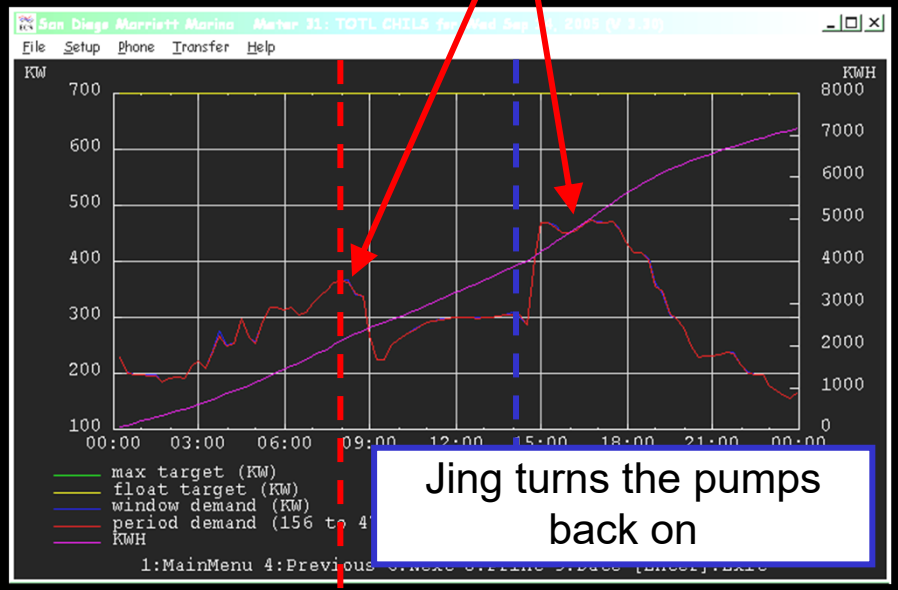
Boiler gas consumption

Chiller kW consumption



Jing turns the pumps back on

Jing turns the pumps serving the guest room fan coil units off

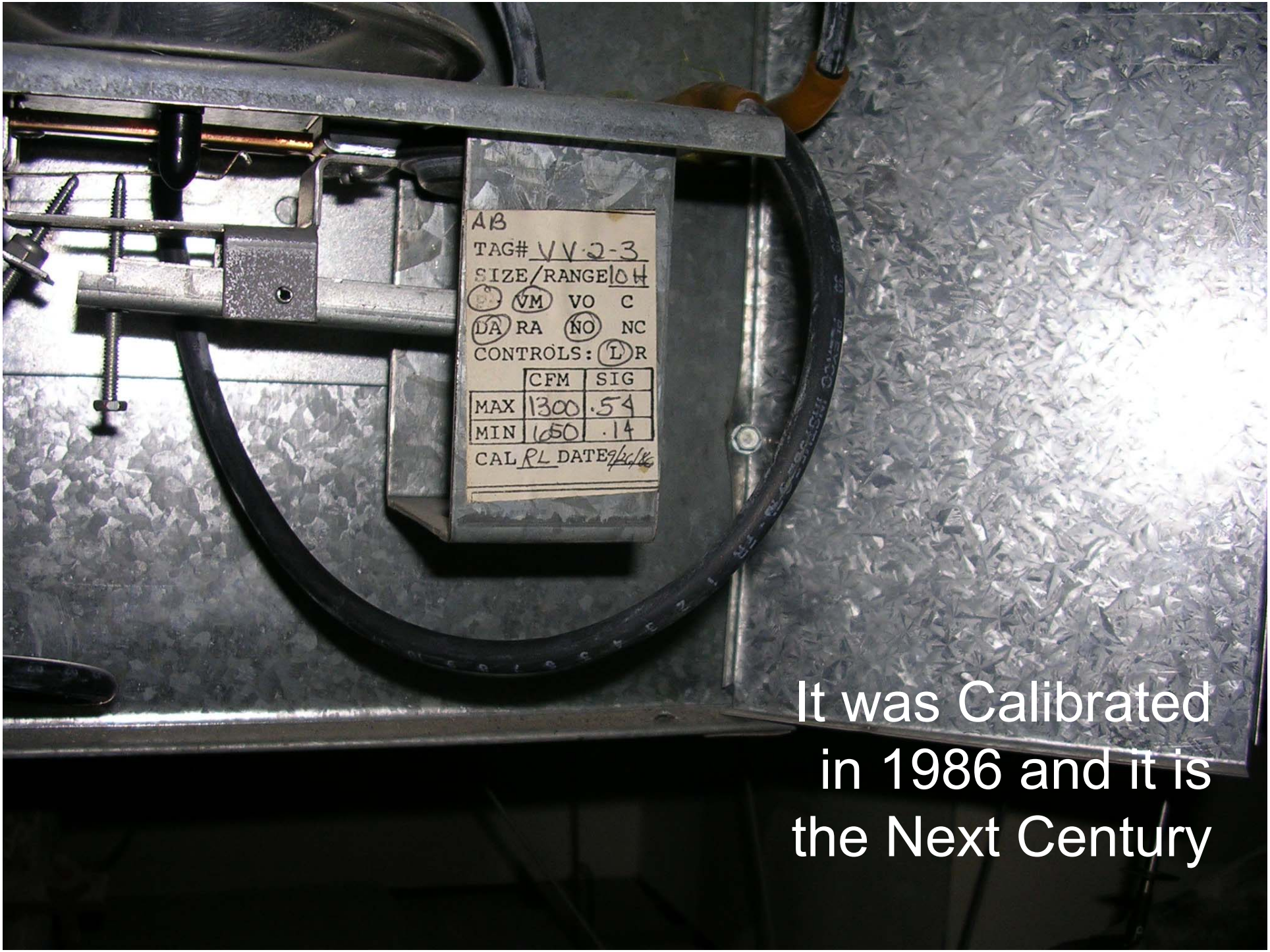


Jing turns the pumps back on

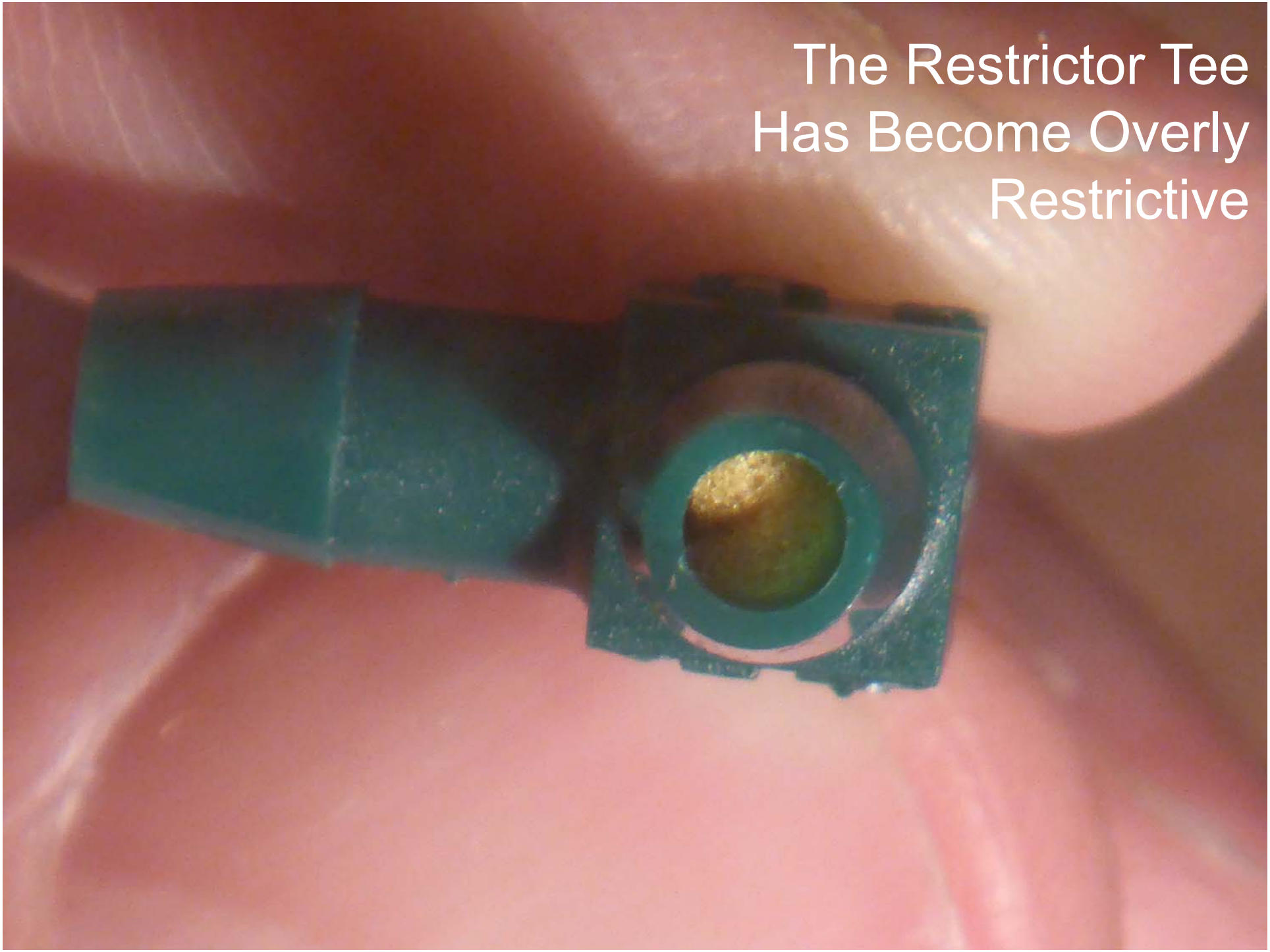
Jing turns the pumps serving the guest room fan coil units off


It’s Hot When It
Should Be Cold


It’s Hot When It
Should Be Cold
68°


AB
TAG# VV-2-3
SIZE/RANGE 10H
VM VO C
DA RA NO NC
CONTROLS: L R
CFM SIG
MAX 1300 .54
MIN 150 .14
CAL RL DATE
It was Calibrated in 1986 and it is the Next Century

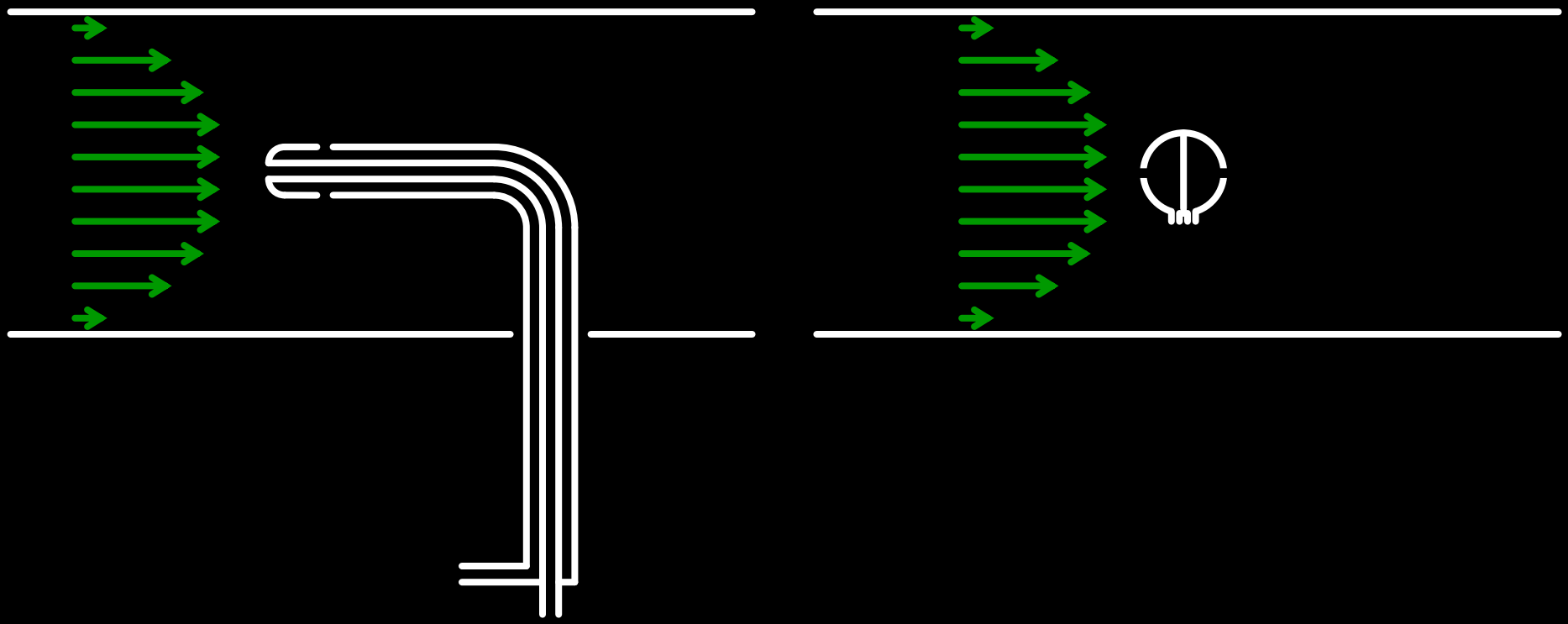

It was Calibrated in 1986 and it is the Next Century
AB
TAG# VV-2-3
SIZE/RANGE 10H
VM VO C
DA RA NO NC
CONTROLS: L R
CFM SIG
MAX 1300 .54
MIN
CAL RL DATE 9/26/86


