A Field Perspective on Pneumatic Control and Actuation Systems

Control System Building Blocks – Part 2

Presented By:
David Sellers
Senior Engineer, Facility Dynamics Engineering

Previously
On Control System Building Blocks

Automatically adjust a piece of machinery to give us what we want by comparing what is going on to what we want to go on and making appropriate adjustments to the process we want to control

Inputs

Measure the process variable

Previously
On Control System Building Blocks

Automatically adjust a piece of machinery to give us what we want by comparing what is going on to what we want to go on and making appropriate adjustments to the process we want to control

Inputs — Measure the process variable

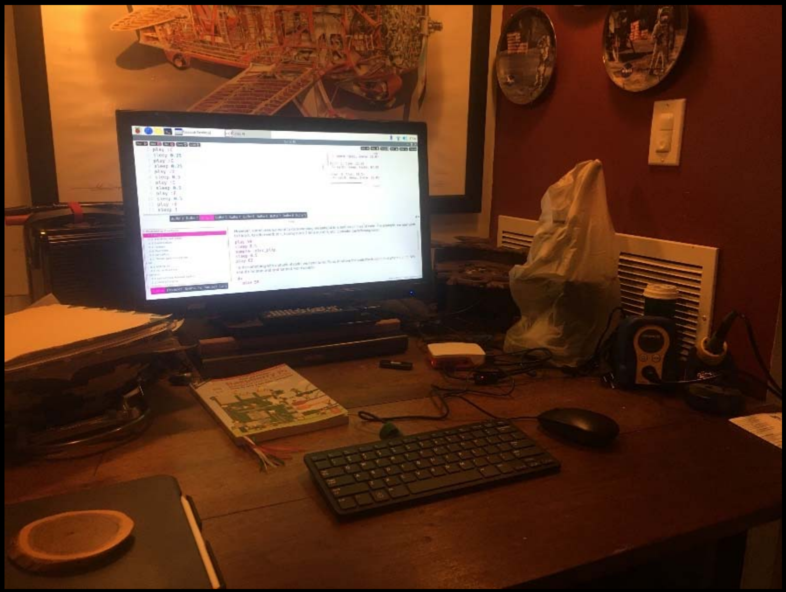
Outputs — Adjust the controlled variable

Previously
On Control System Building Blocks

Automatically adjust a piece of machinery to give us what we want by comparing what is going on to what we want to go on and making appropriate adjustments to the process we want to control

Inputs	Measure the process variable
Outputs	Adjust the controlled variable
Control Process	Logic and mechanisms that tries to bring the controlled variable into agreement with the set point

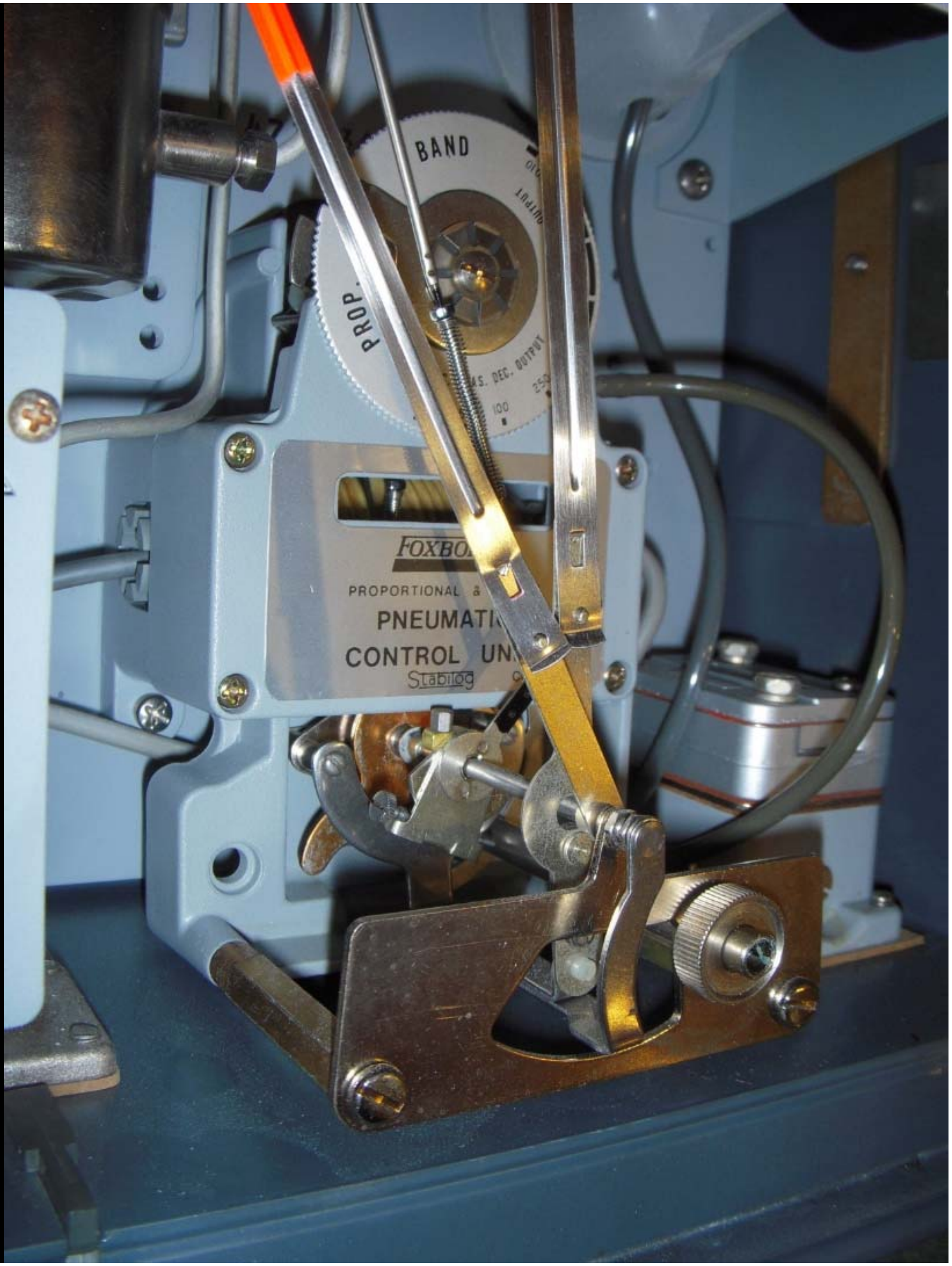
Digital Logic



Learn by doing

- https://av8rdas.wordpress.com/2011/12/04/learning-about-relay-logic-build-your-very-own-jeopardy-game/
- https://av8rdas.wordpress.com/2011/12/19/making-a-jeopardy-game-board-in-powerpoint-to-supplement-your-light-and-buzzer-system-and-learning-a-bit-about-powerpoint-templates/
- https://www.raspberrypi.org/

Analog Logic



A Long, Long, Time Ago, in a Galaxy Far, Far, Away, Logic Was a Physical Thing

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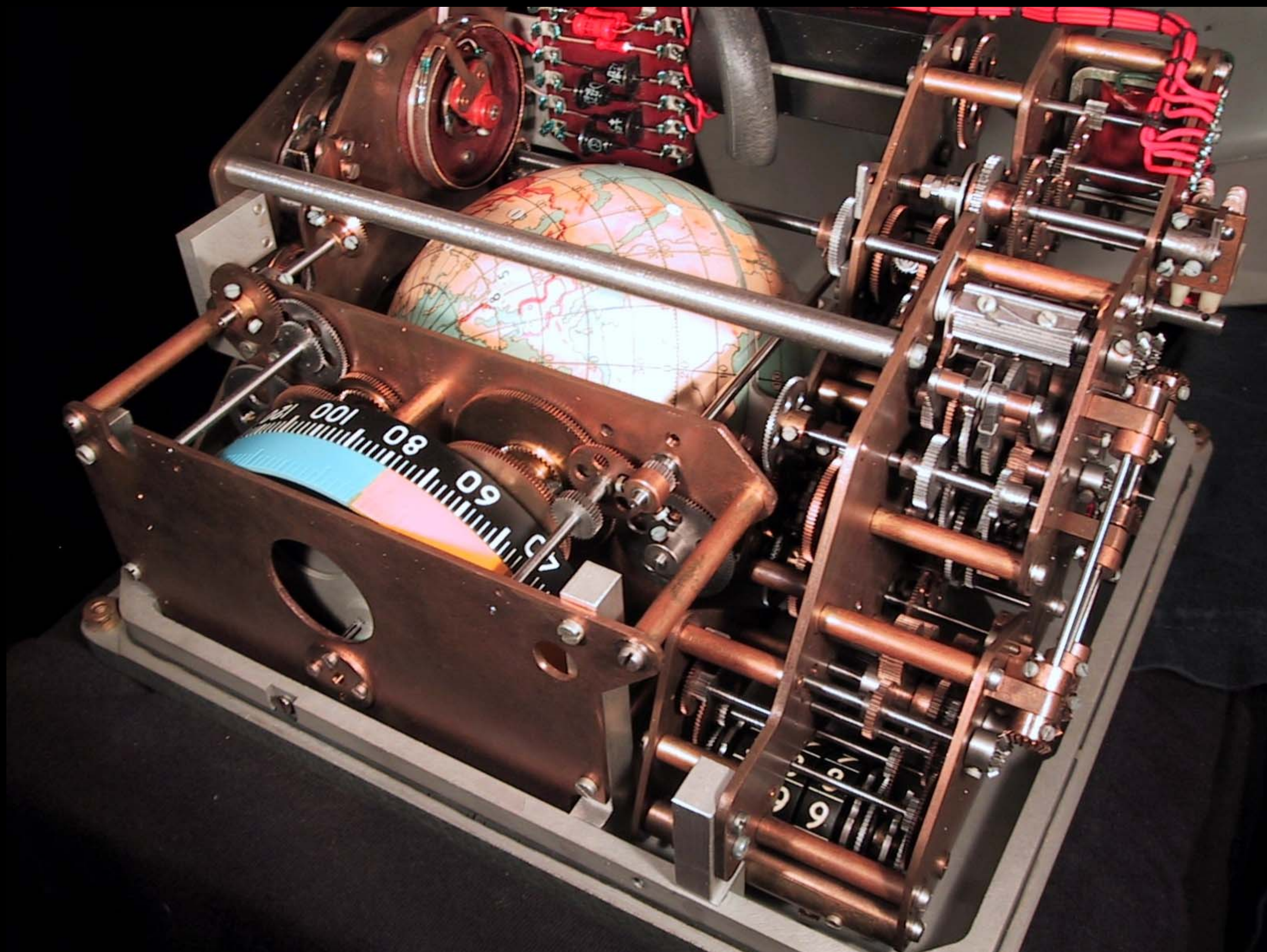
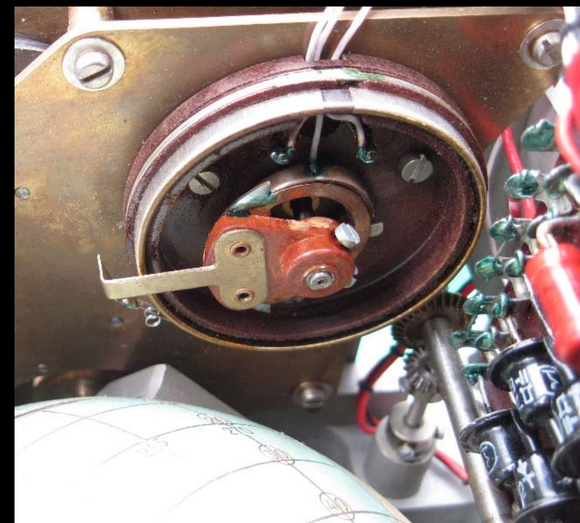