The Restrictor Tee
Has Become Overly
Restrictive

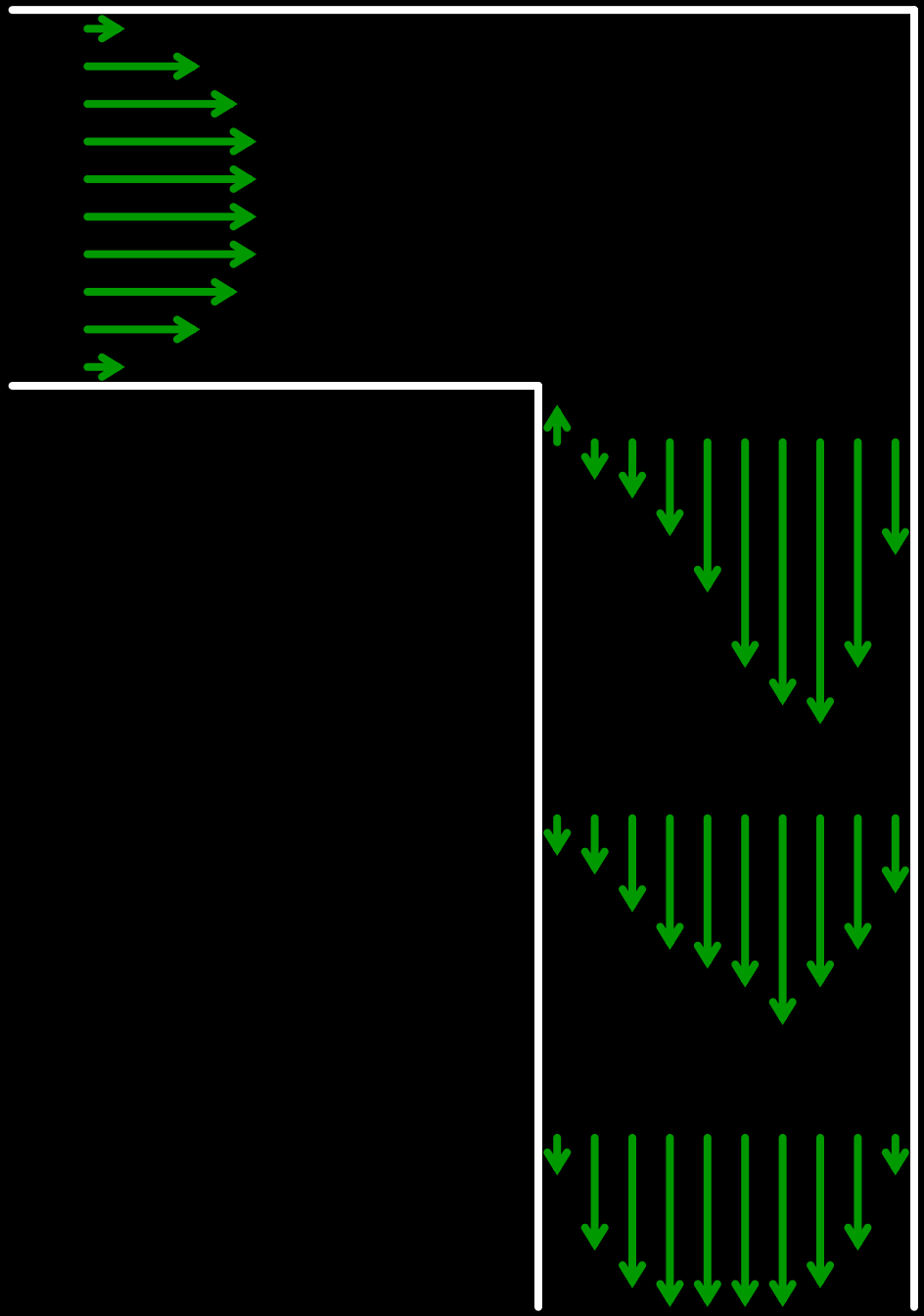

Things are a
Bit Dusty


The Valve Plugs and Seats are
Not All that they Could Be

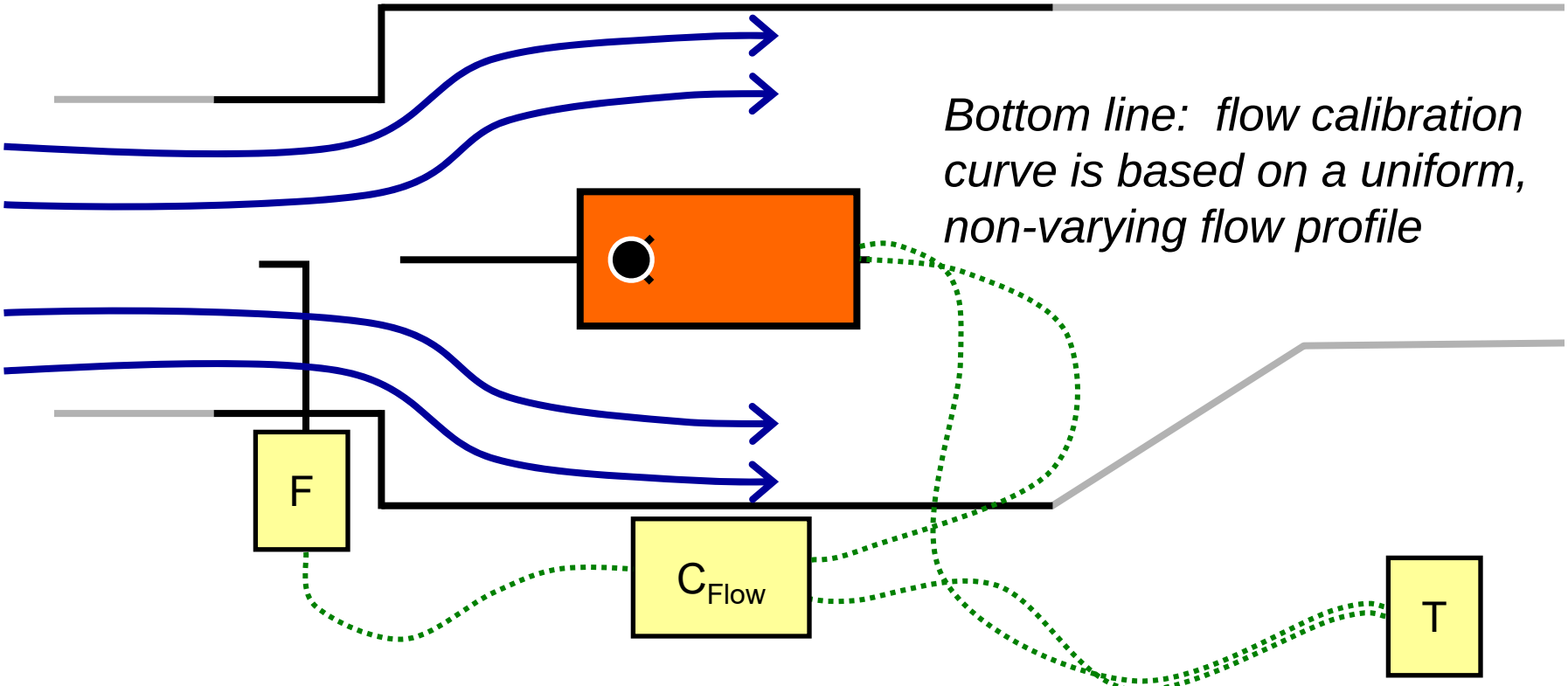

A Bit Less than the Recommended 3-5 Feet of Straight Inlet Duct has been Provided



Pitot tubes and VAV flow sensors rely on a uniform velocity profile for accurate measurements



- Turns and other obstructions distort the flow profile
- Interactions between the air and the duct wall will eventually restore the uniform flow profile
- Generally takes 5-10 equivalent duct diameters of distance

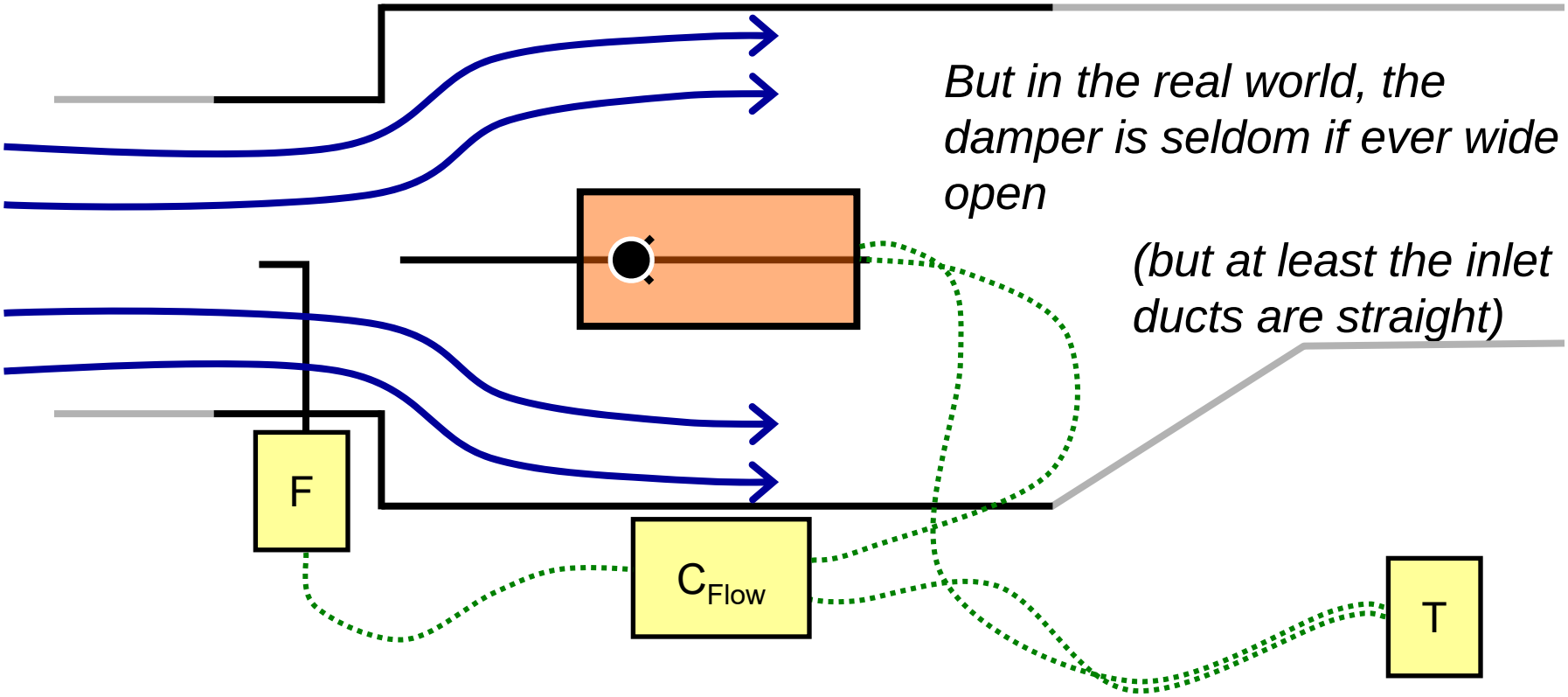


Bottom line: flow calibration curve is based on a uniform, non-varying flow profile

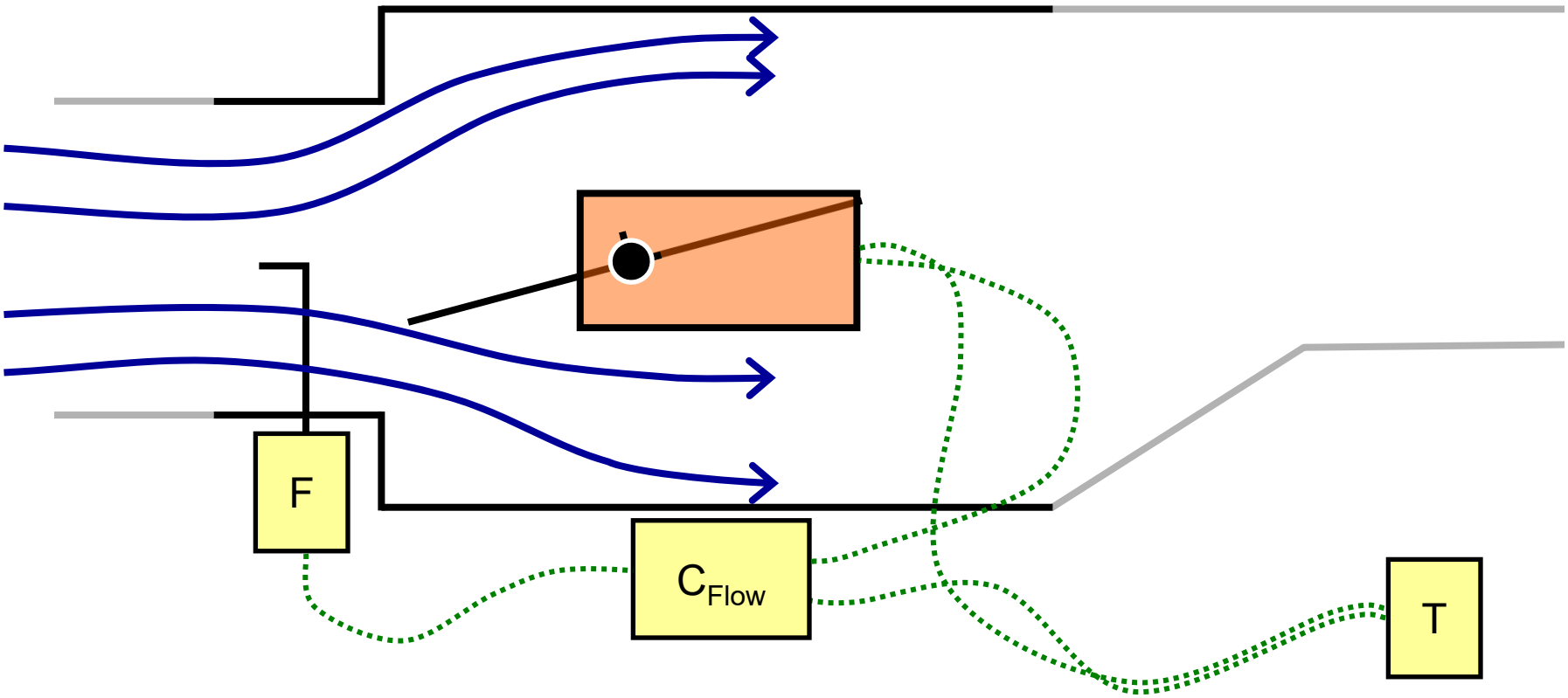
Flow sensors calibration curves established by factory test

Damper held fully open for the entire flow range

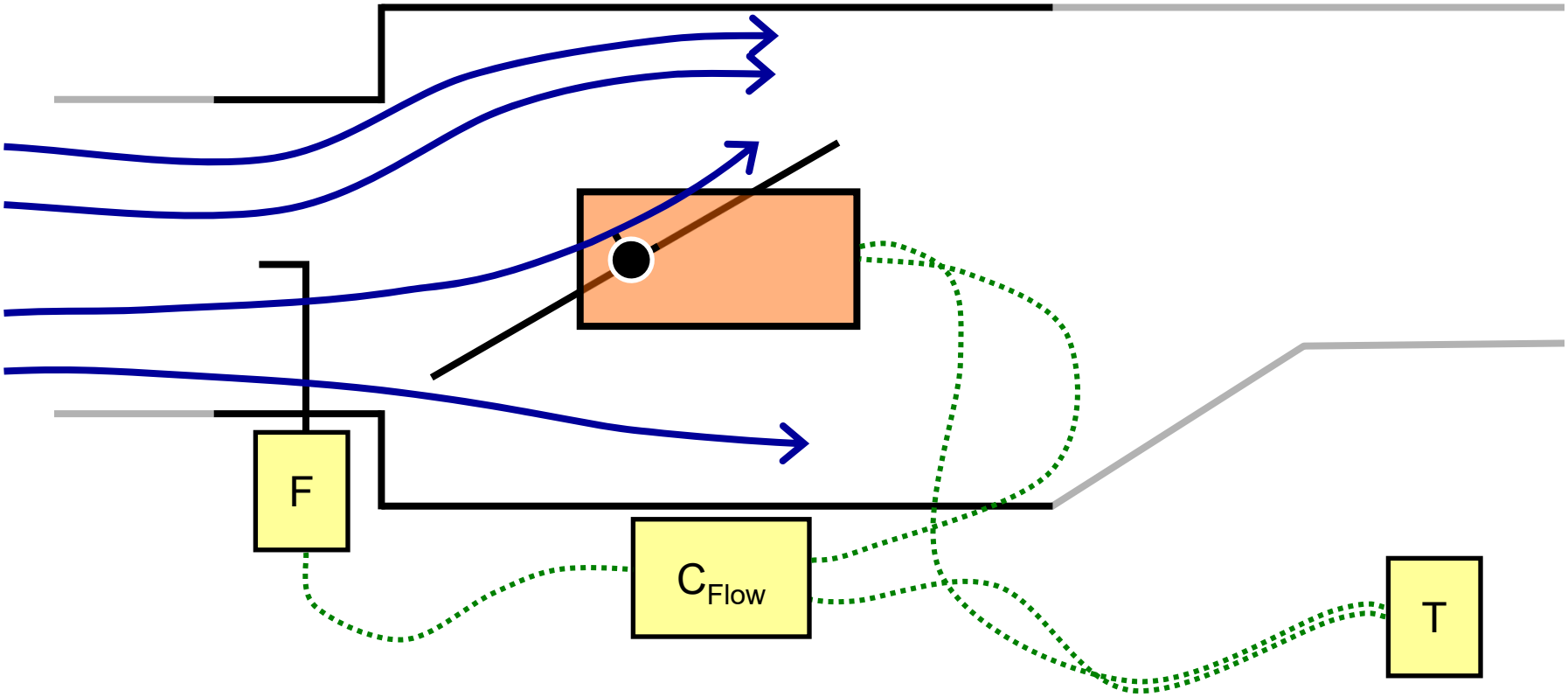
Flow varied by varying fan speed on the fan in the test rig



In the real world, with a good inlet condition and a wide open damper, things tend to match up pretty well



As the terminal unit damper begins to throttle the flow profile upstream of it begins to distort because the air is directed towards the sides of the box and accelerated by the closing damper



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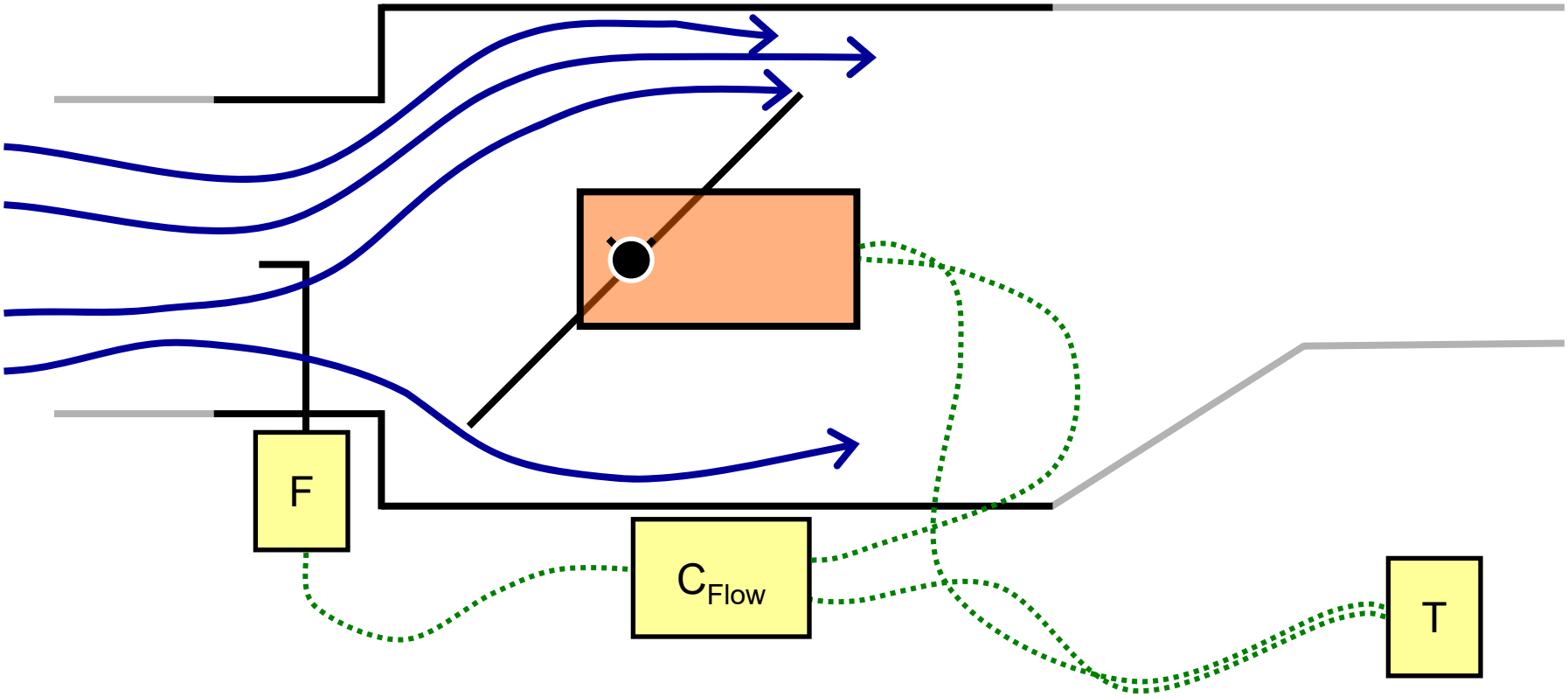

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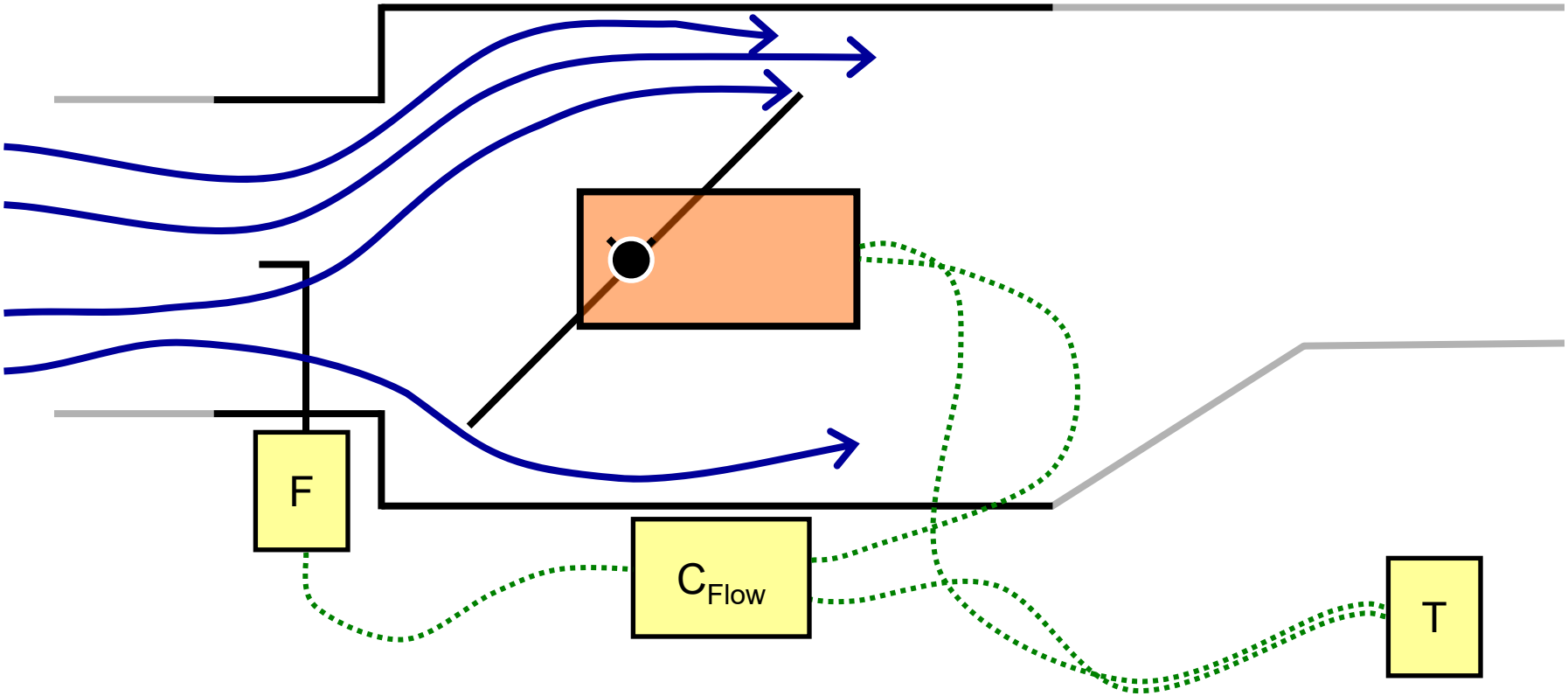


Calibrations based on at least two data points representative of the actual extreme operating conditions of the terminal unit will generally provide better results vs. a one point calibration

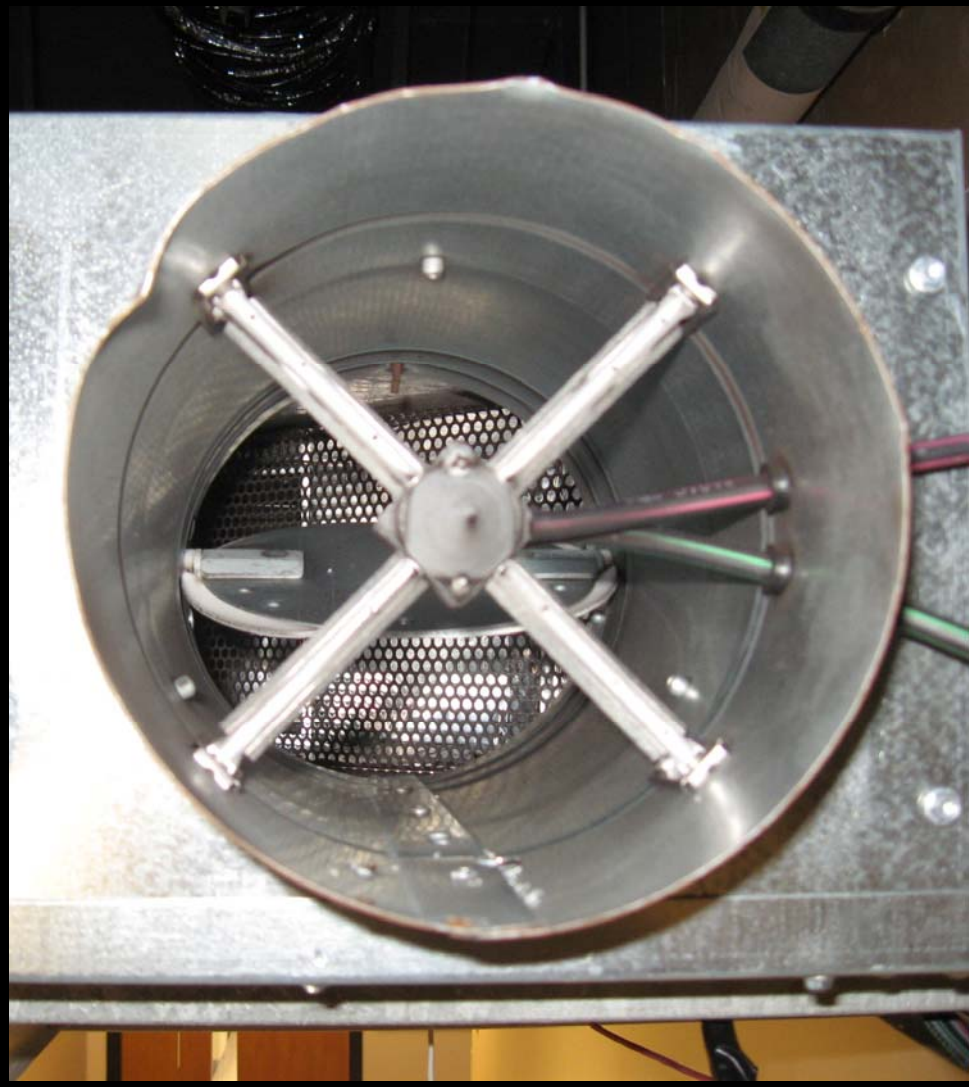
Field Data from the “Show Me” State

Building Control System Data

Set point	1,800 cfm
Indicated Flow	1,835 cfm
	(102% of set point)
Set point	700 cfm
Indicated flow	717 cfm
	(102% of set point)

Field Test Data (Traverse basis)

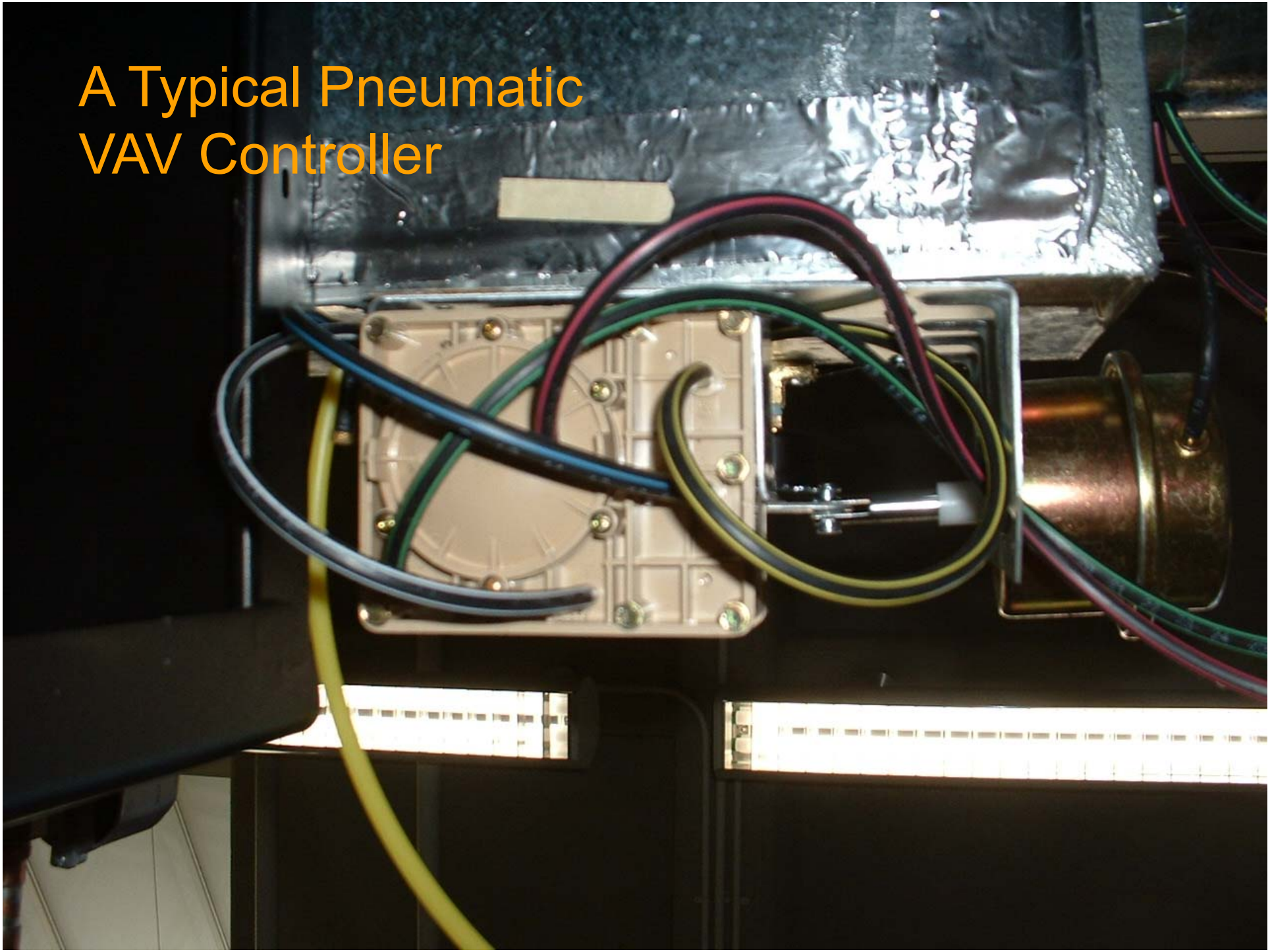
Set point	1,800 cfm
Traversed flow	1,962 cfm
	(107% of indicated)
Set point	700 cfm
Traversed flow	1,125 cfm
	(157% of indicated)