A Long, Long, Time Ago, in a Galaxy Far, Far, Away, Logic Was a Physical Thing



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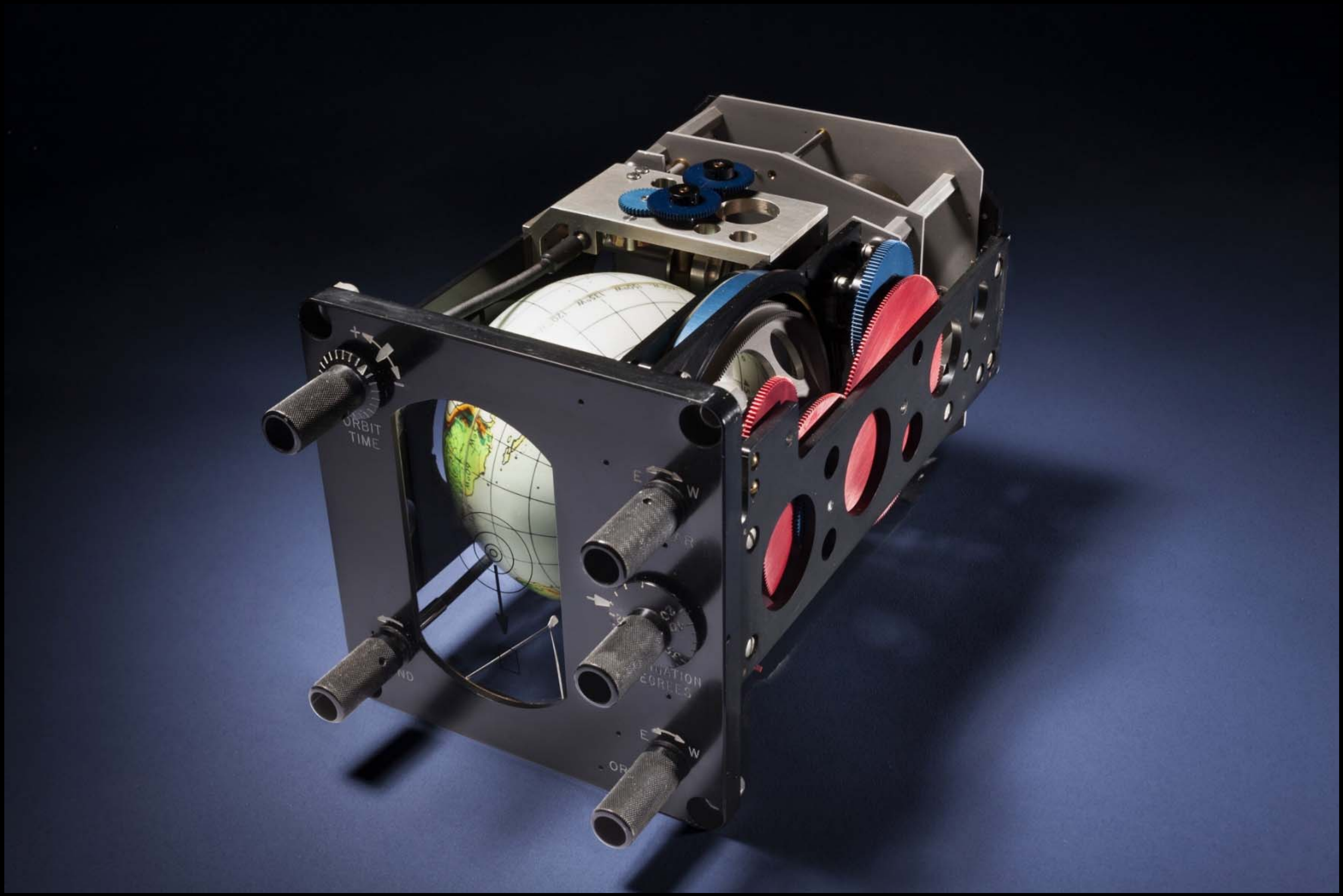
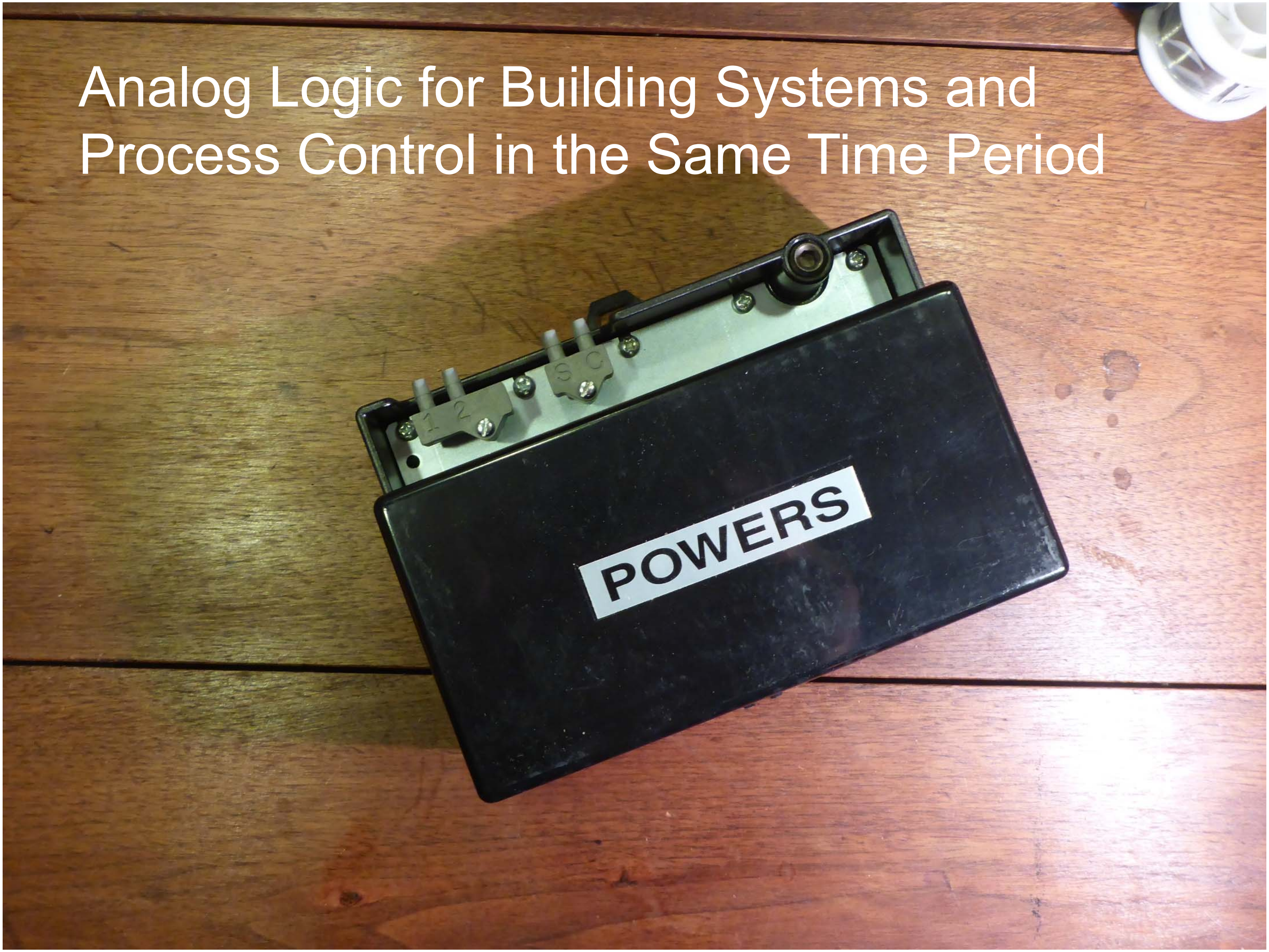
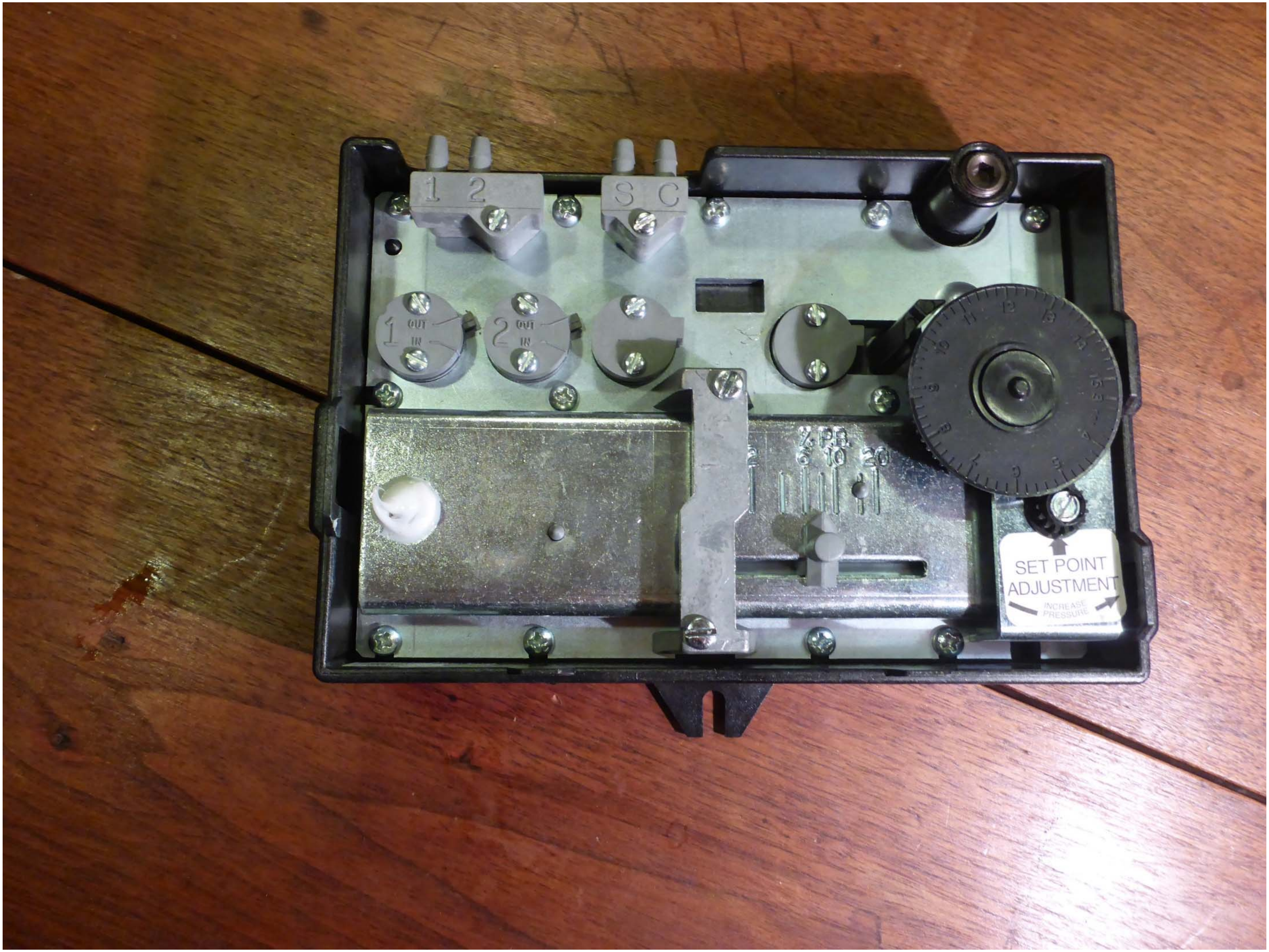


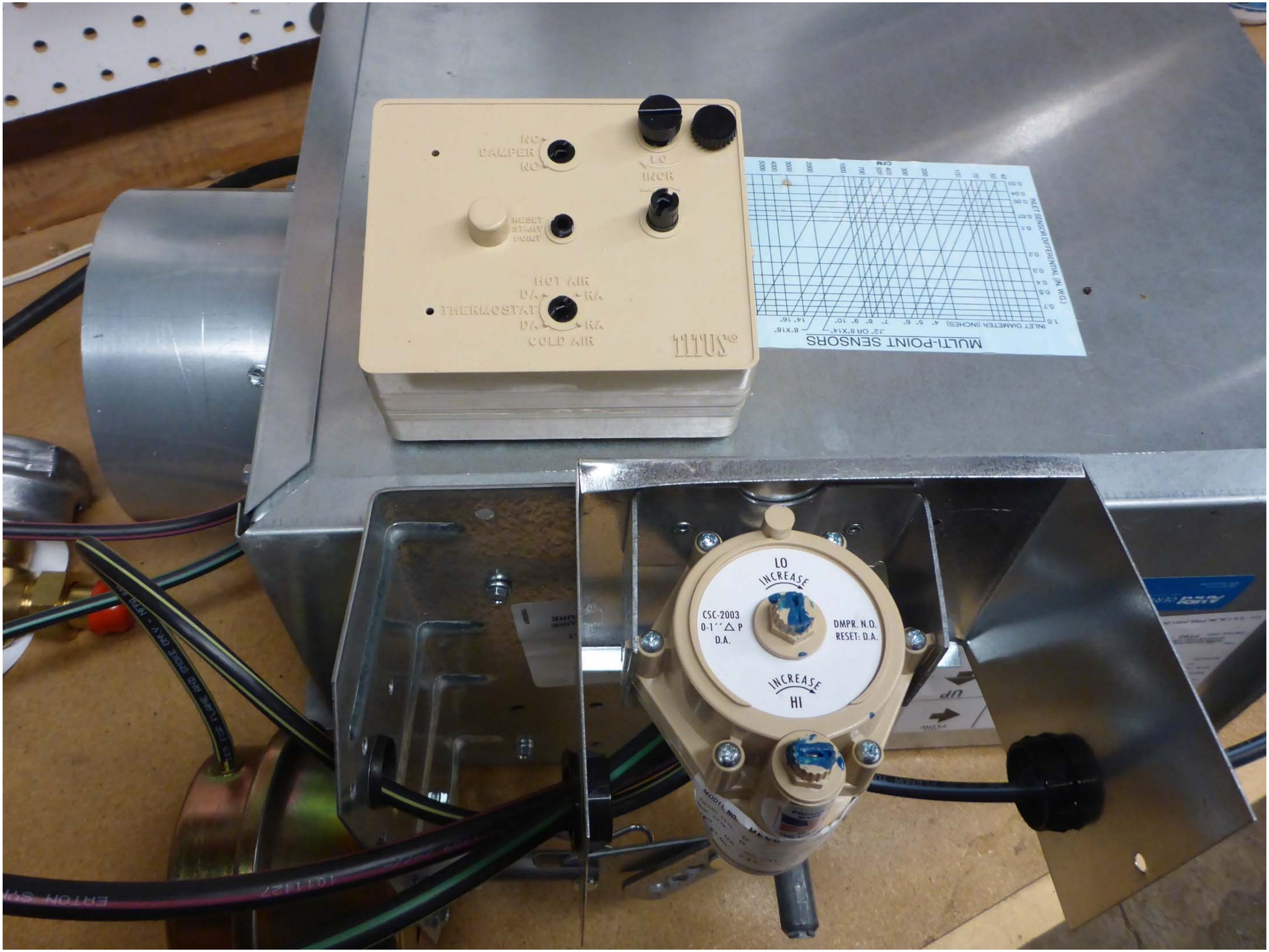
Analog Logic for Building Systems and Process Control in the Same Time Period