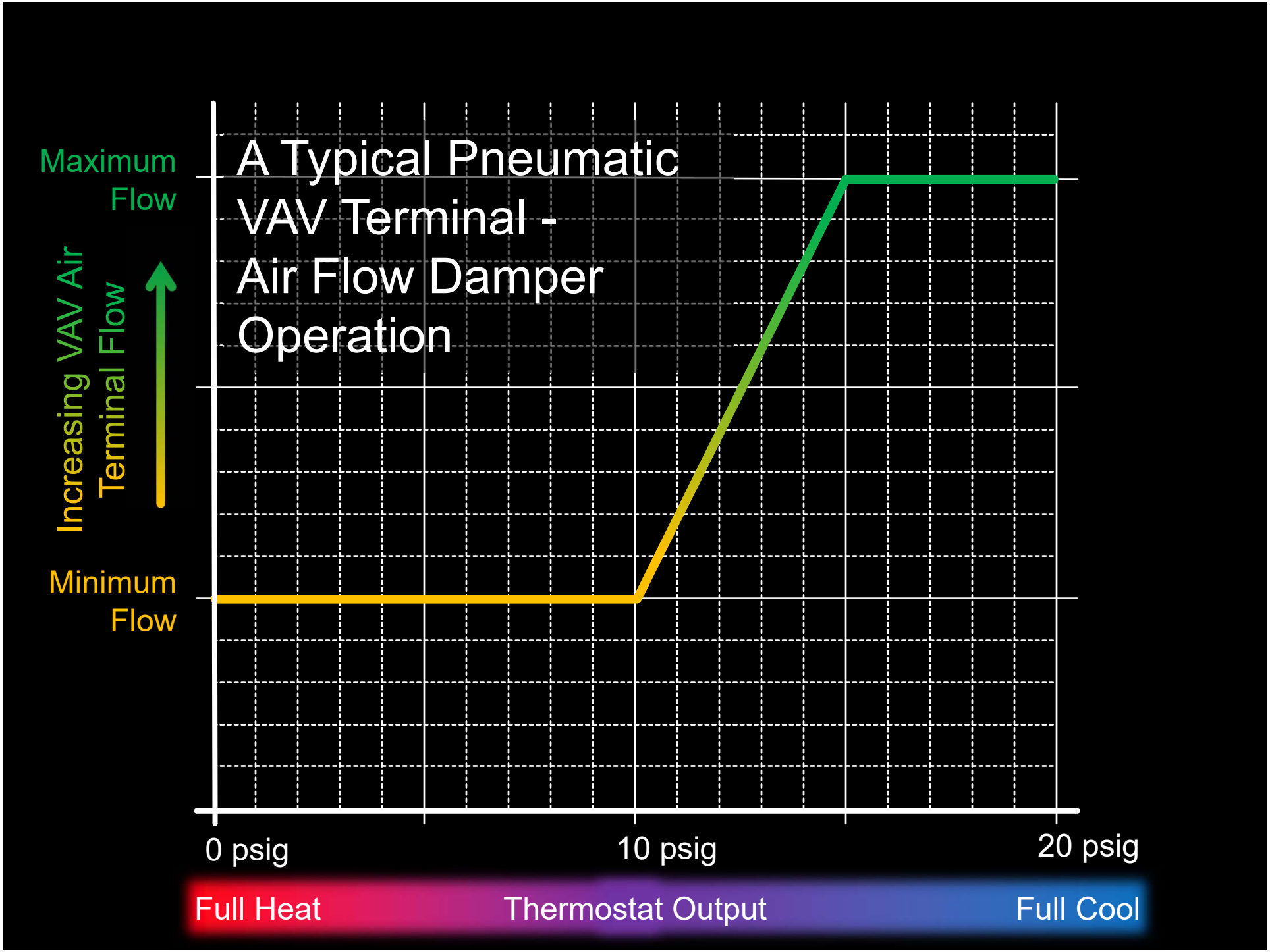


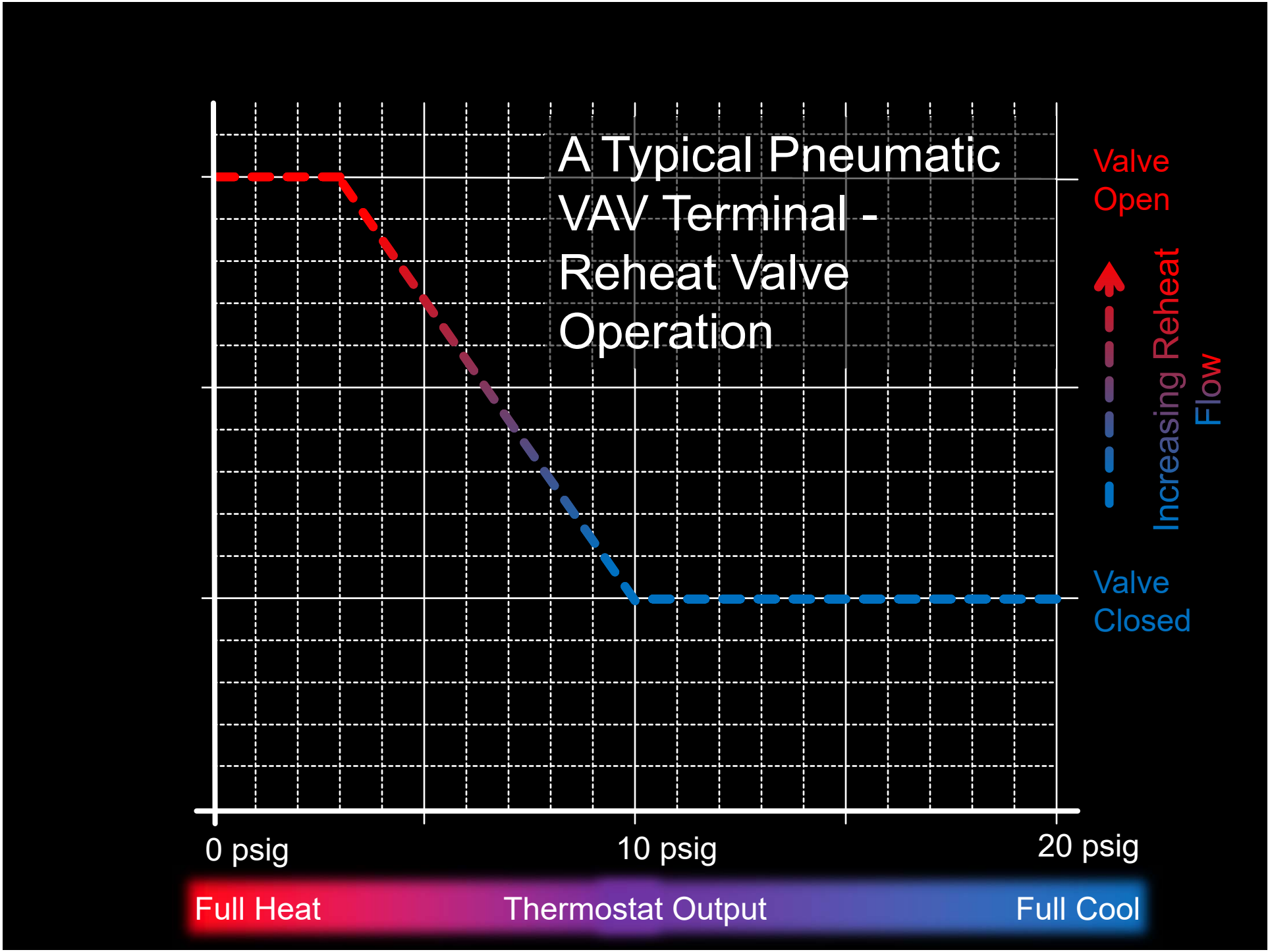
Field Data from the “Show Me” State

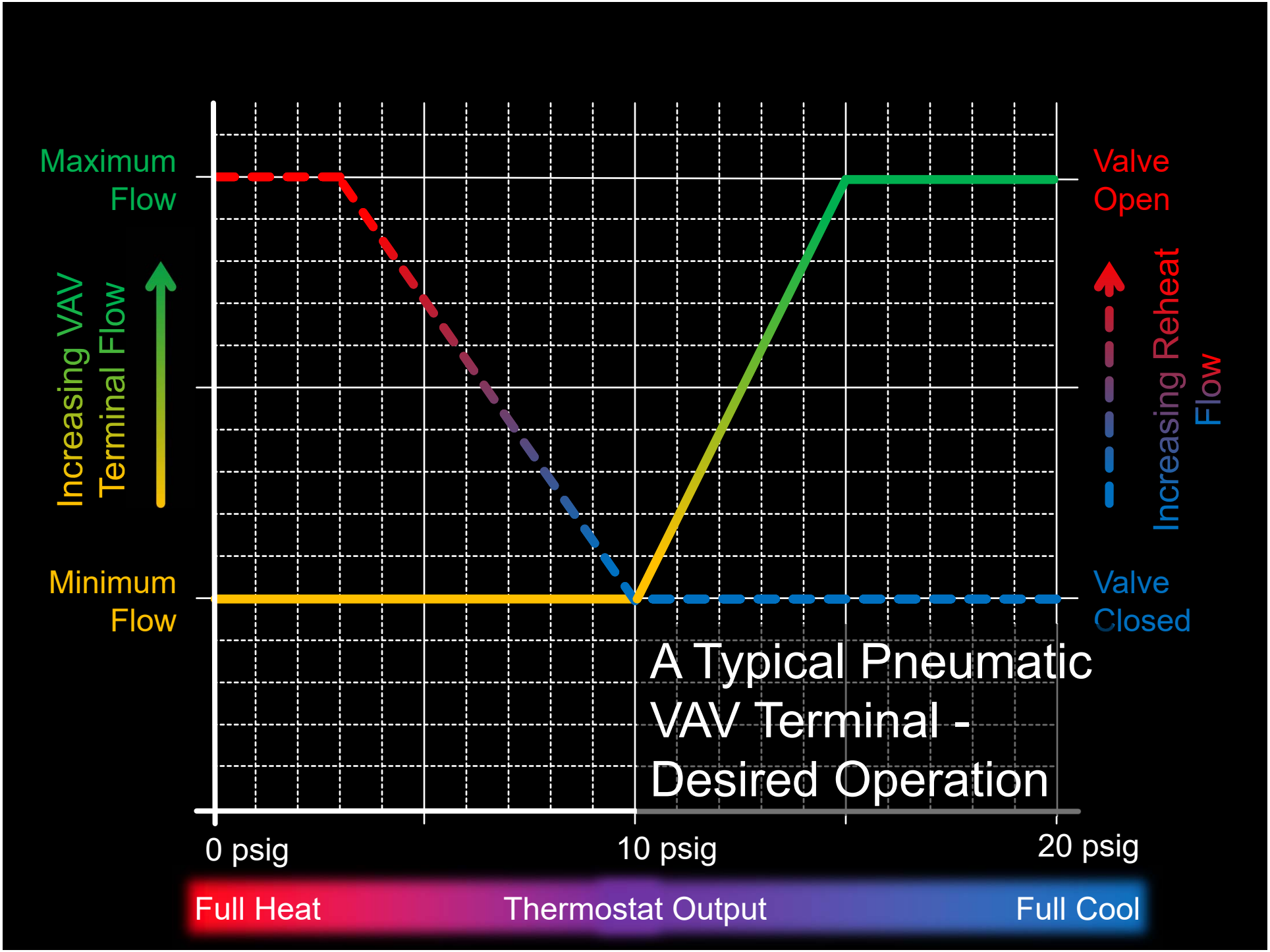
Read the paper and the presentation from NCBC 2013 at http://tinyurl.com/RonNCBC2013Presentation and http://tinyurl.com/RonNCBC2013Paper

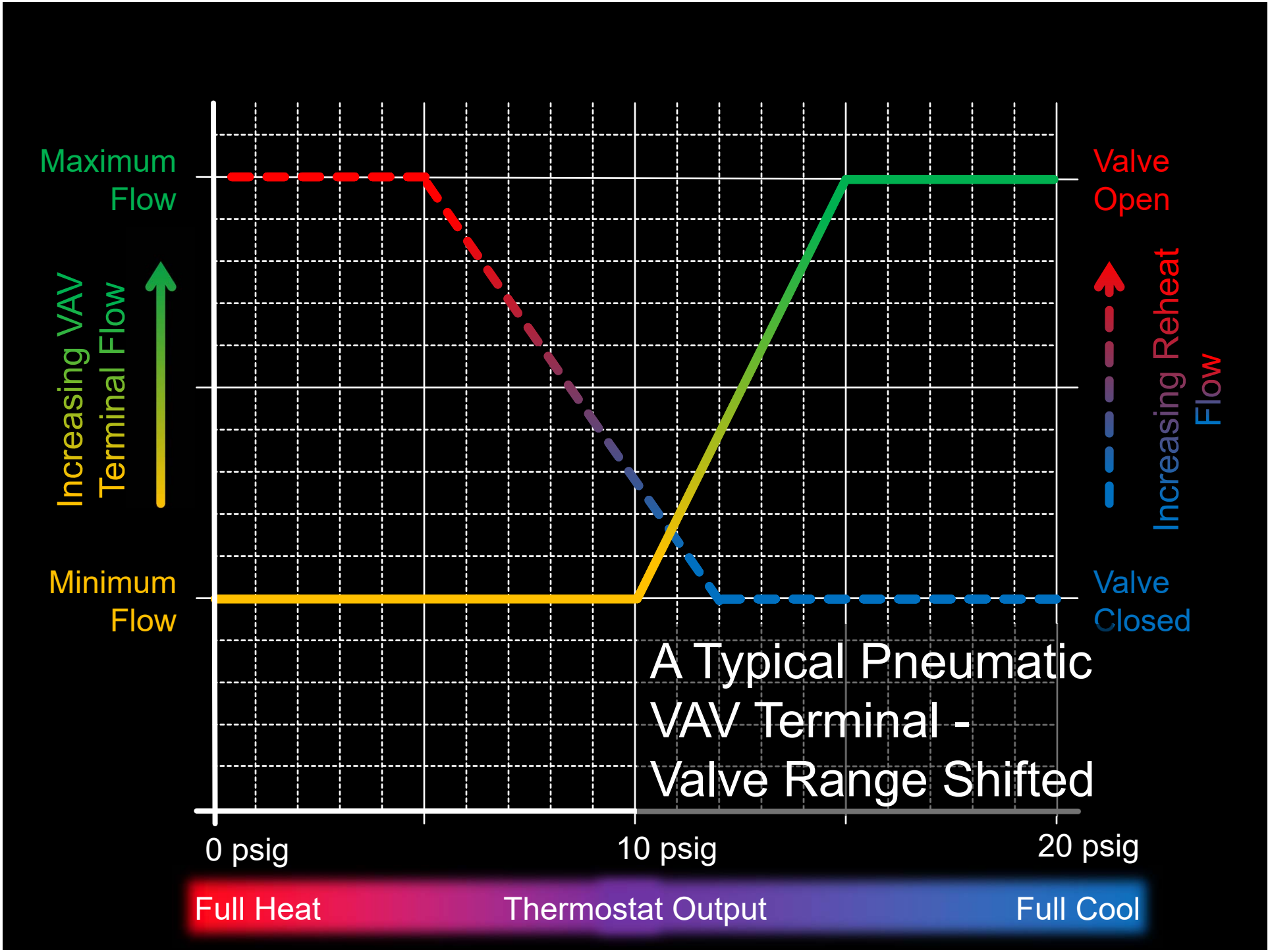
A Typical Pneumatic VAV Controller

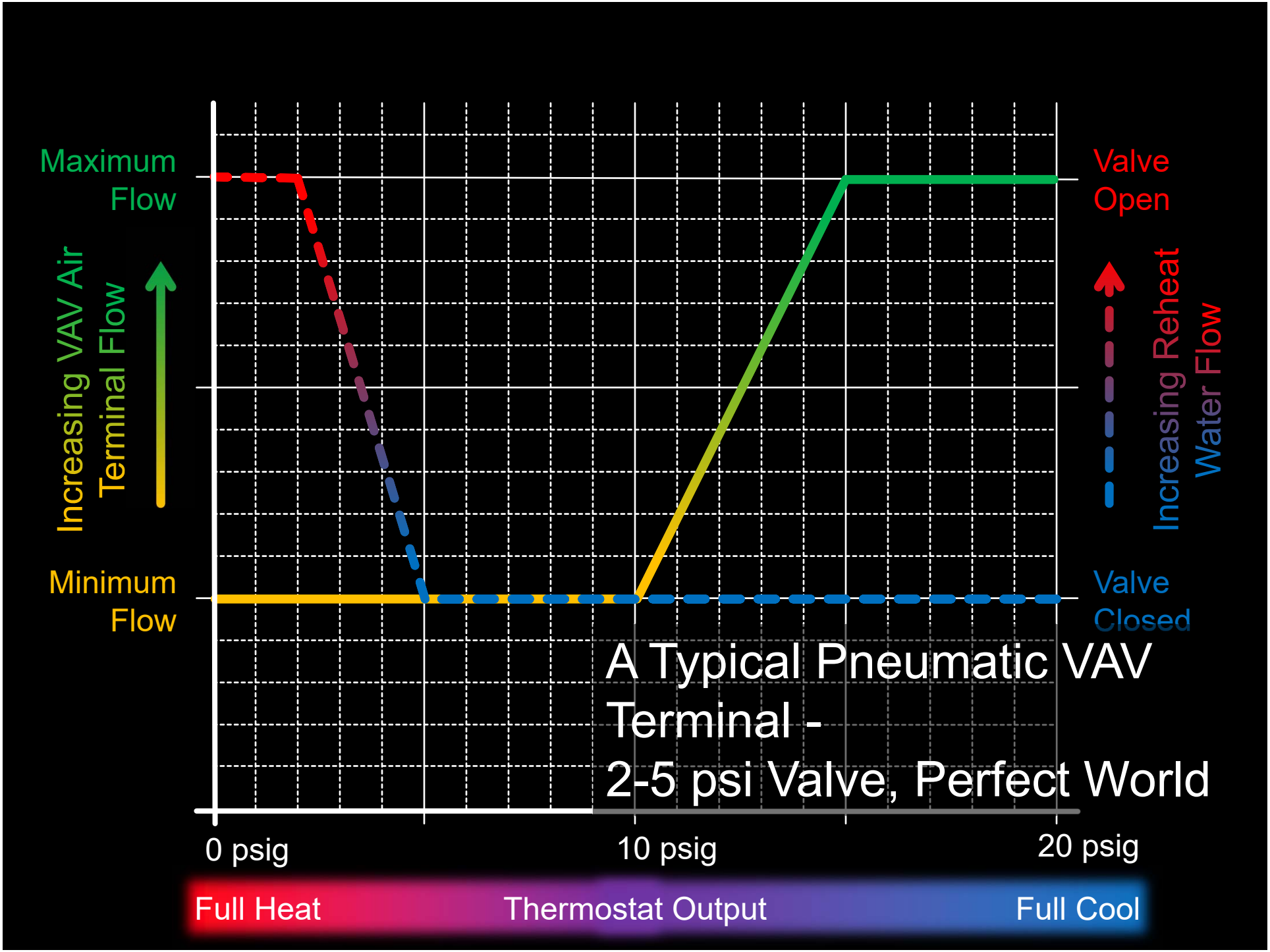


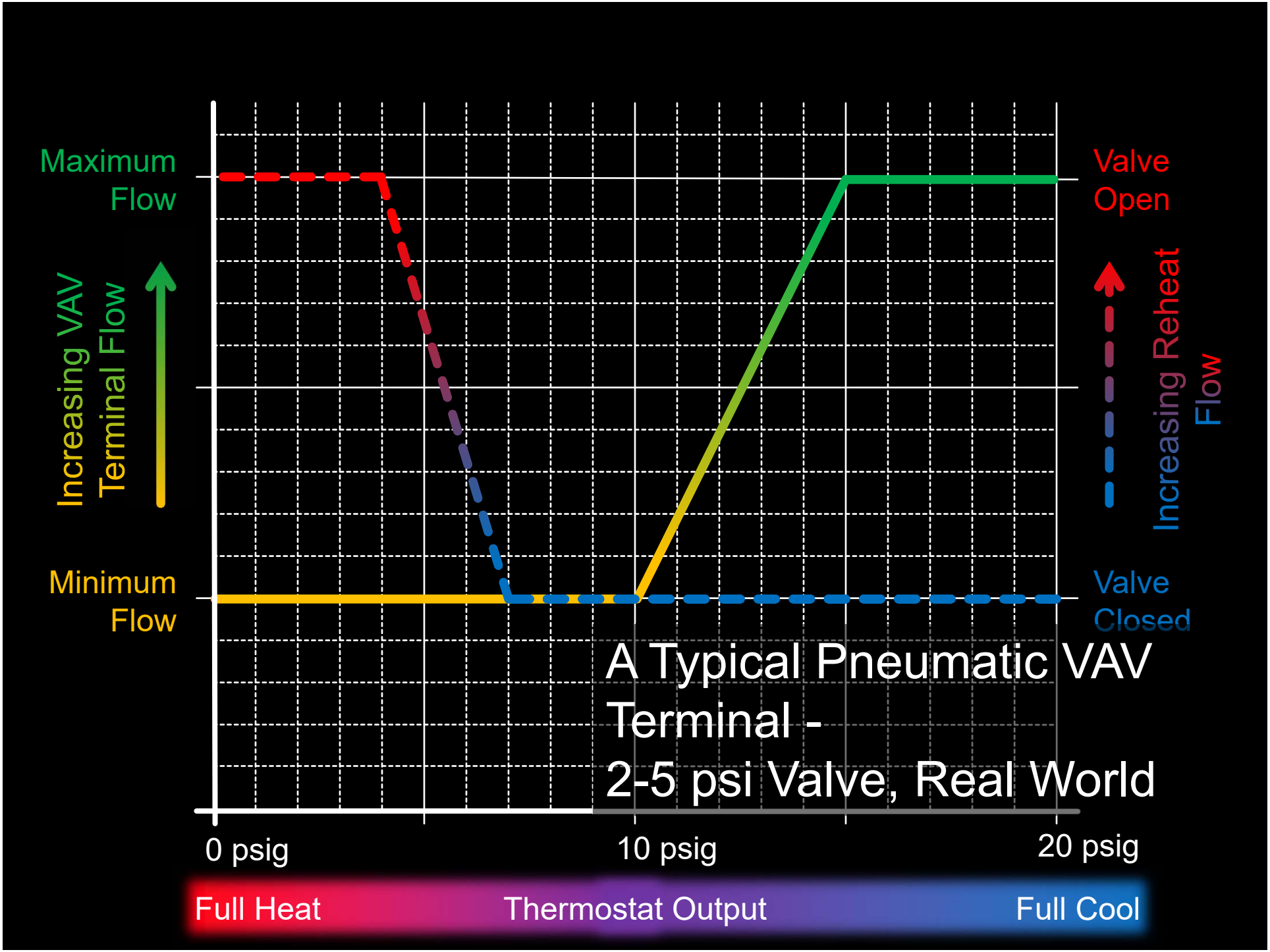

A Typical Pneumatic VAV Terminal - Air Flow Damper Operation
Maximum Flow
Increasing VAV Air Terminal Flow
Minimum Flow
0 psig
10 psig
20 psig
Full Heat
Thermostat Output
Full Cool


A Typical Pneumatic VAV Terminal - Reheat Valve Operation
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

Let’s Discuss Thermostat Calibration

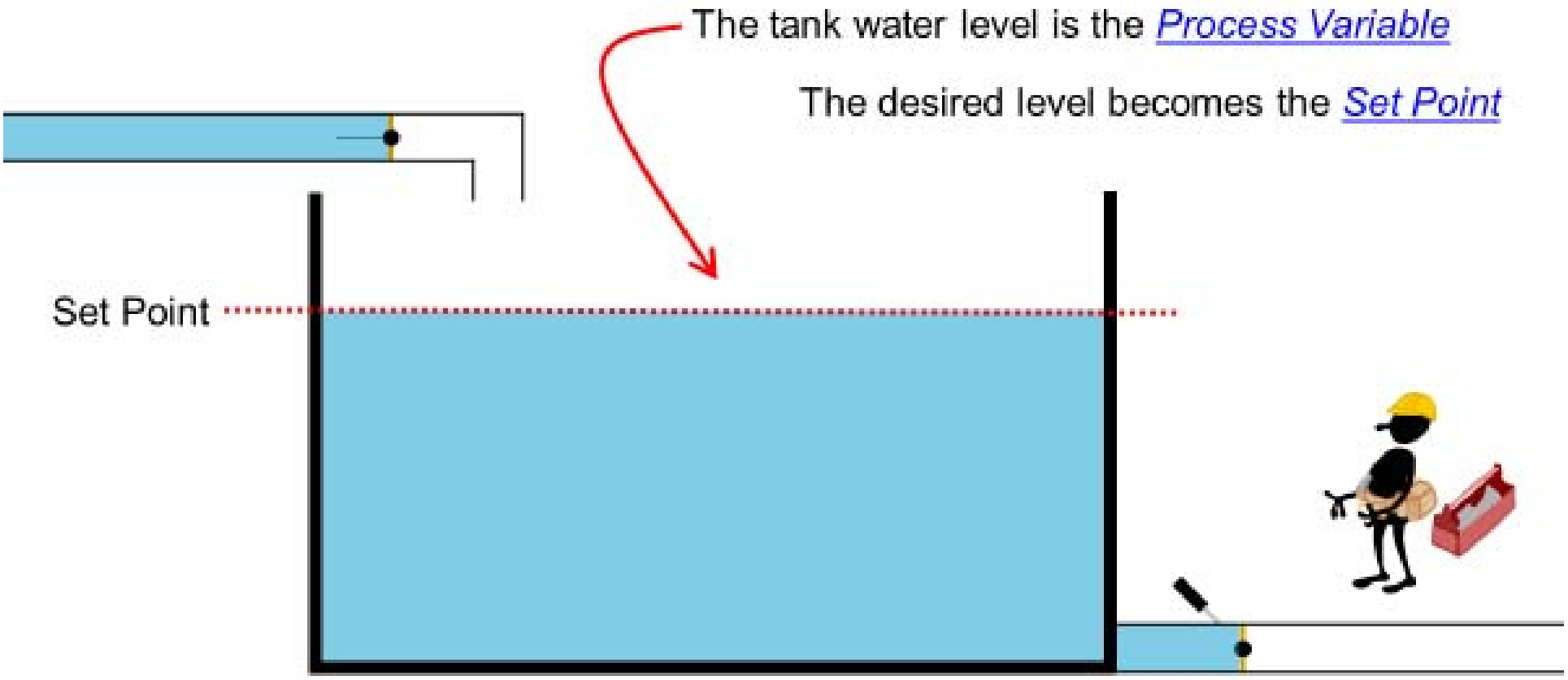
Goals

- Set up the thermostat (controller) so that its output causes the set point and the process variable to converge

Considerations

- Due to the nature of proportional control, this can only be true for one, very specific condition