1 2
S C
1 OUT IN
2 OUT IN
% P.B.
5 10 20
SET POINT
ADJUSTMENT
INCREASE
PRESSURE

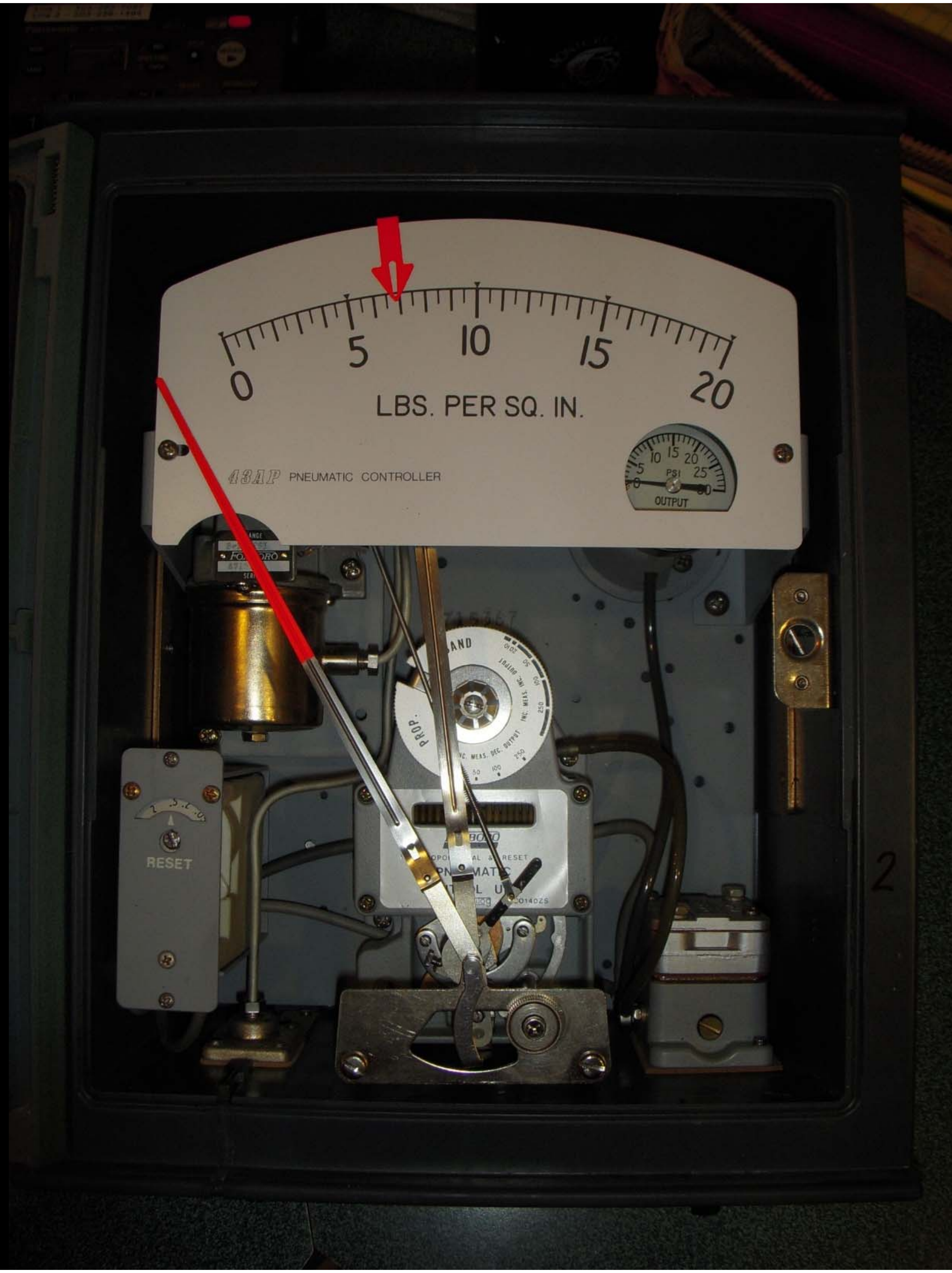

36X46
POWERS


50
60
70
80
70
80



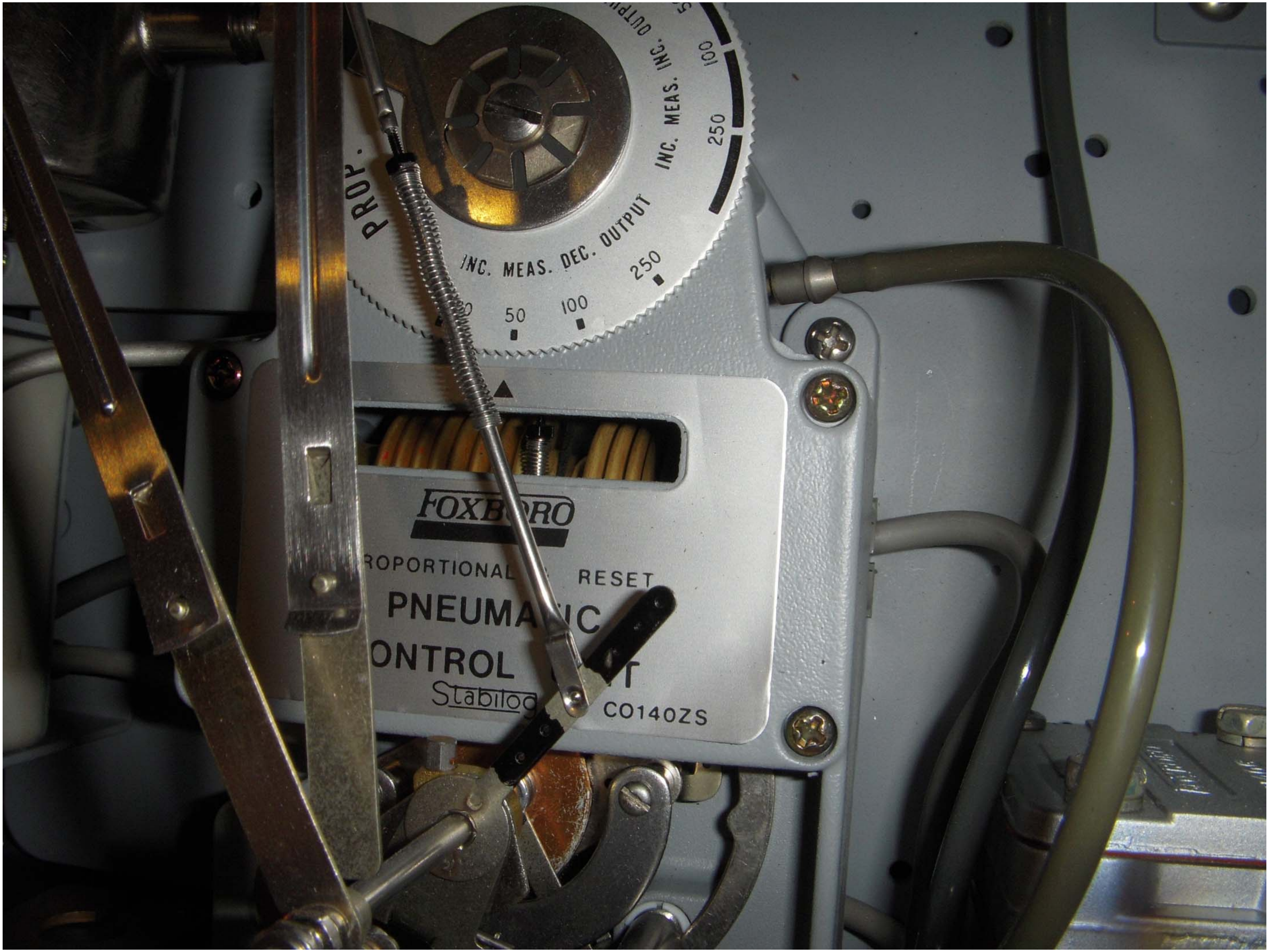
NC
DAMPER
NO
LO
INCR
RESET
START
POINT
HOT AIR
DA
RA
THERMOSTAT
DA
RA
COLD AIR
TITUS
MULTI-POINT SENSORS
LO
INCREASE
CSC-2003
0-1'' △ P
D.A.
DMPR. N.O.
RESET: D.A.
INCREASE
HI