A Simple Control System



Let’s Discuss Thermostat Calibration

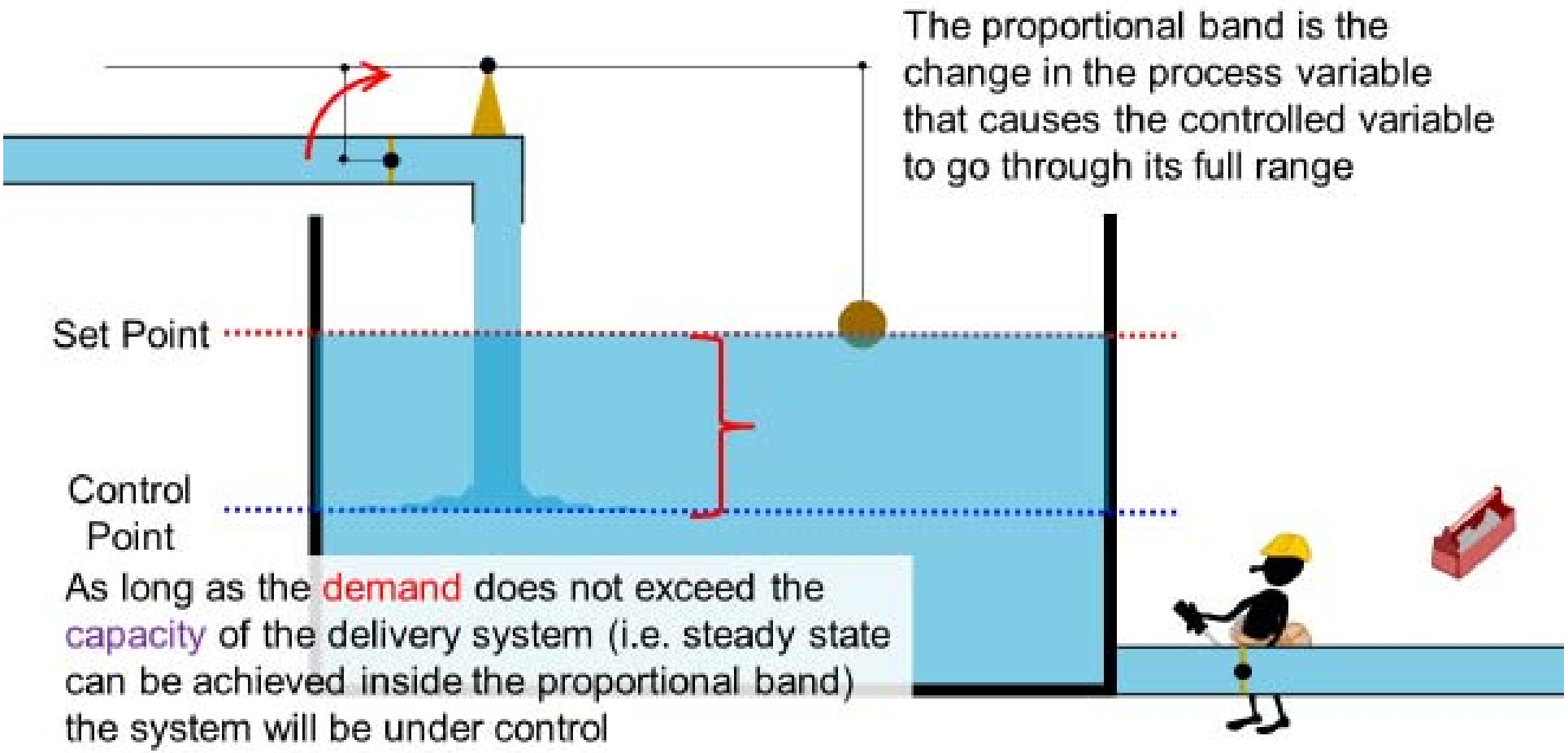
Goals

- Minimize the throttling range (proportional band) so that the error (deviation from set point) is minimized

Considerations

- If the throttling range is sufficiently narrow so that the controller output runs through the span over the course of several hours, nobody will notice the deviation from set point

A Simple Proportional Control System



Let’s Discuss Thermostat Calibration

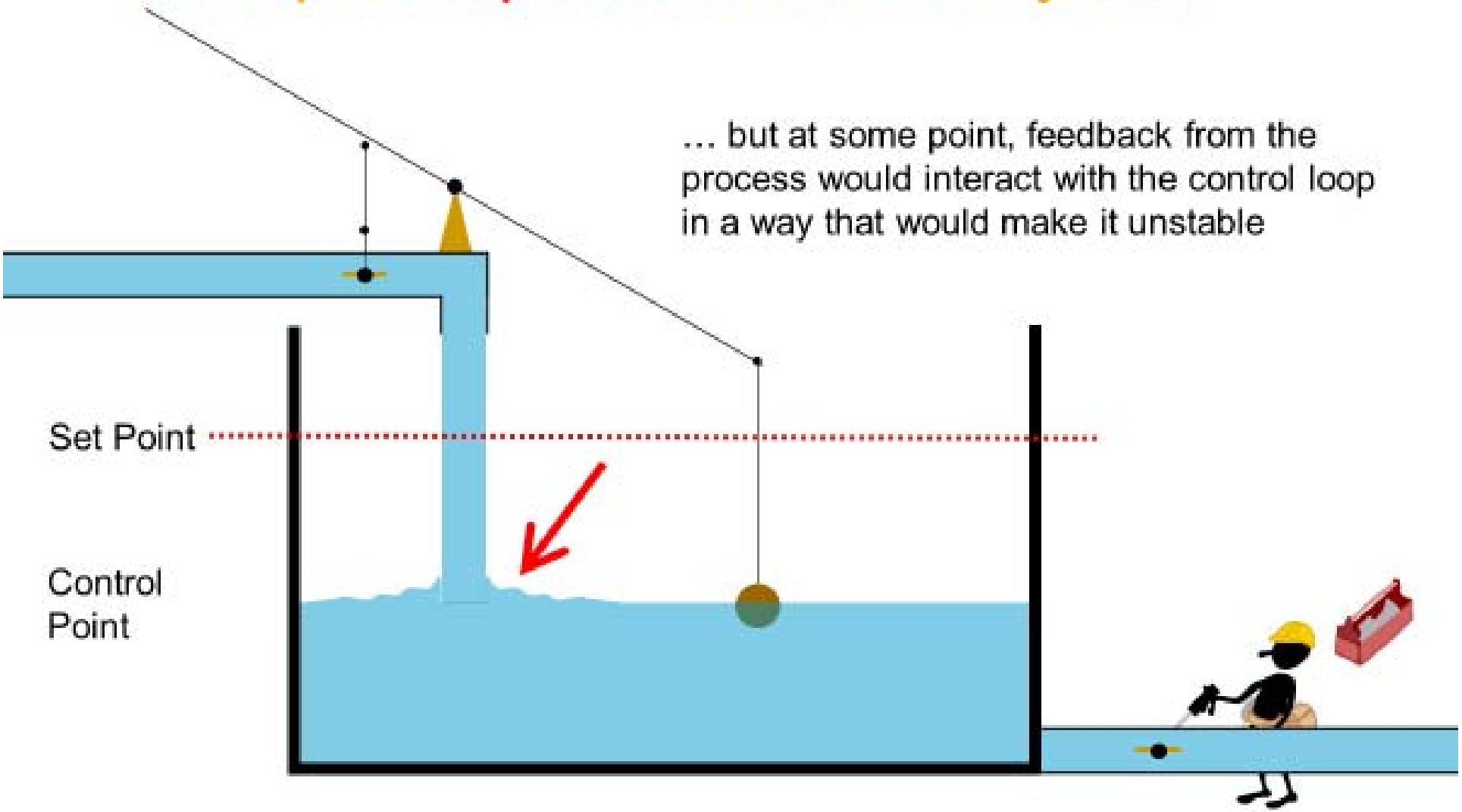
Goals

- Keep the throttling range large enough to prevent hunting

Considerations

- If the throttling range is *too* small, causing the controller output run through the span over the course of minutes, your phone will ring off the wall

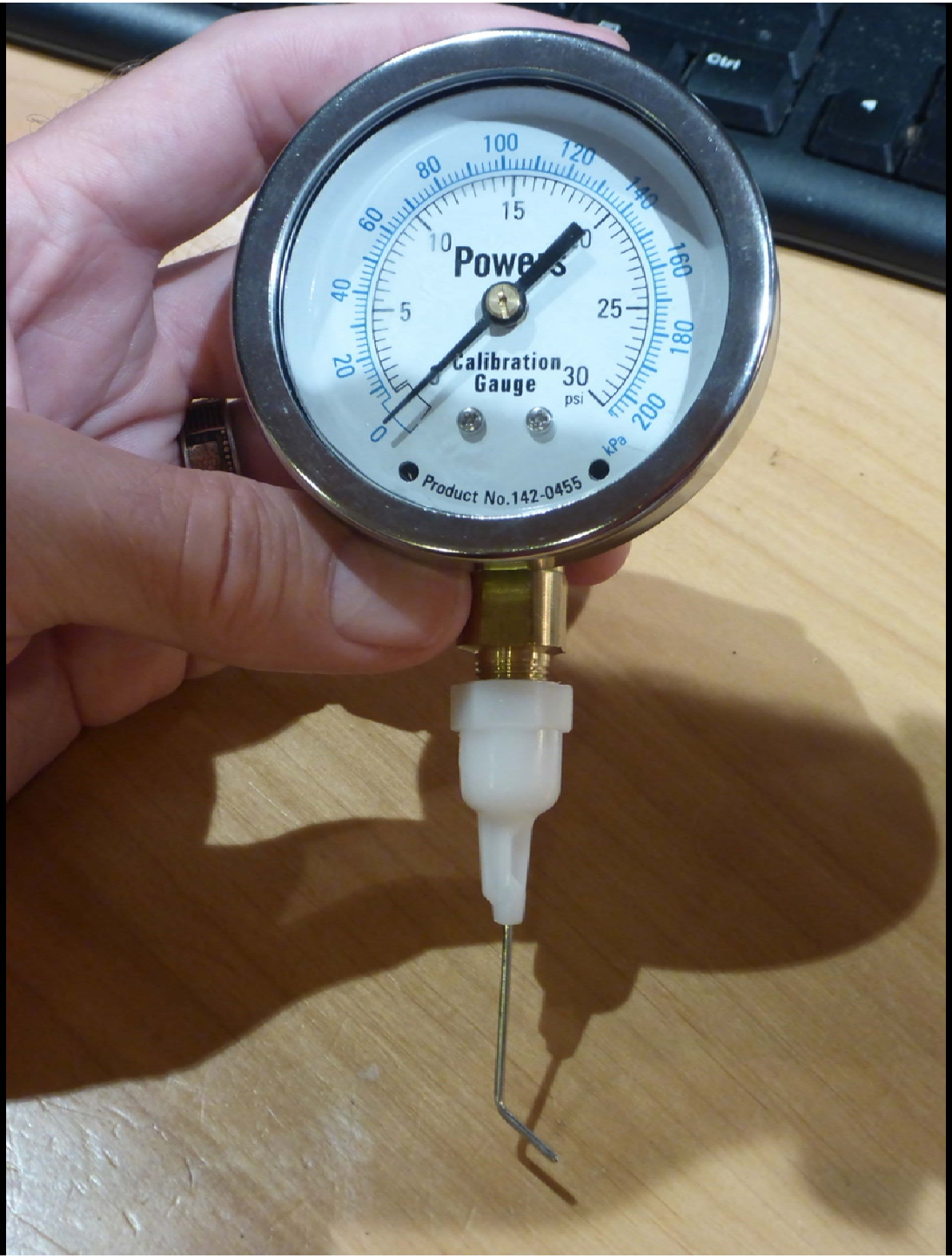
A Simple Proportional Control System



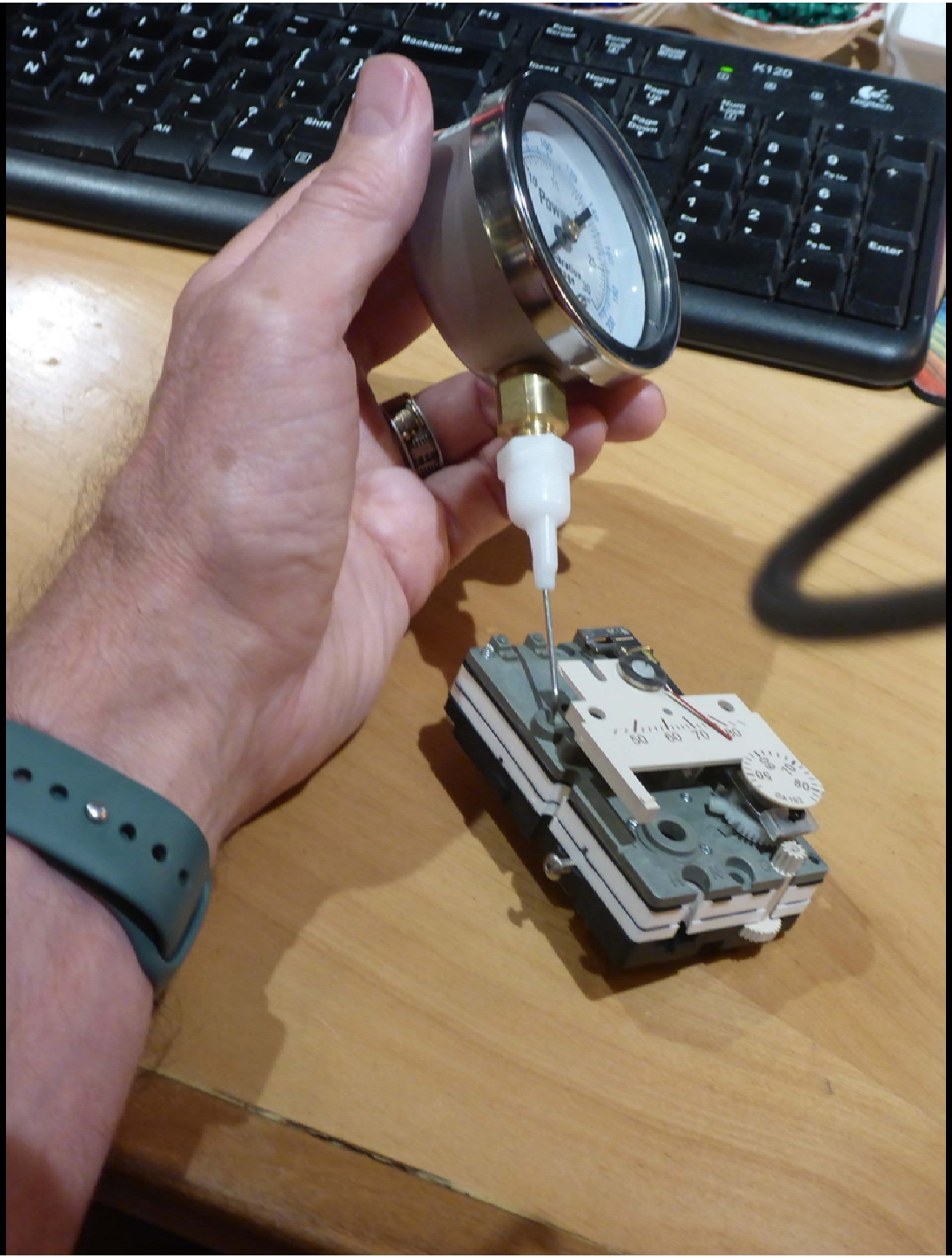
A Calibration Kit

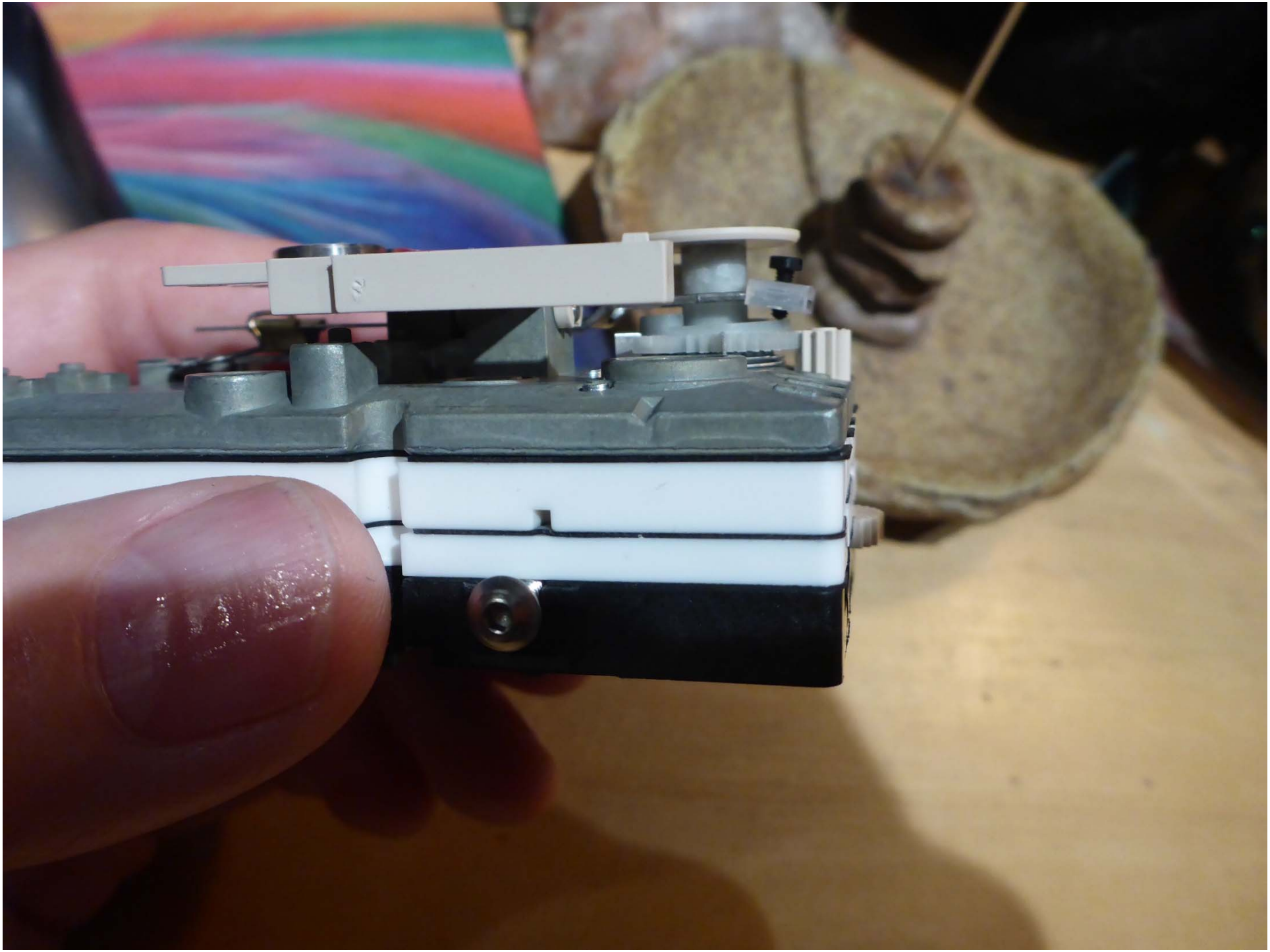

CLASSIFIED FOR
Power
Calibration
Gauge
Product No. 142-0455

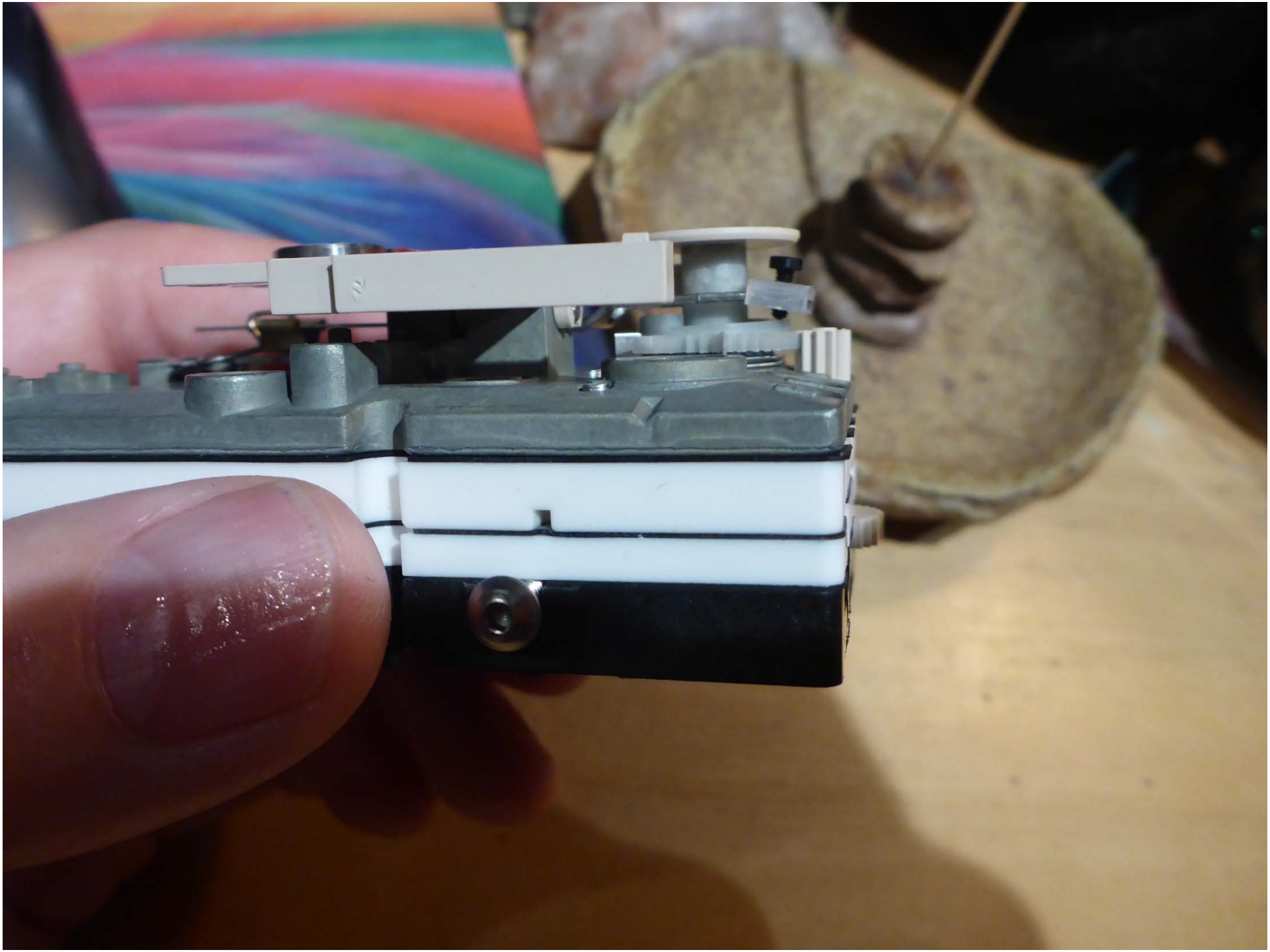

50
60
70
80

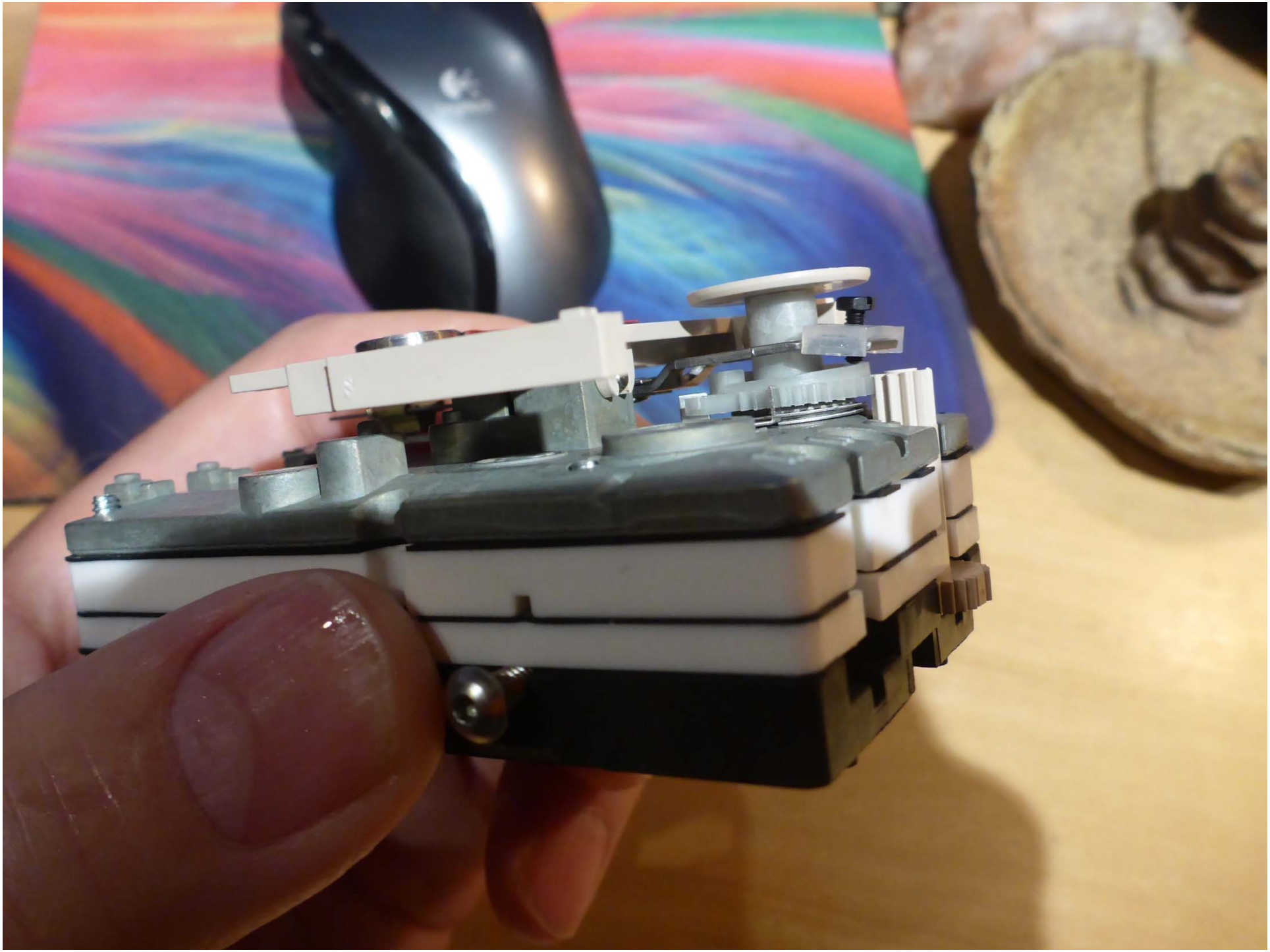

Power
Calibration Gauge
psi
kPa
Product No.142-0455

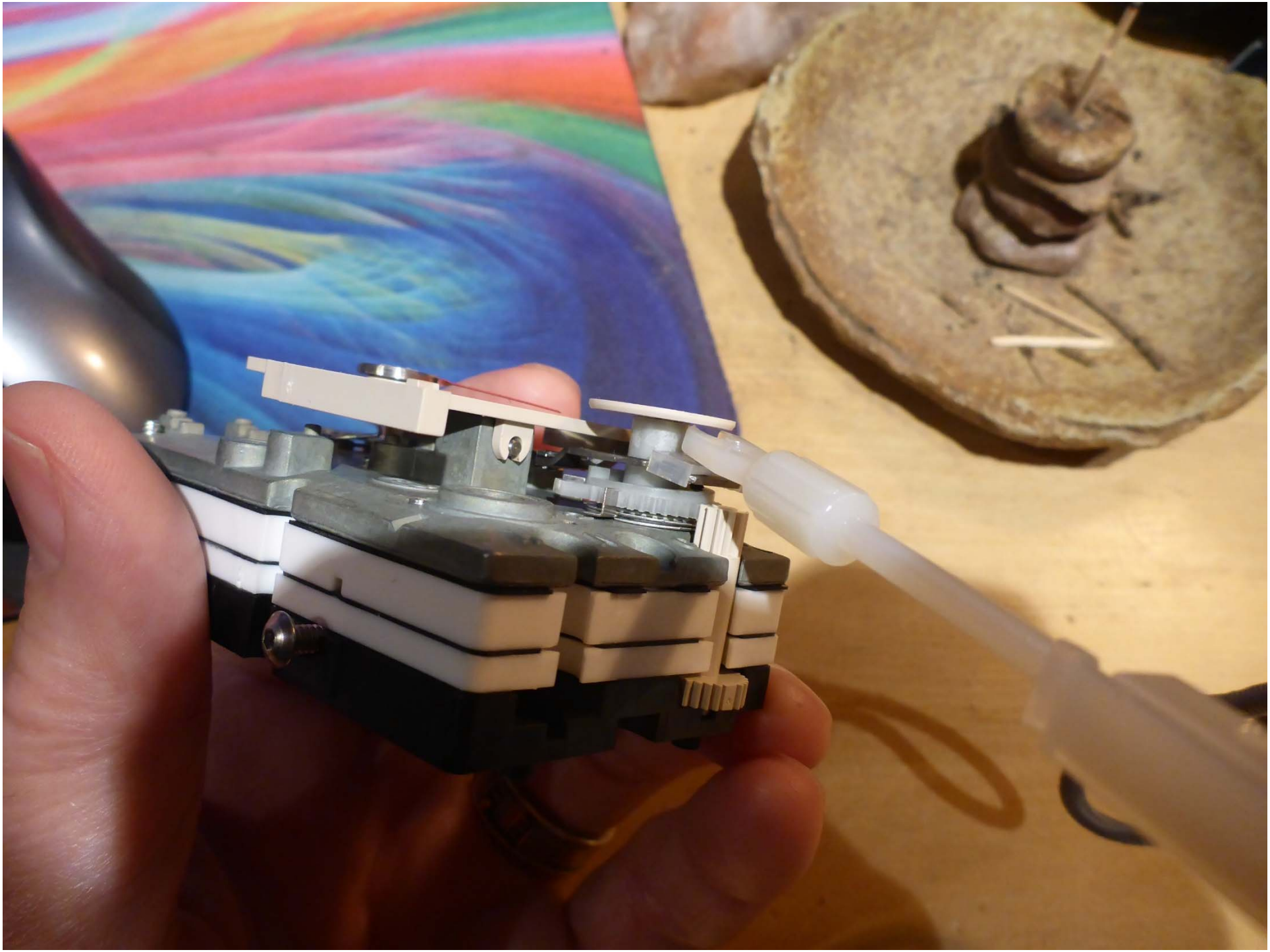

Calibration
Gauge
Product No.142-0455
K120

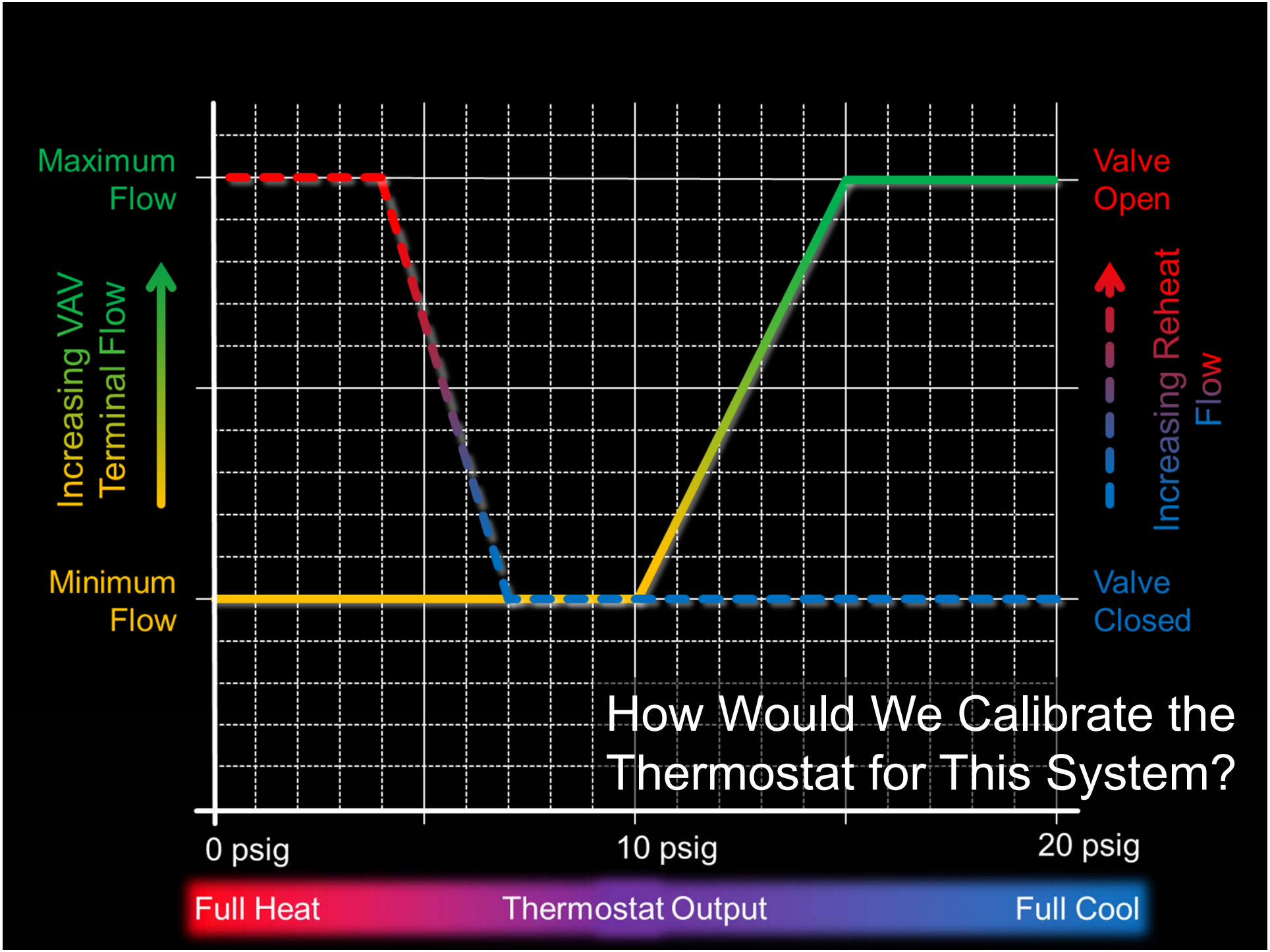

K120
Logitech
Backspace
Shift
Enter

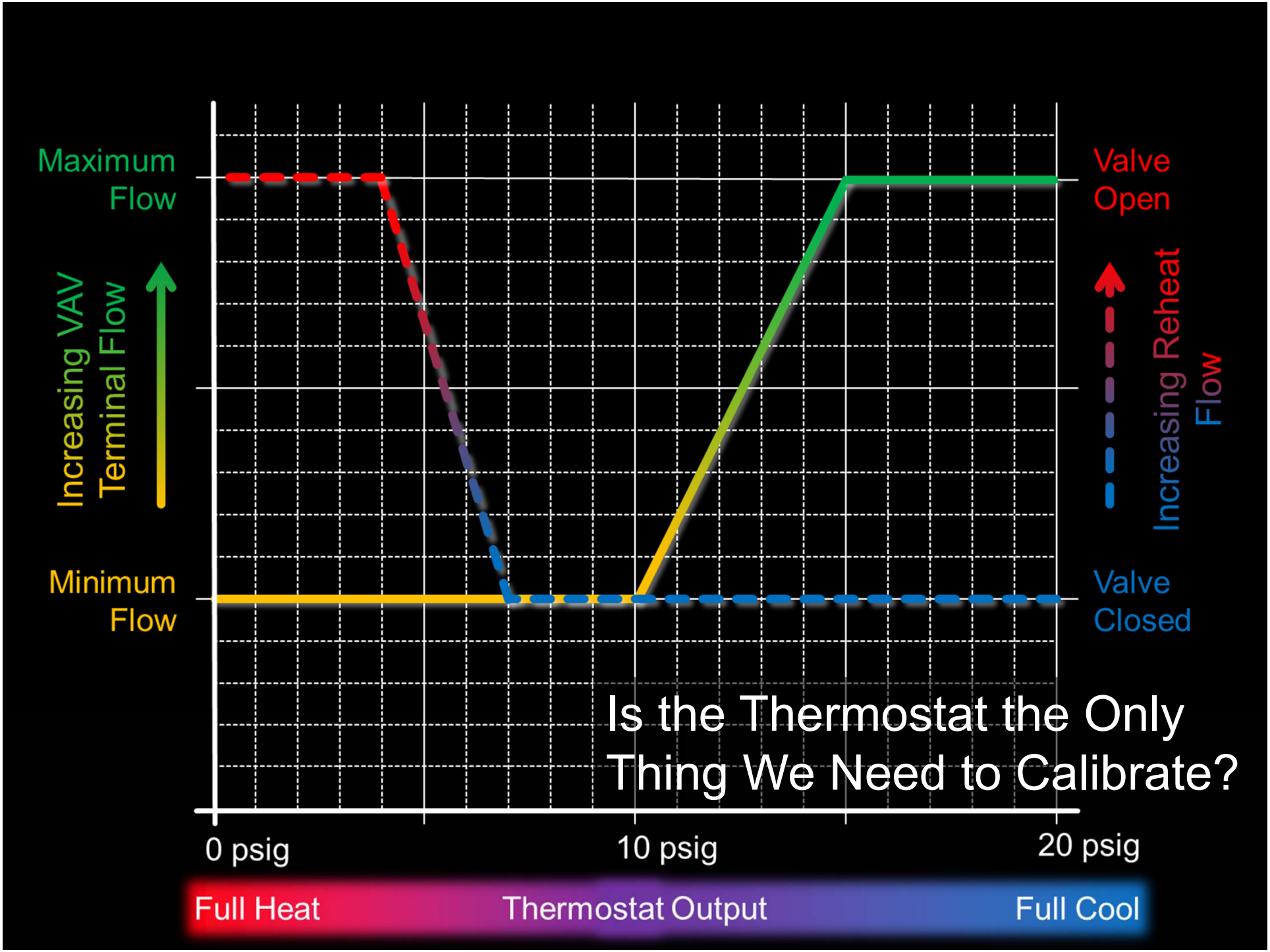