S-2
0 5 10 15 20
LBS. PER SQ. IN.
43AP PNEUMATIC CONTROLLER
PSI
FOXBORO

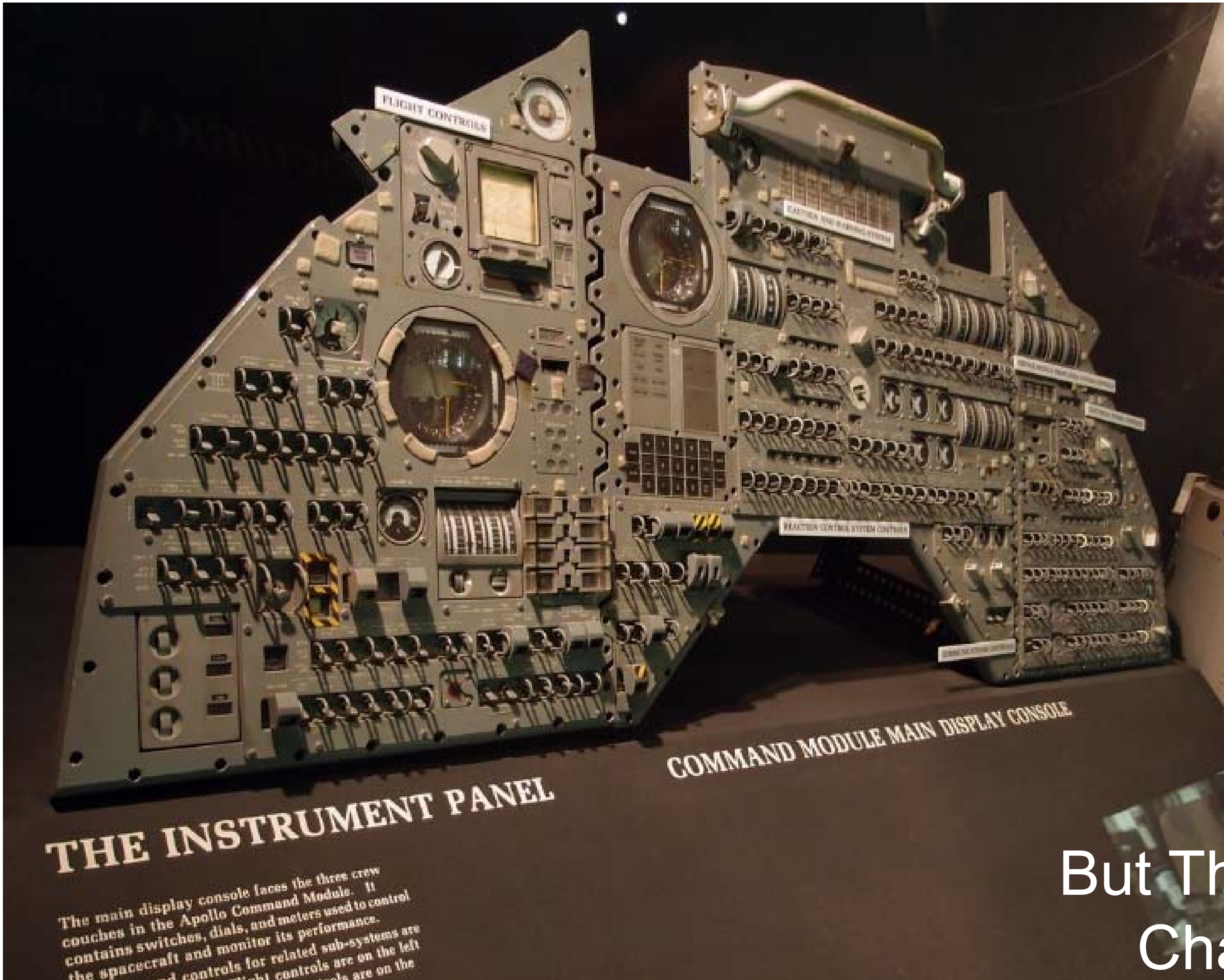

0 5 10 15 20
LBS. PER SQ. IN.
43AP PNEUMATIC CONTROLLER
5 10 15 20 25 30
PSI
OUTPUT
PROP.
RESET
2


5.2
RESET


0
5
15
LBS. PER SQ. IN.
43AP PNEUMATIC CONTROLLER
RANGE
3-15 PSI
FOXBORO
SERIAL
PROP.
BAND
OUTPUT

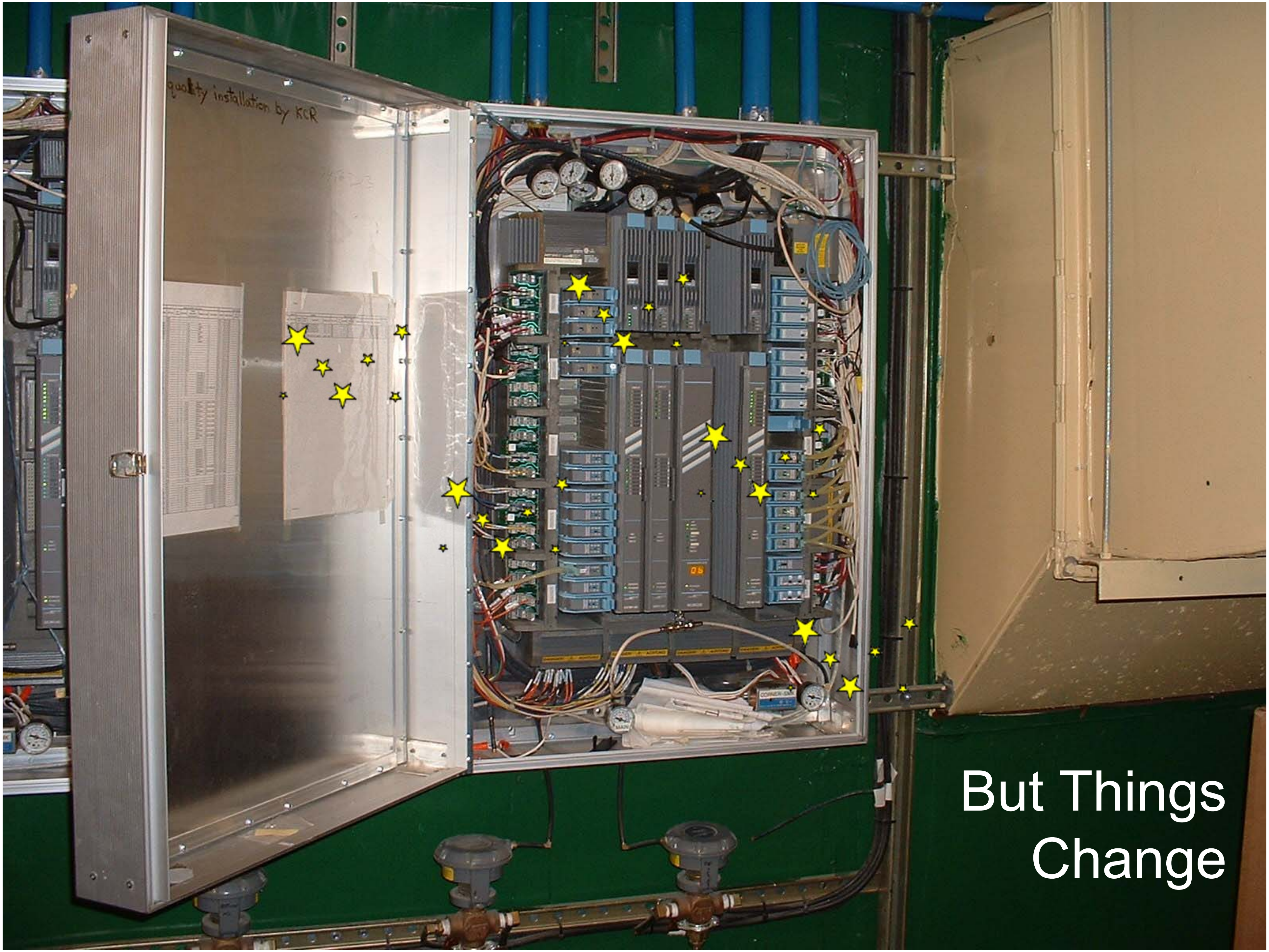


PROP.
INC. MEAS. DEC. OUTPUT
50
100
250
INC. MEAS. INC.
250
100
FOXBORO
ROPORTIONAL
RESET
PNEUMA
ONTROL
Stabilog
CO140ZS

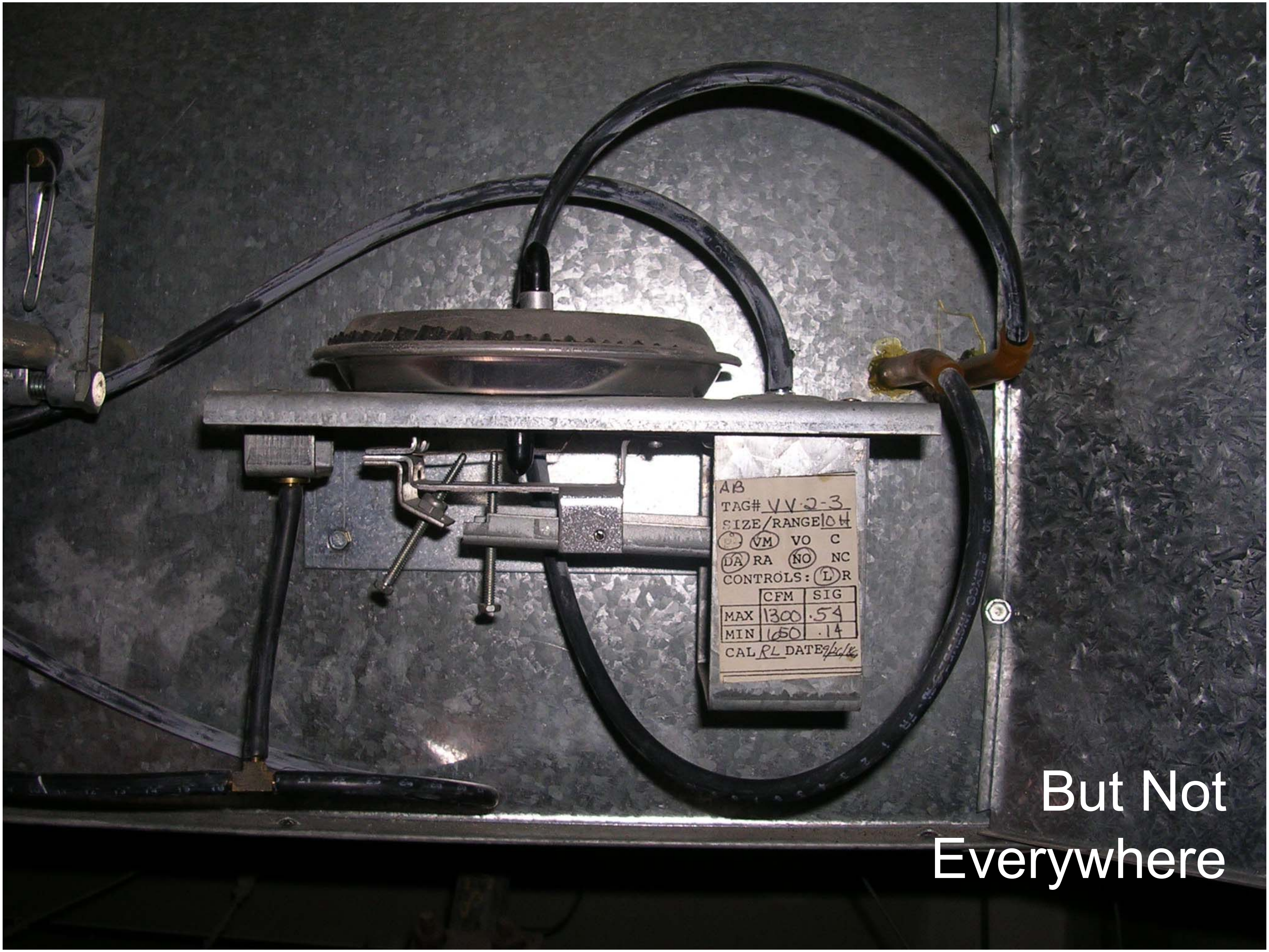


But Things Change

But Things Change

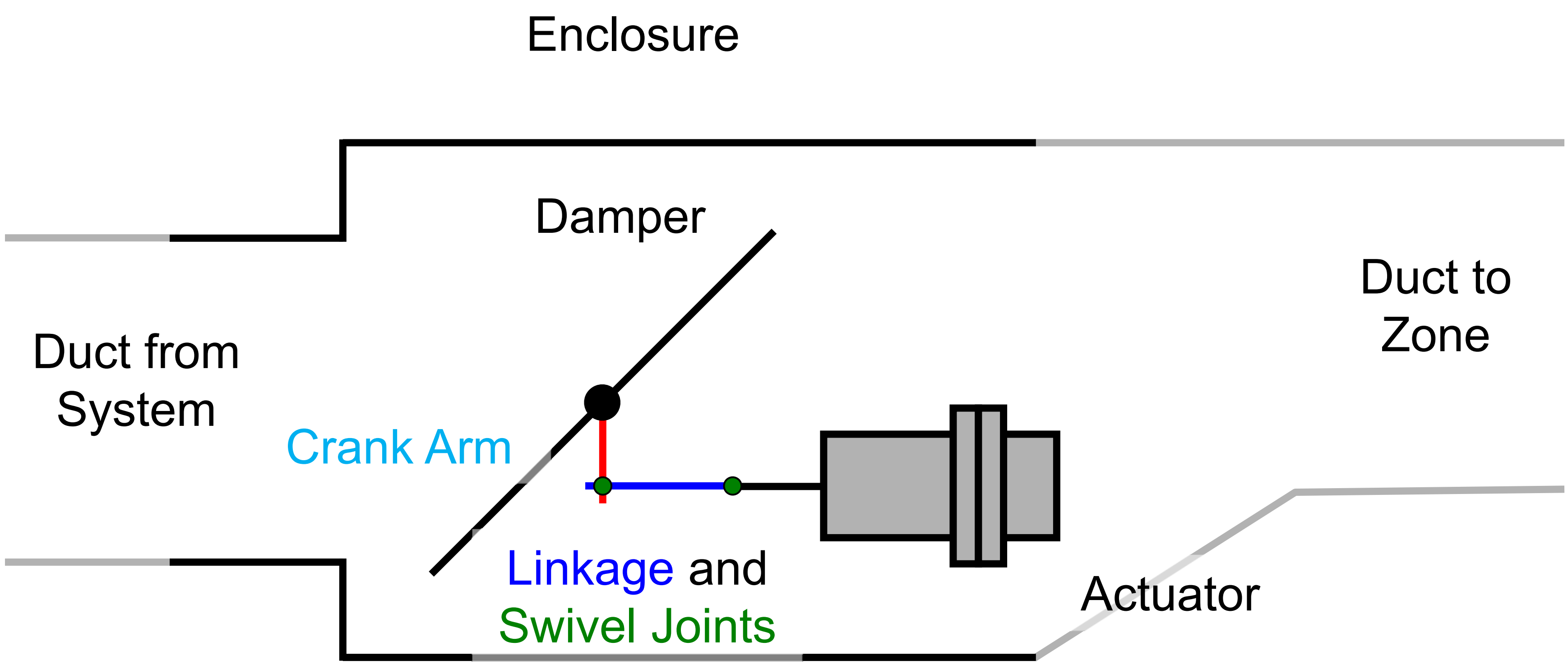


But Things Change

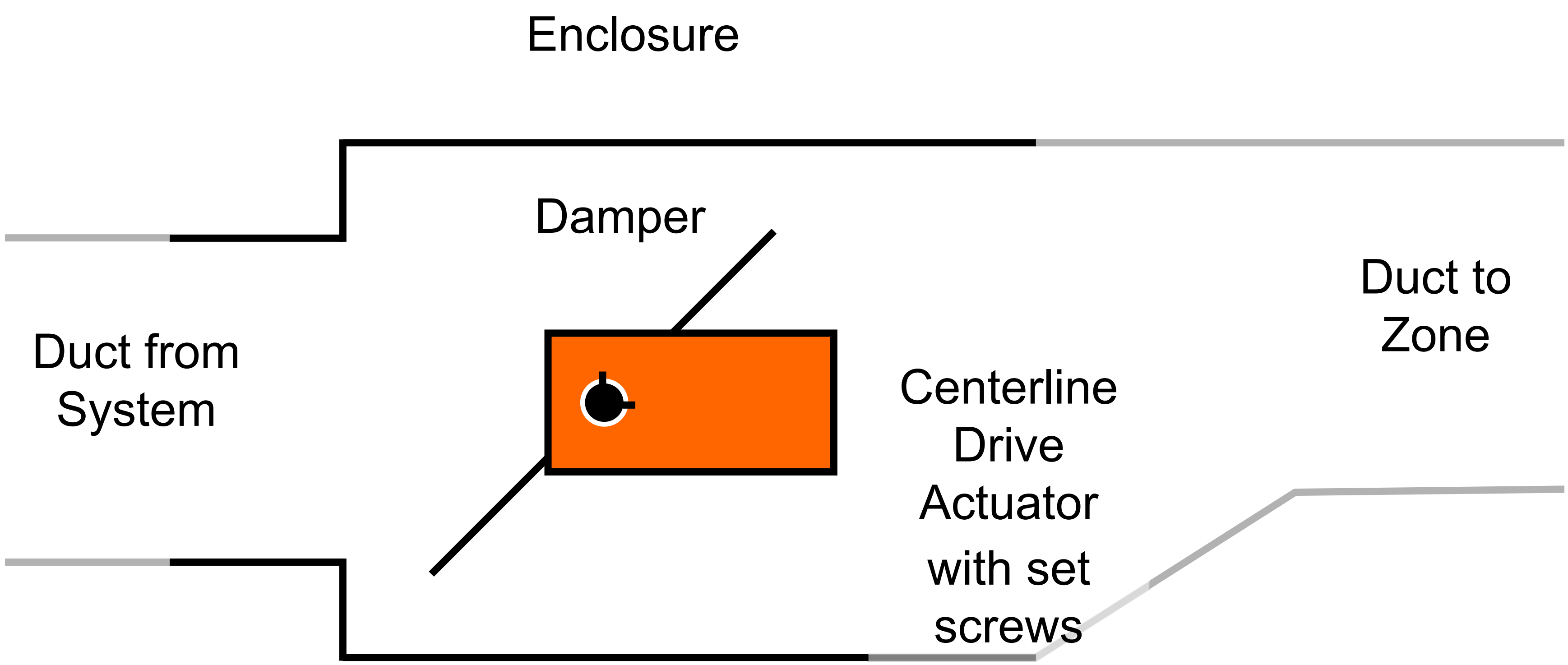


But Not Everywhere

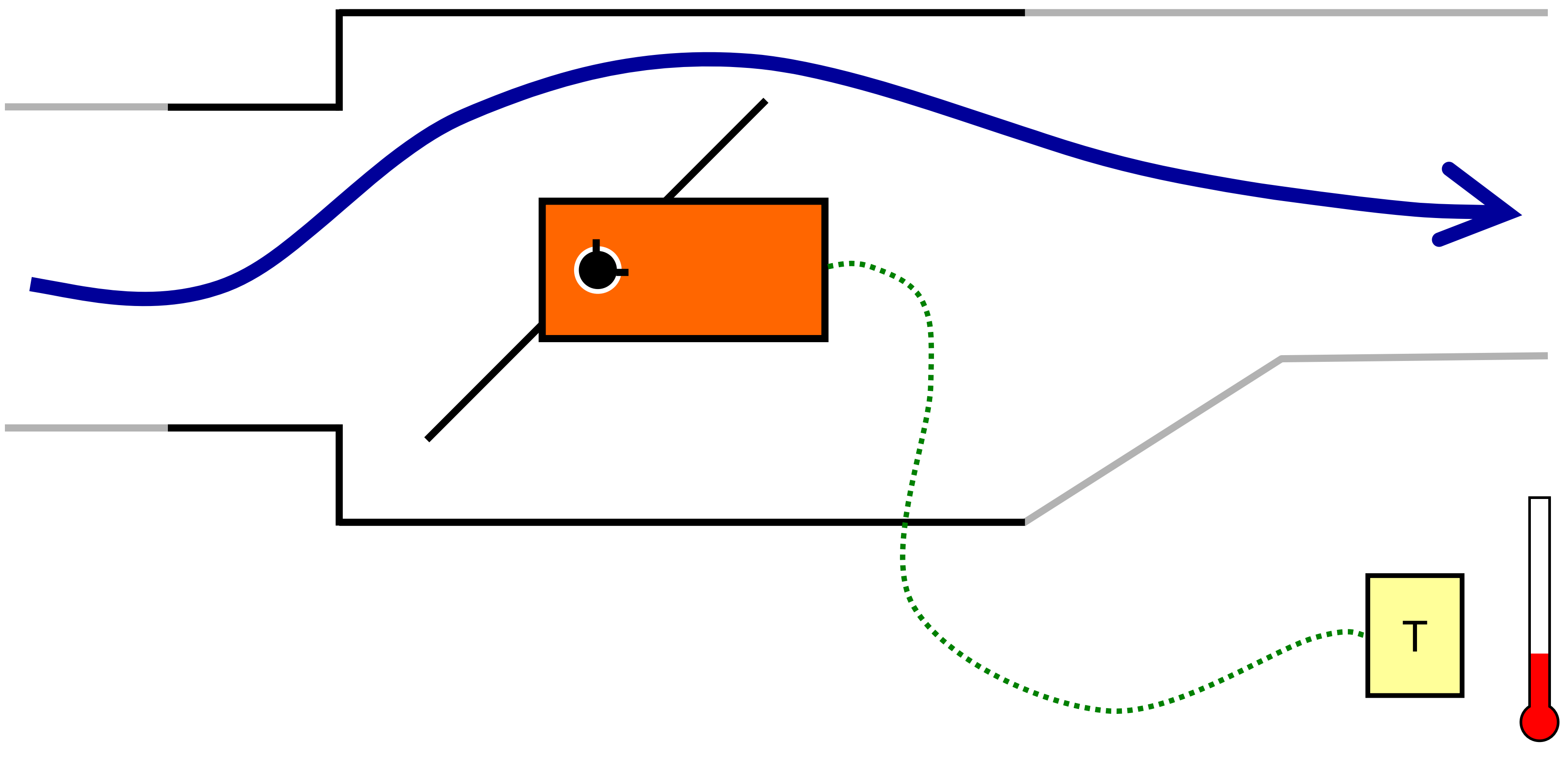
Your Basic Box



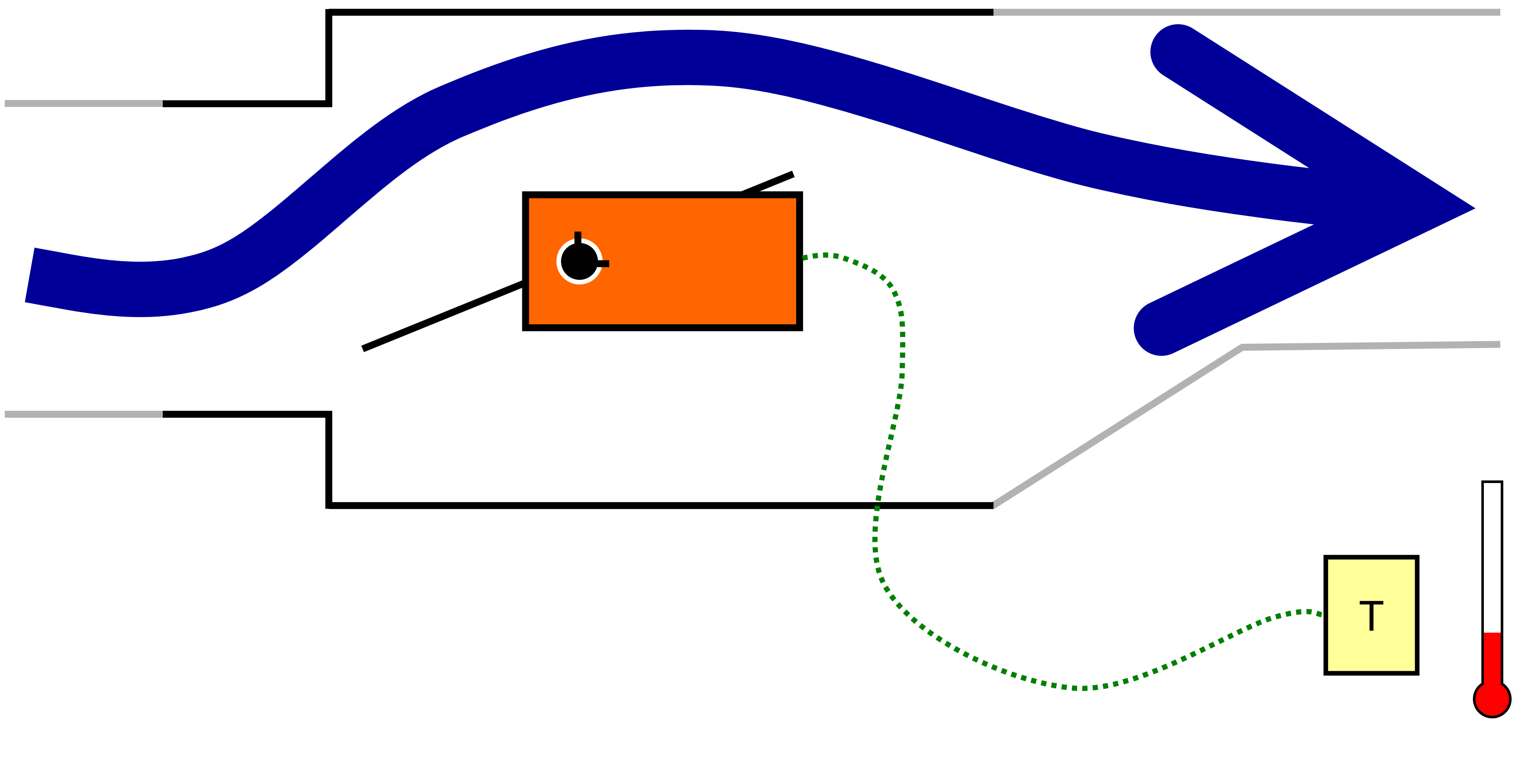
Your Basic Box



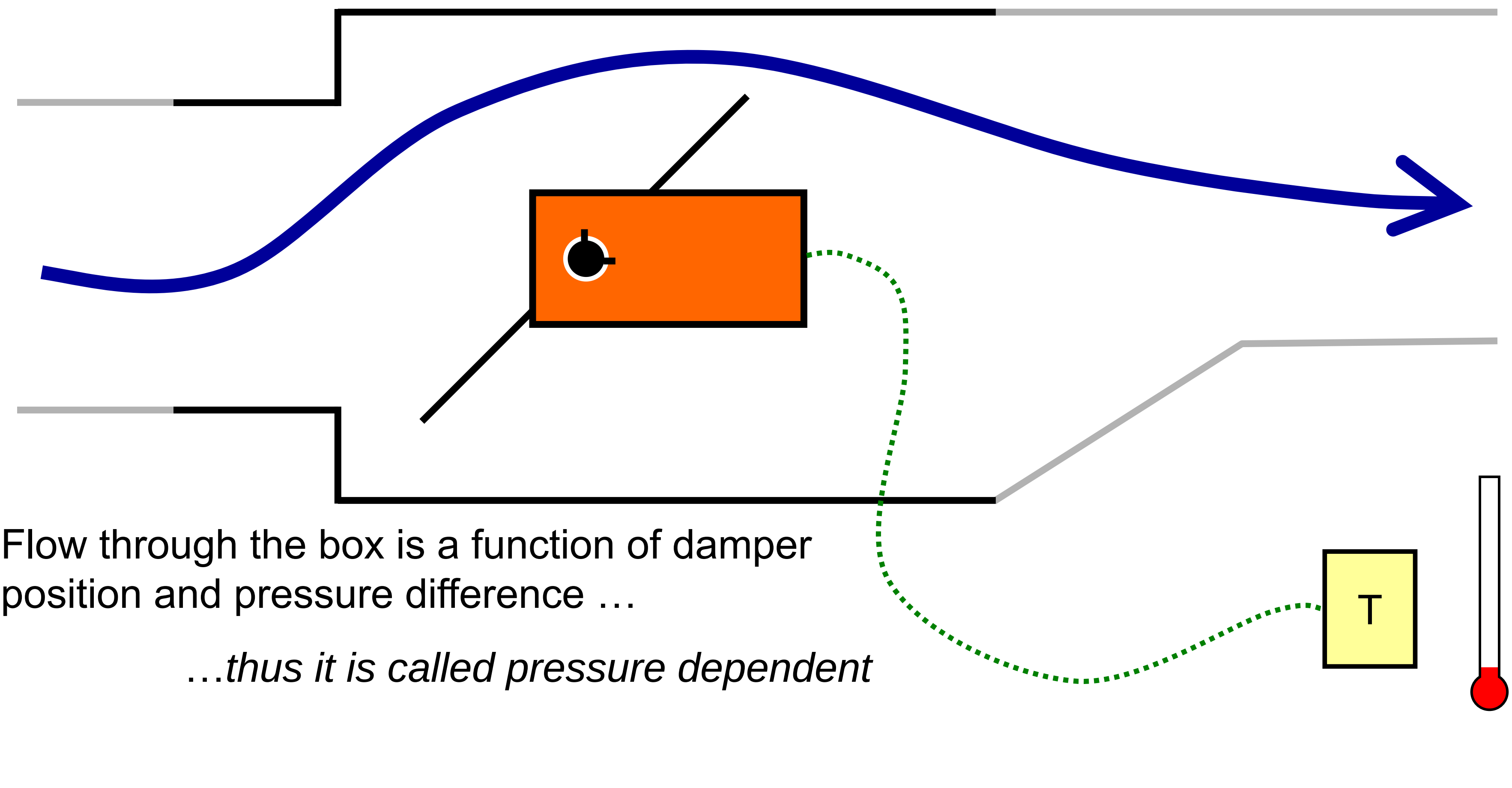
Your Basic Box



Your Basic Box



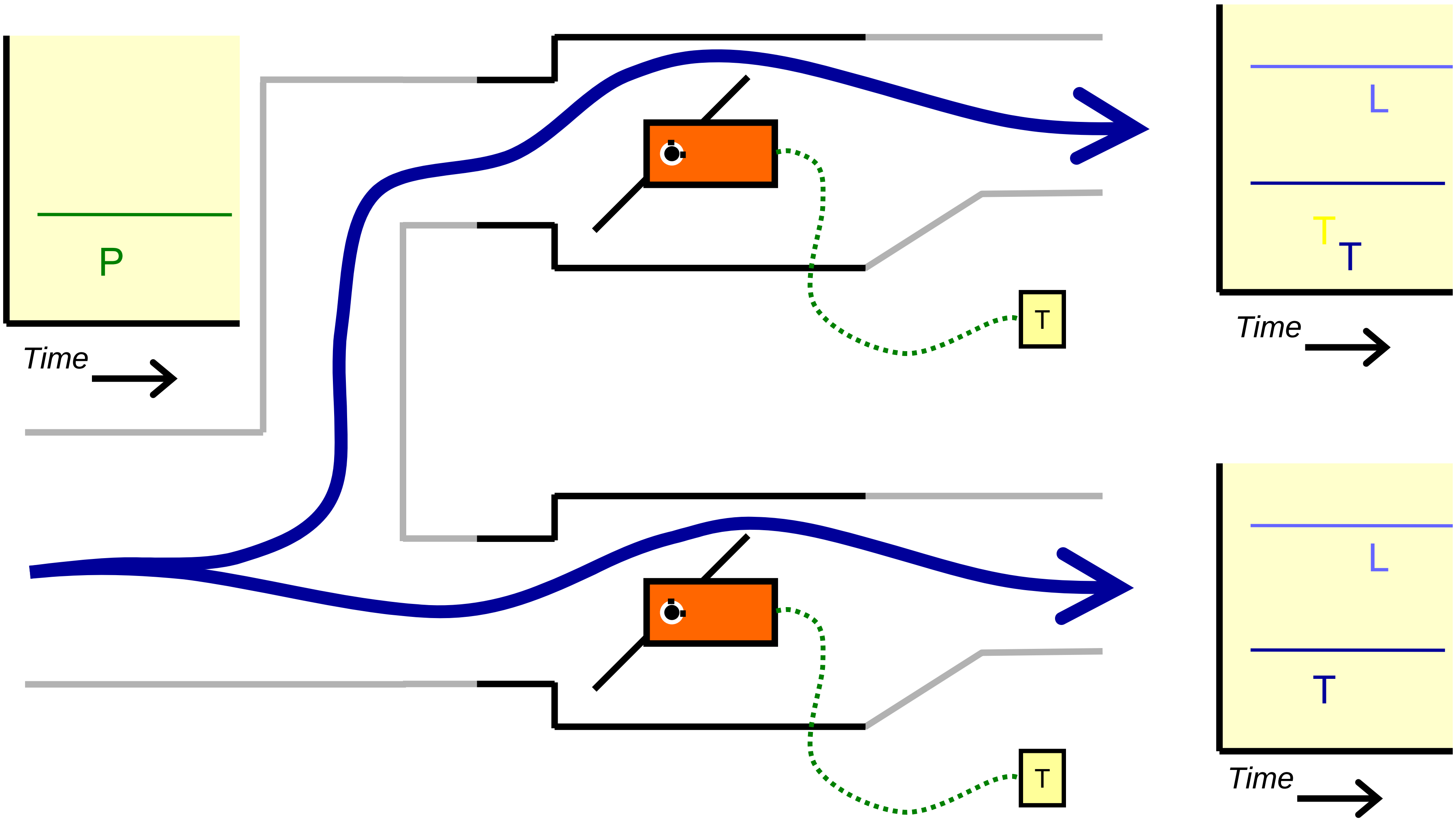
Your Basic Box



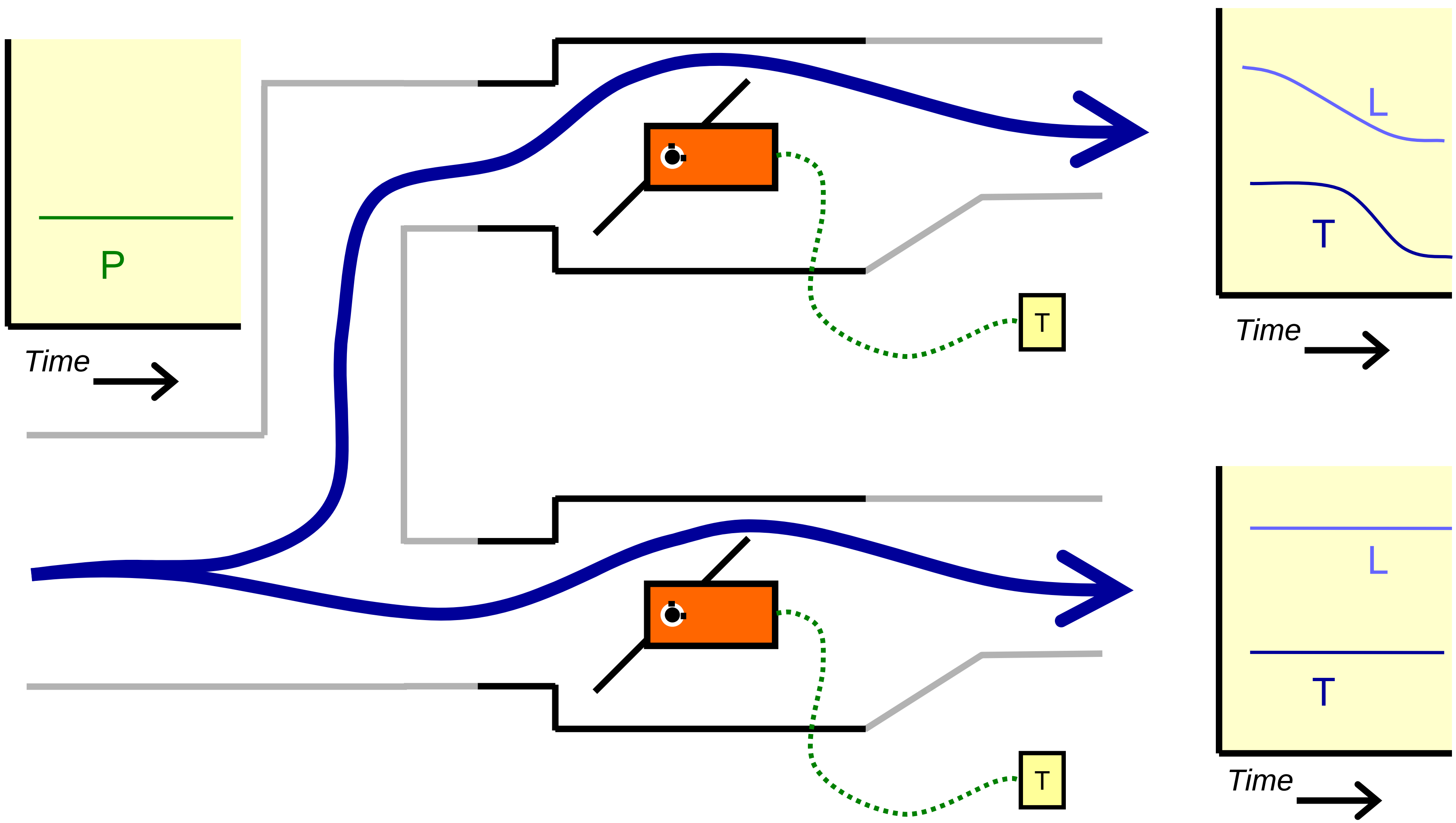
Flow through the box is a function of damper position and pressure difference …