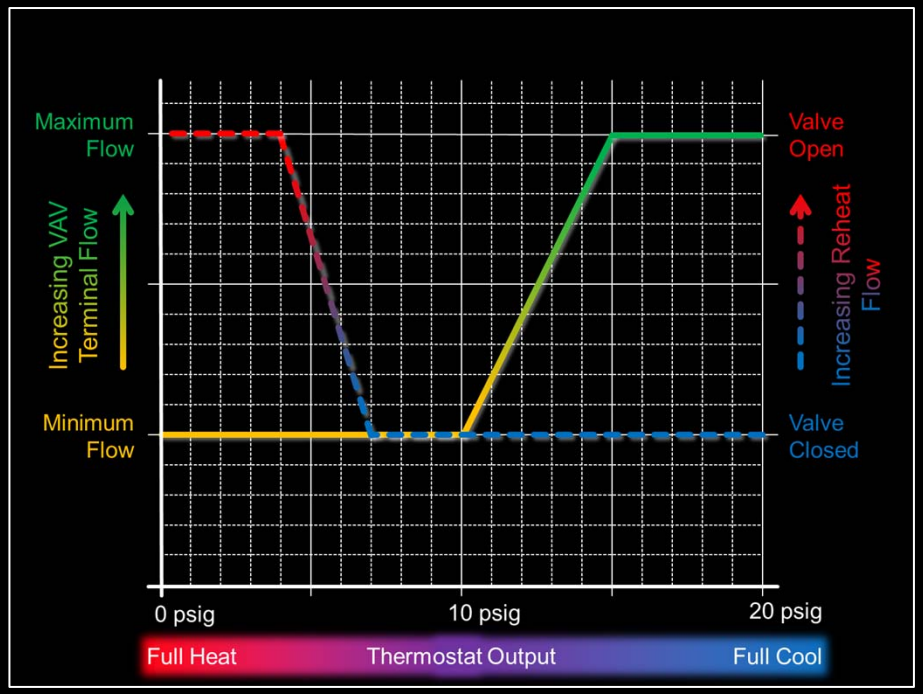


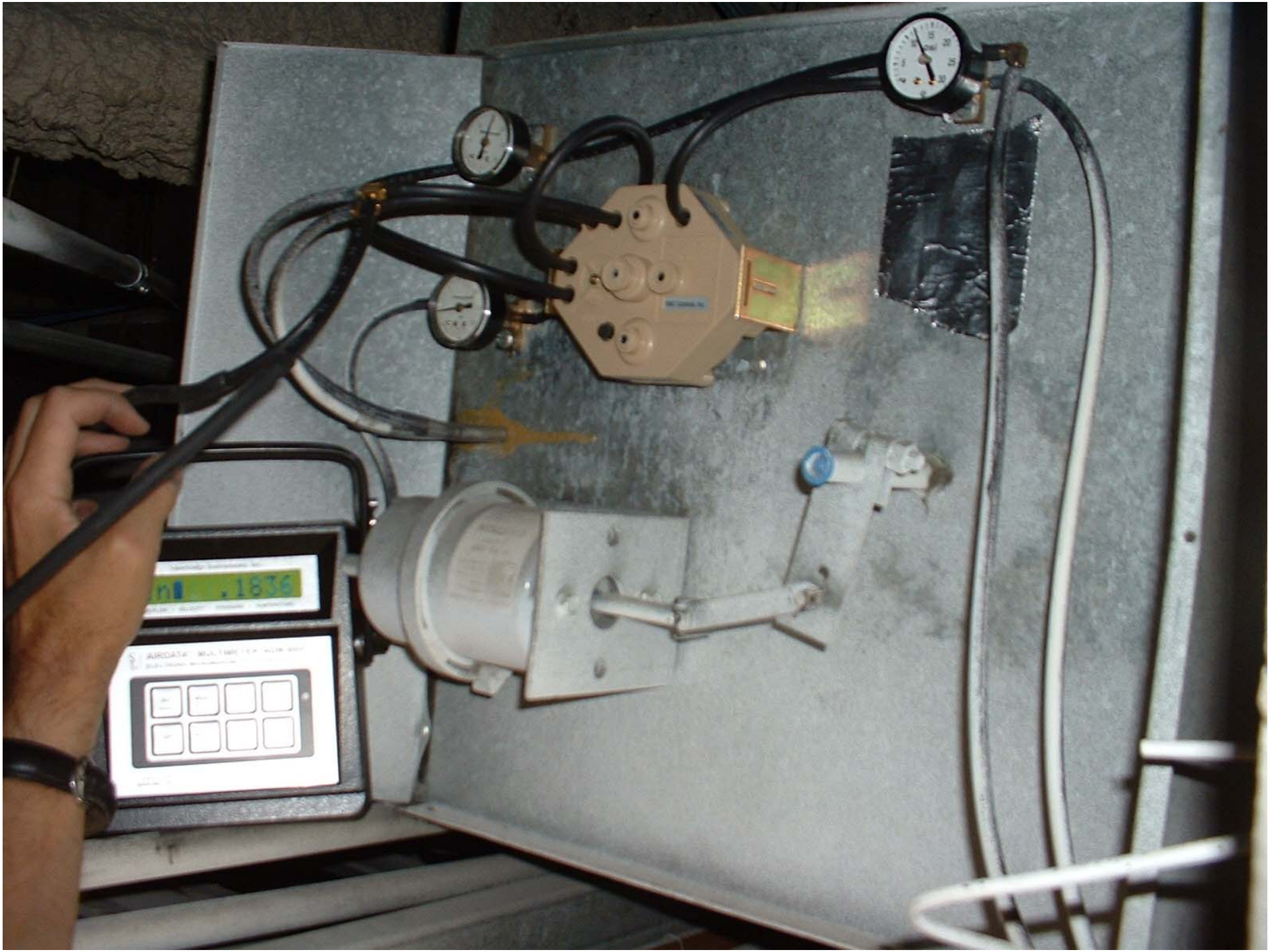



Maximum Flow
Minimum Flow
Increasing VAV Terminal Flow
Valve Open
Valve Closed
Increasing Reheat Flow
How Would We Calibrate the Thermostat for This System?
0 psig
10 psig
20 psig
Full Heat
Thermostat Output
Full Cool


Maximum Flow
Minimum Flow
Increasing VAV Terminal Flow
Valve Open
Valve Closed
Increasing Reheat Flow
Is the Thermostat the Only Thing We Need to Calibrate?
0 psig
10 psig
20 psig
Full Heat
Thermostat Output
Full Cool

Is the Thermostat the Only Thing We Need to Calibrate?

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