…thus it is called pressure dependent

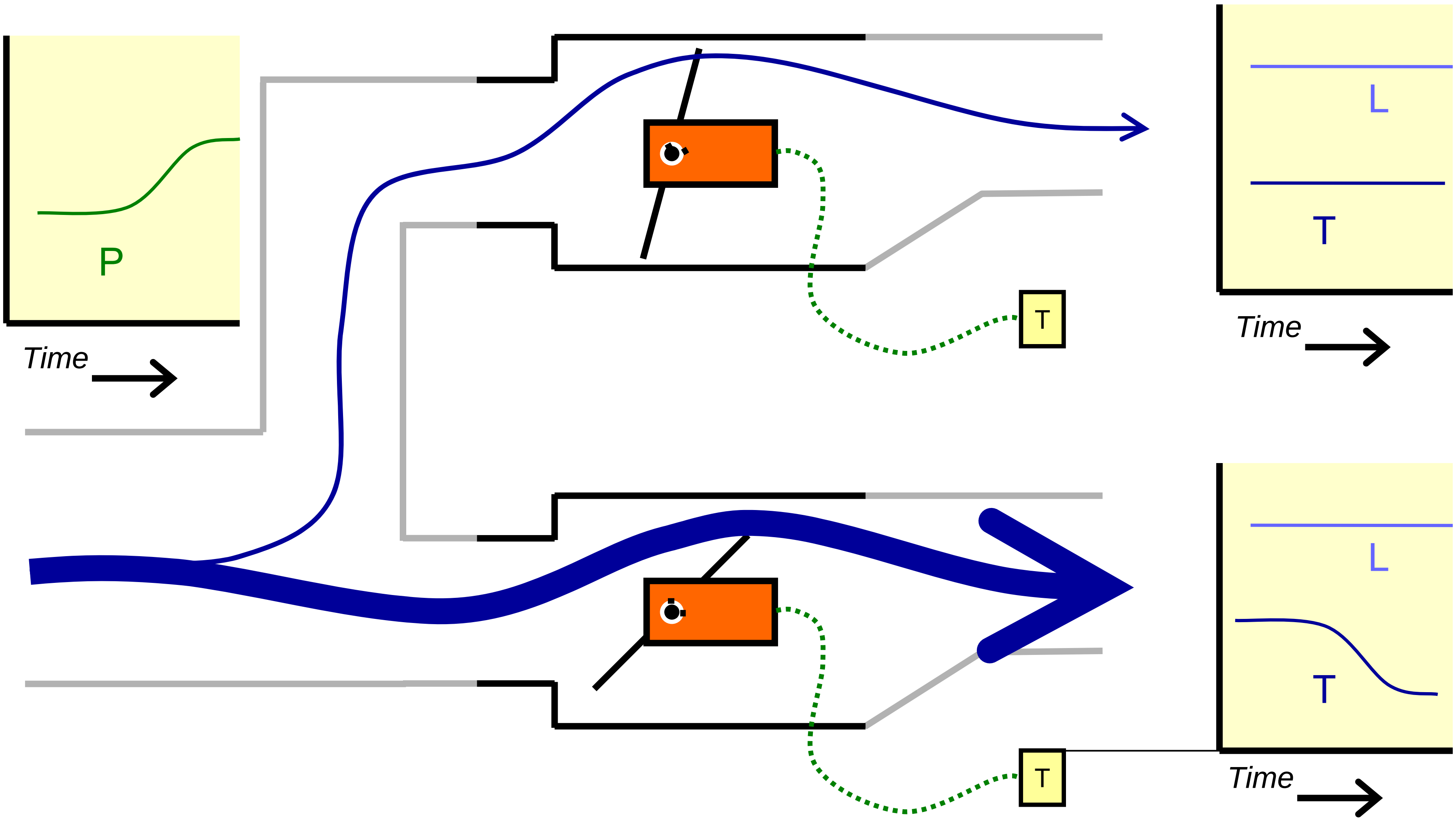
Your Basic Box



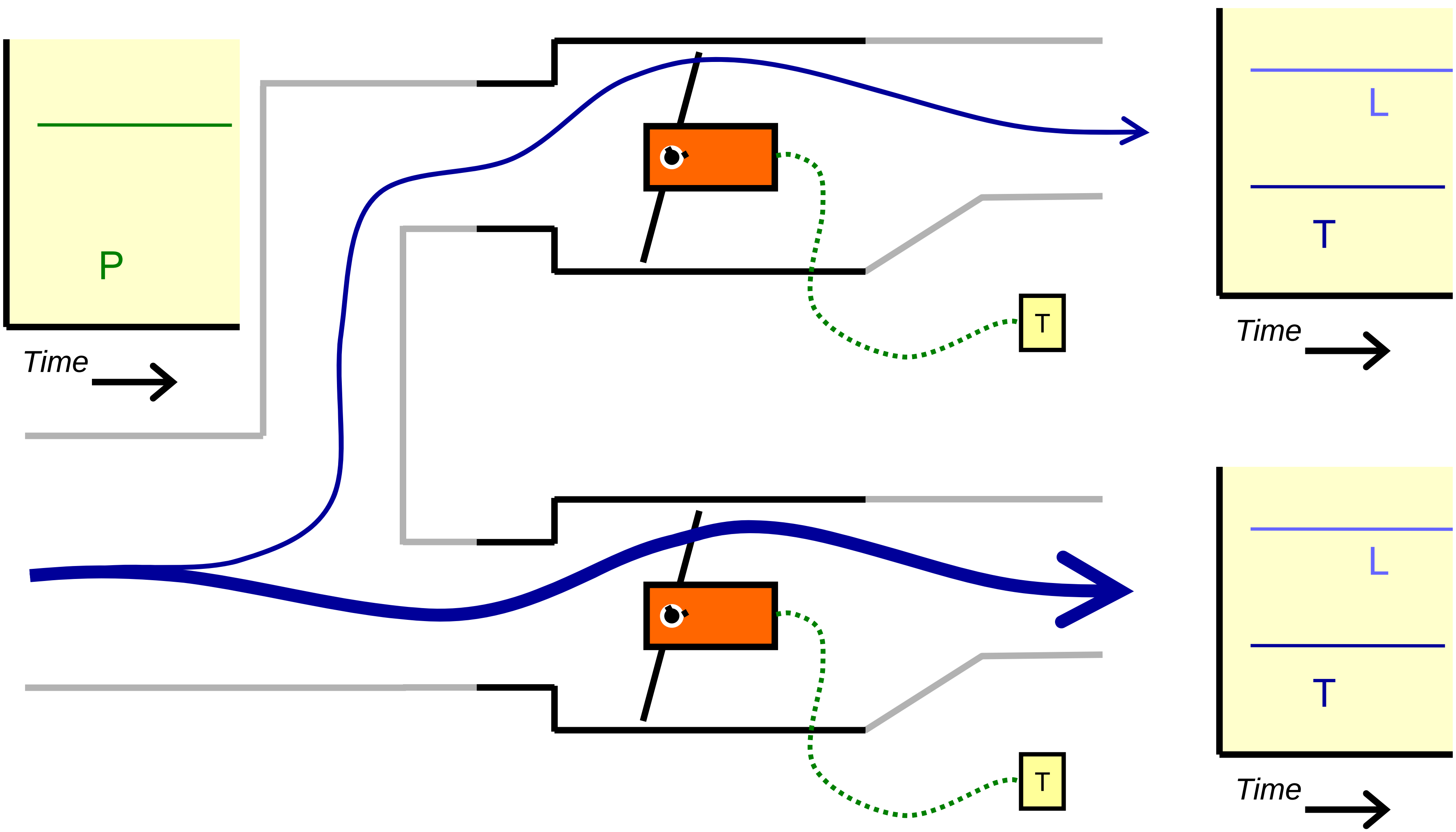
Your Basic Box



Your Basic Box

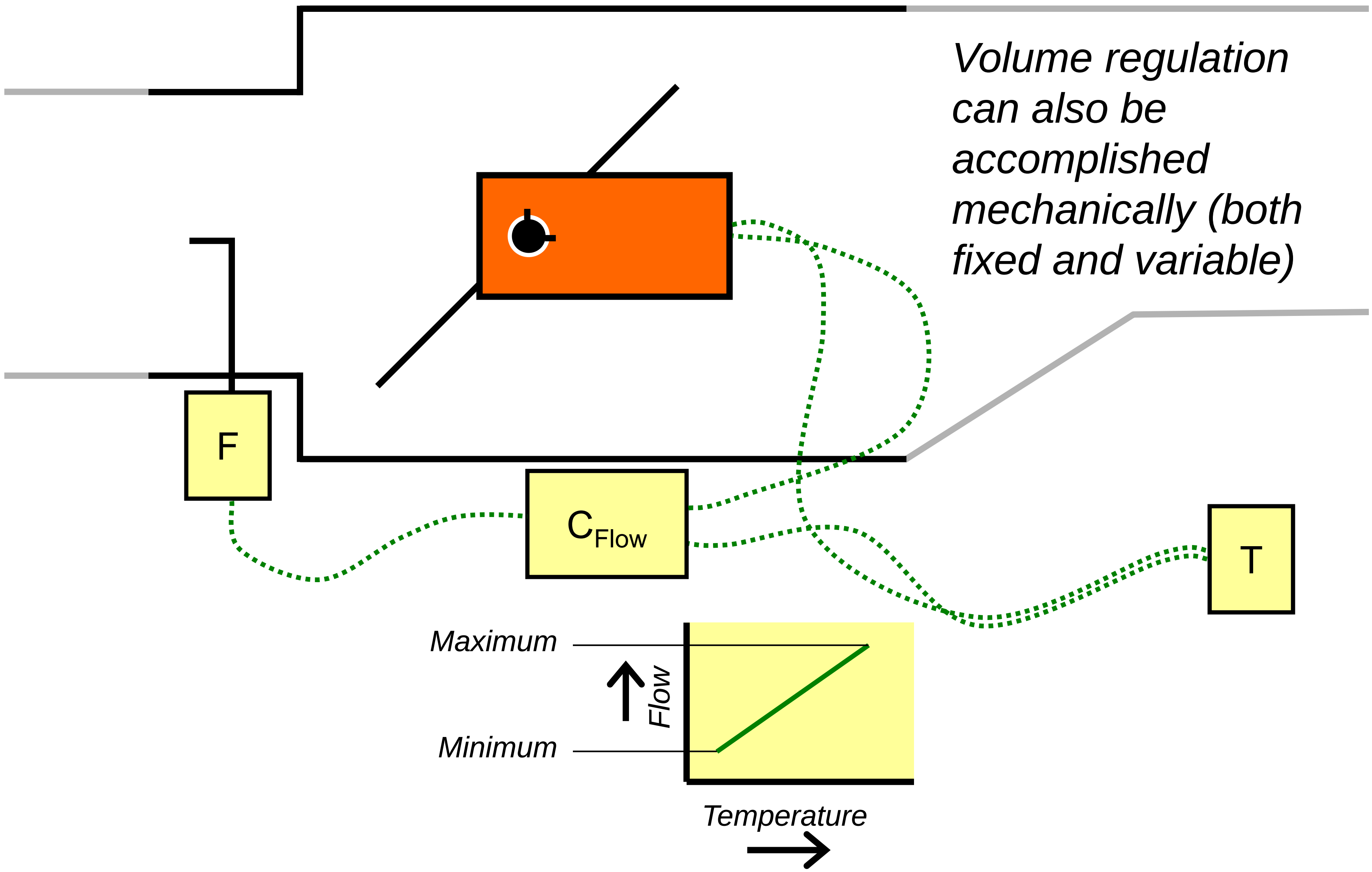


Your Basic Box

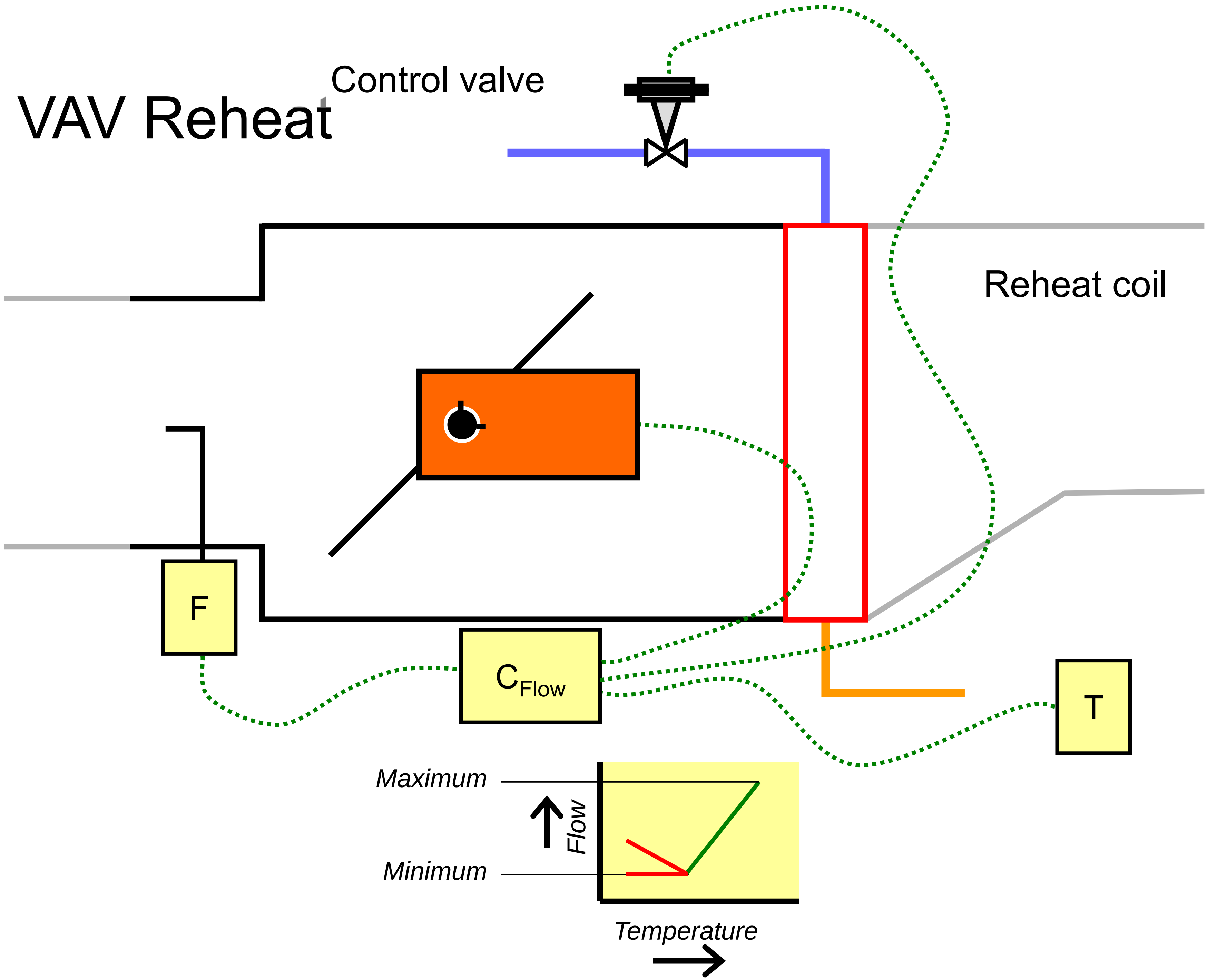


Becoming Pressure Independent

Volume regulation can also be accomplished mechanically (both fixed and variable)

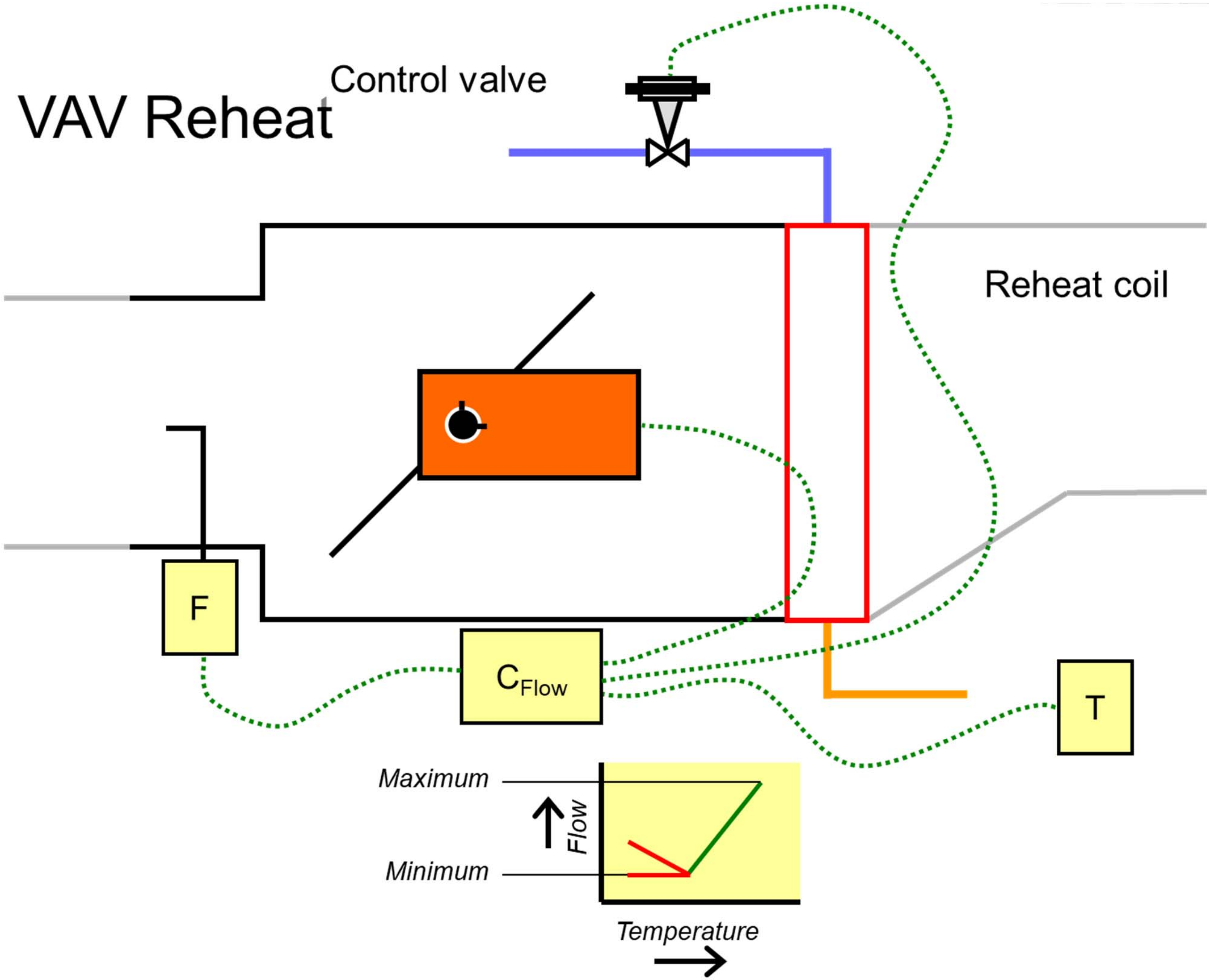


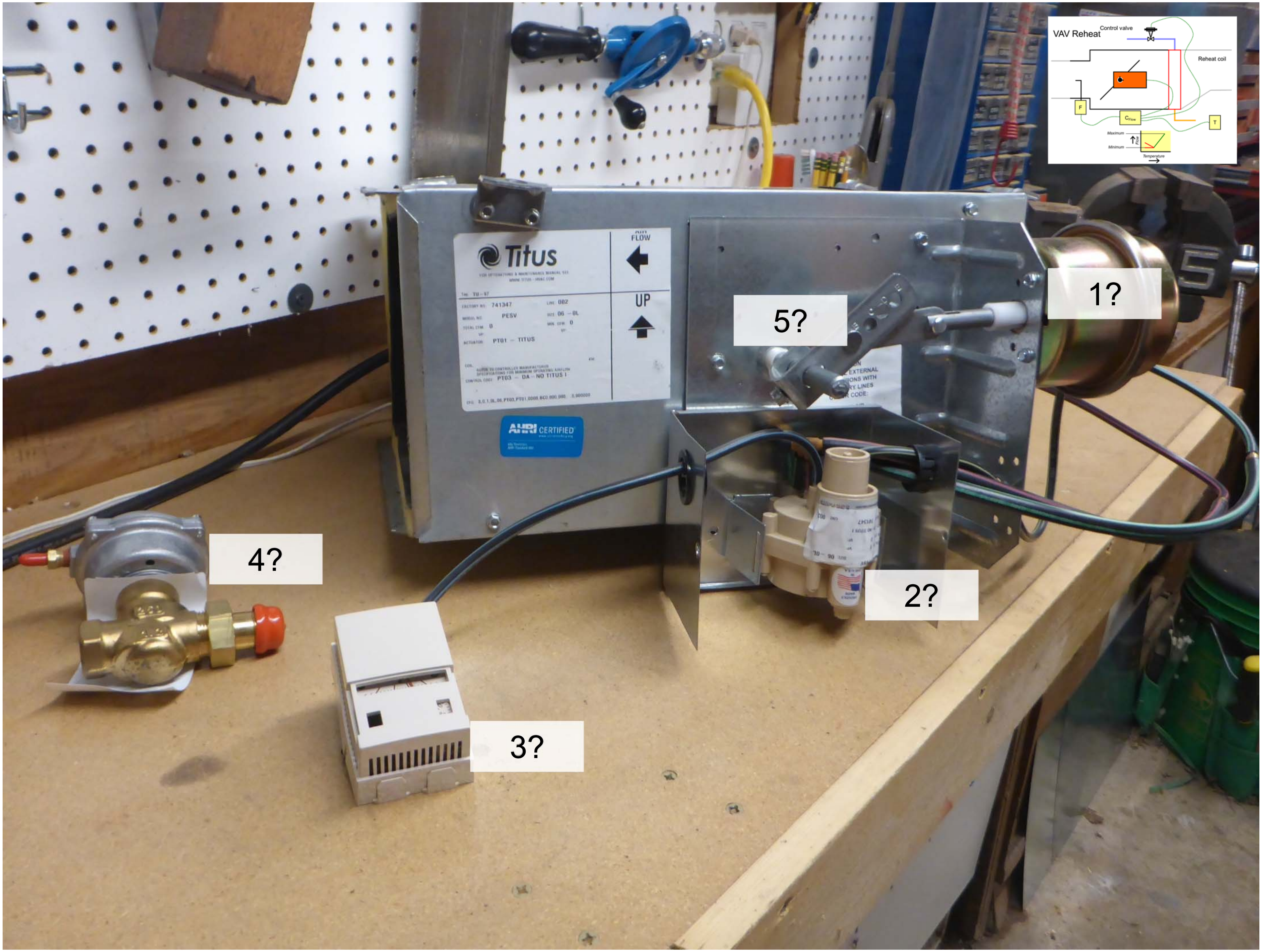
VAV Reheat

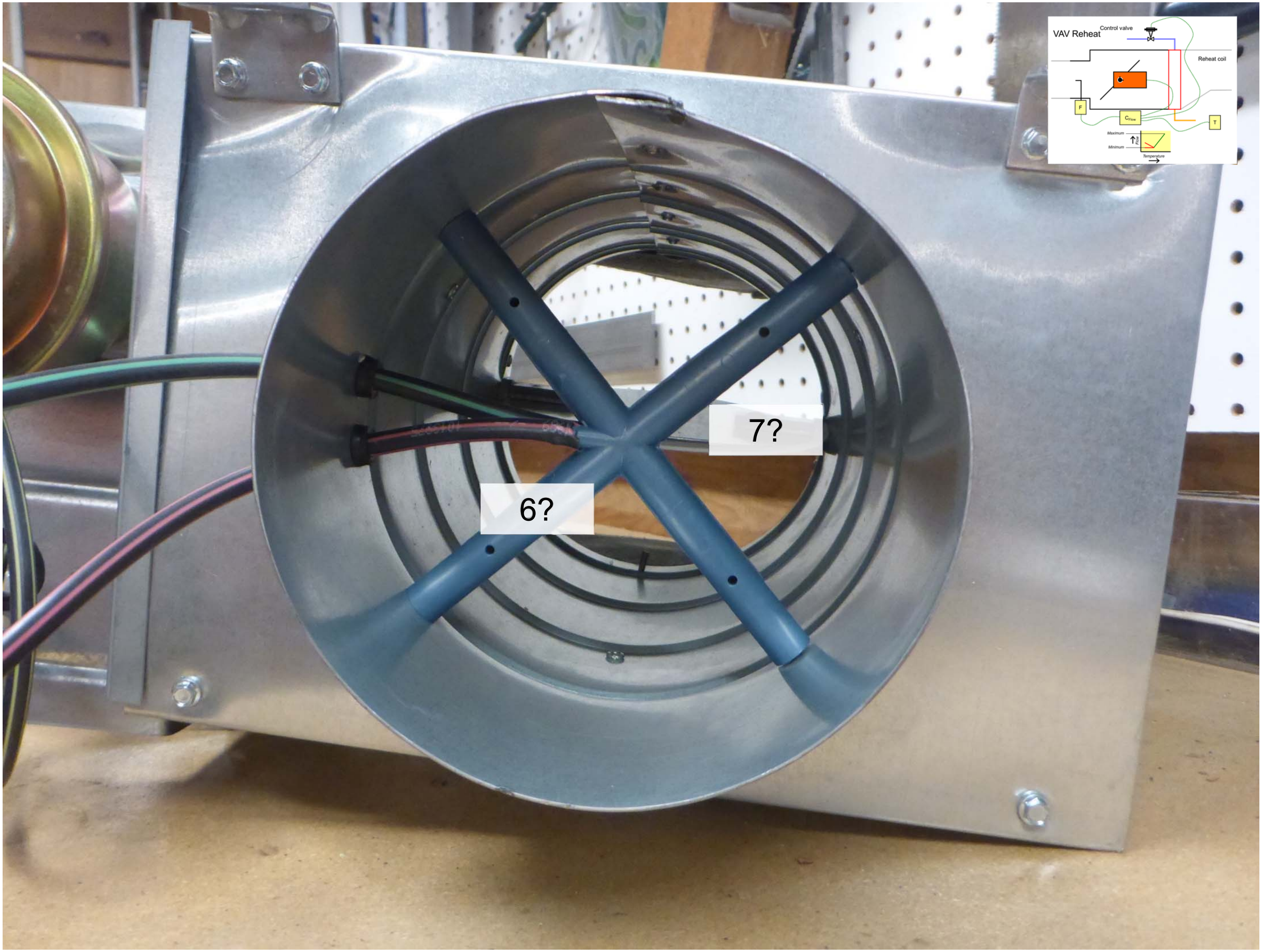


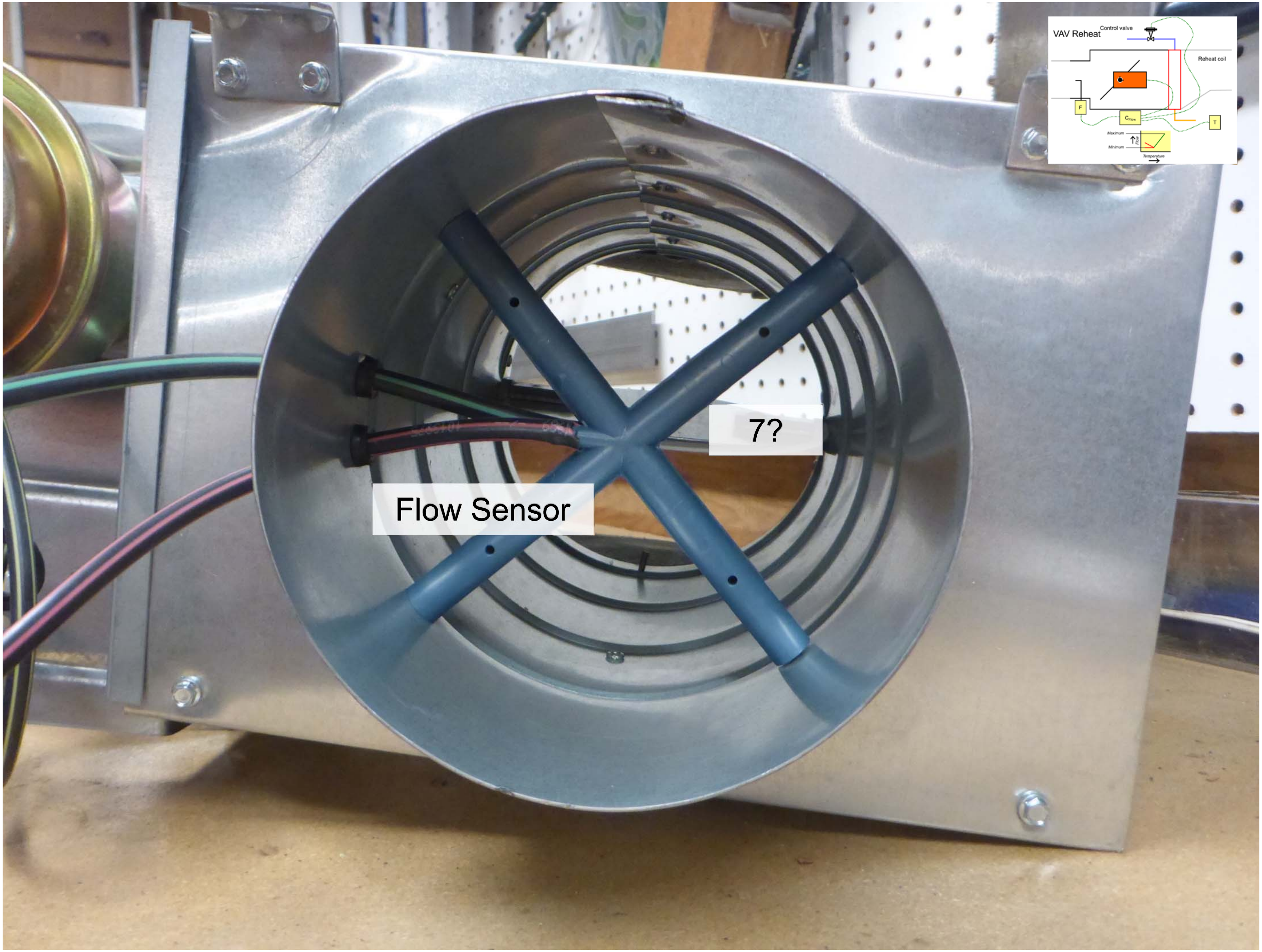
Control valve
Reheat coil
F
C_{Flow}
T
Maximum
Minimum
Flow
Temperature

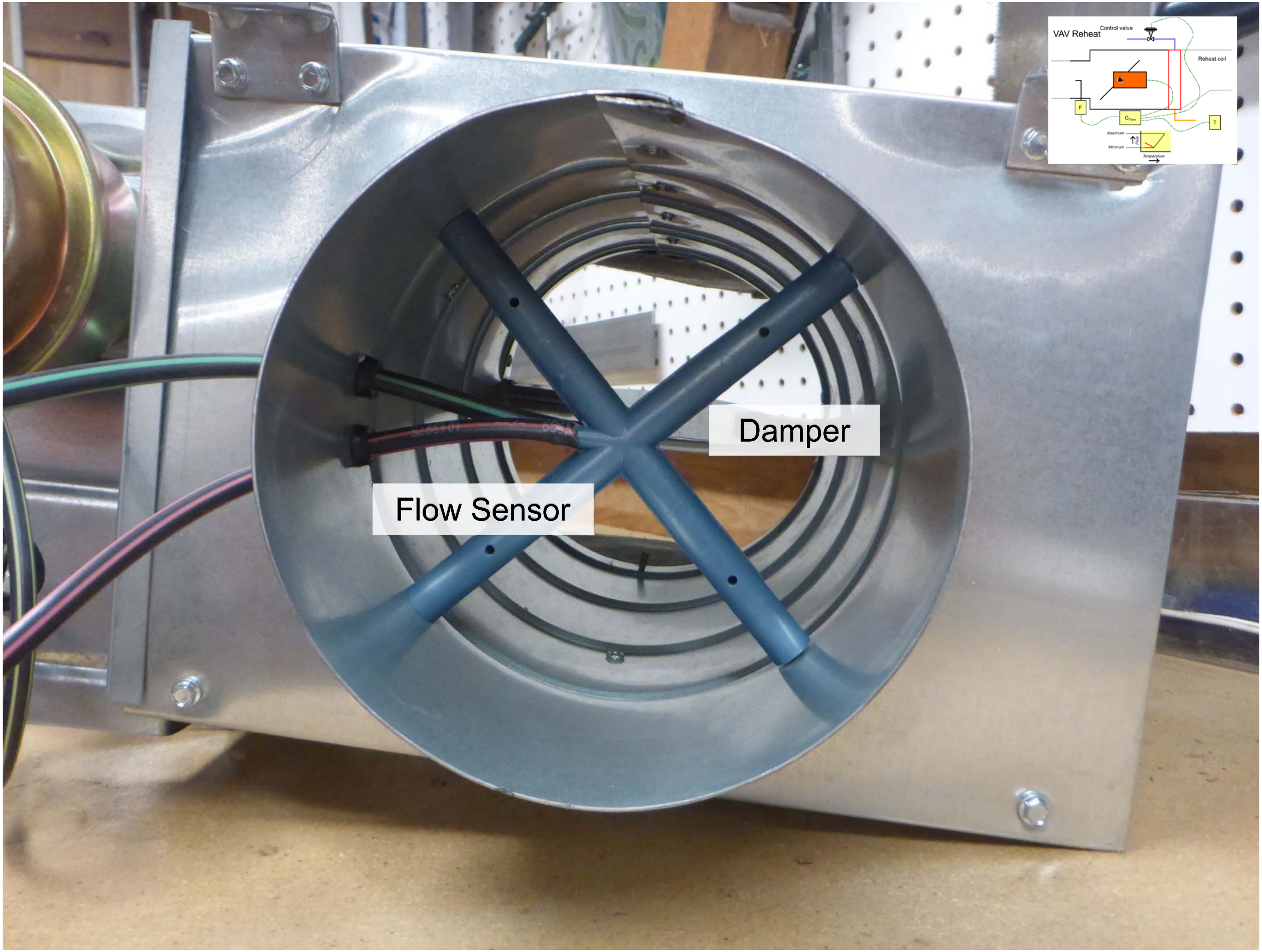
VAV Reheat

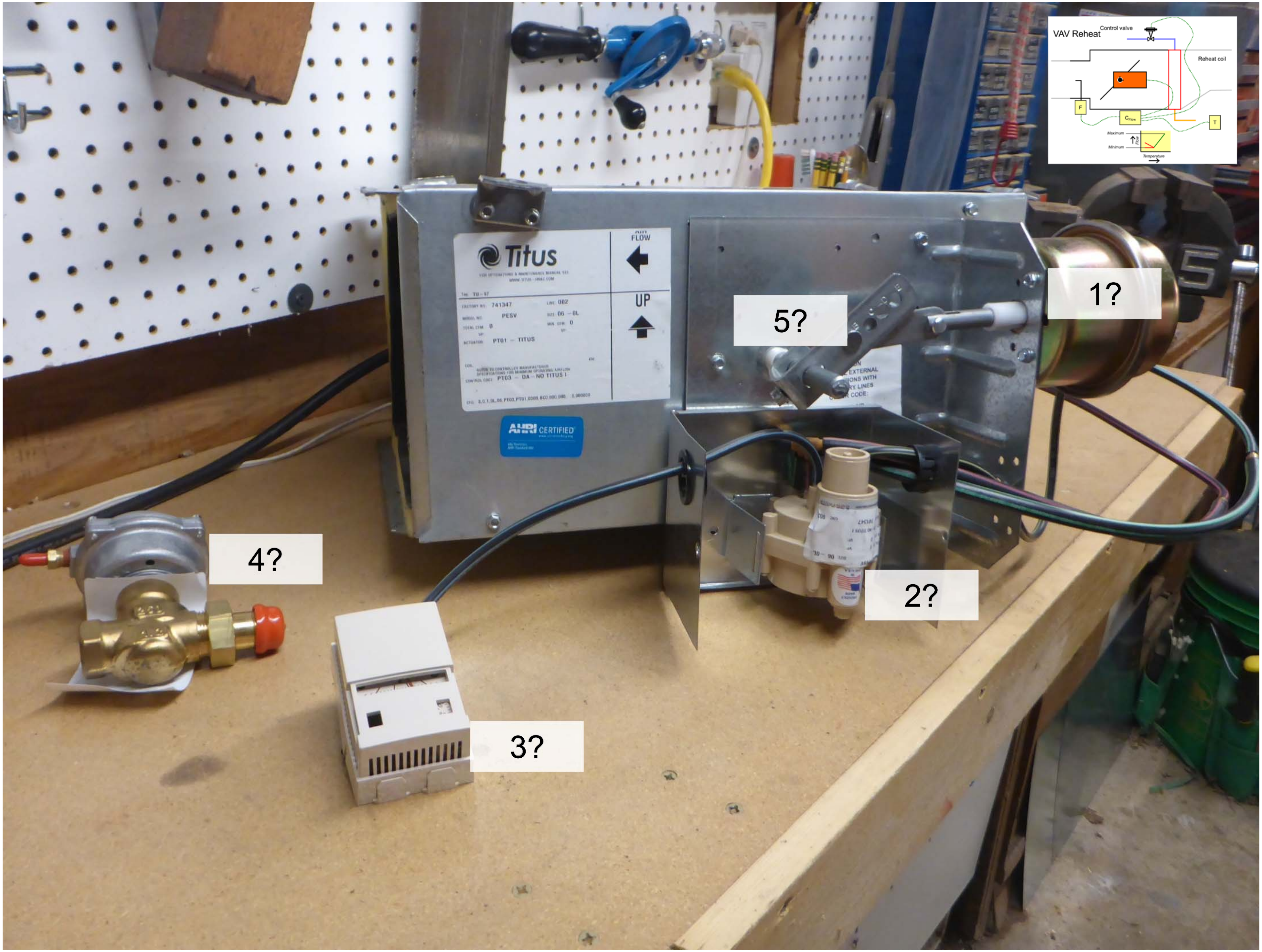

Control valve
Reheat coil
F
C Flow
T
Maximum
Minimum
Flow
Temperature


VAV Reheat
Control valve
Reheat coil
Titus
FLOW
UP
AHRI CERTIFIED
1?
5?
4?
2?
3?

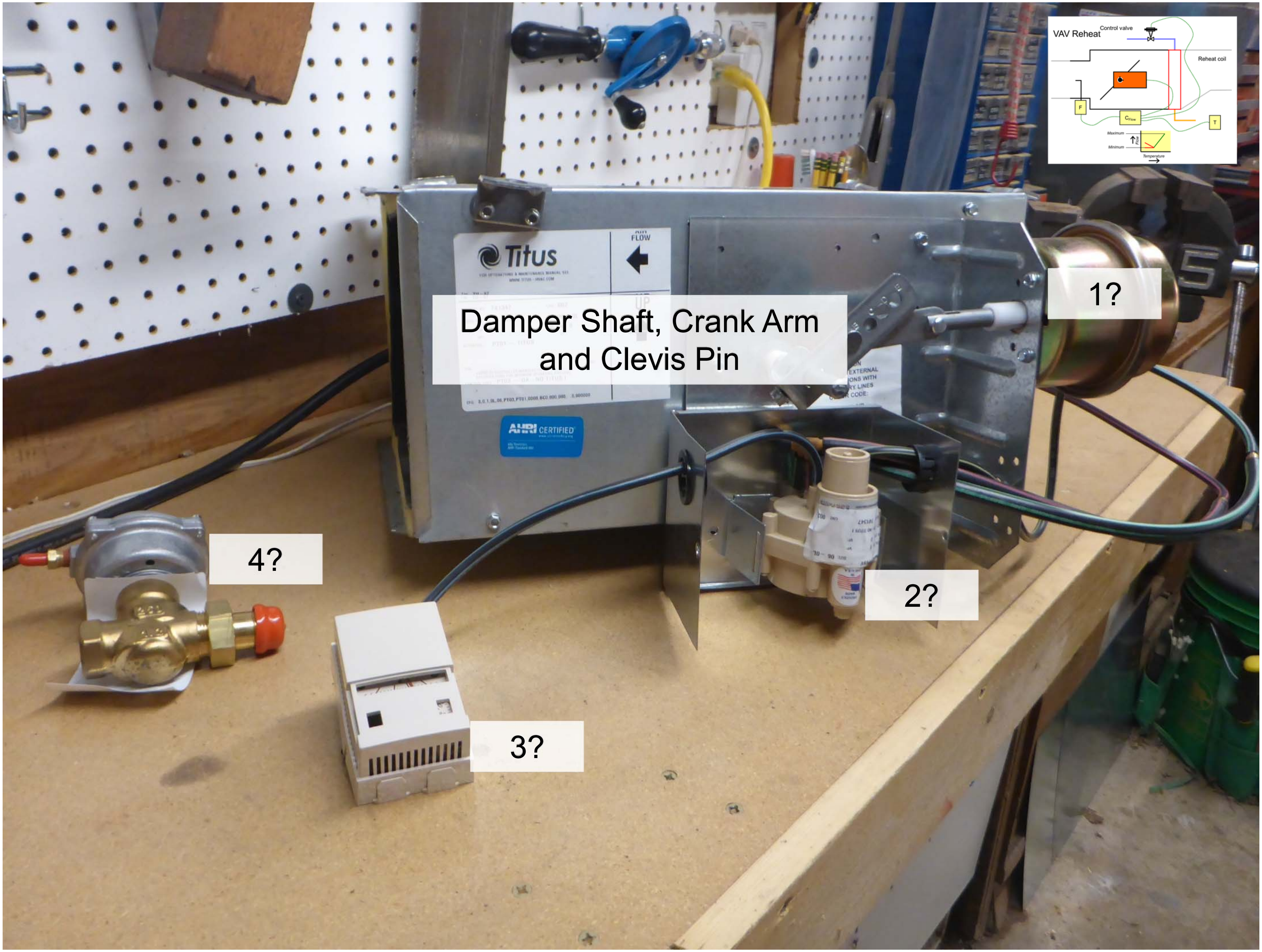

VAV Reheat
Control valve
Reheat coil
F
C Flow
T
Maximum
Minimum
Flow
Temperature
7?
6?

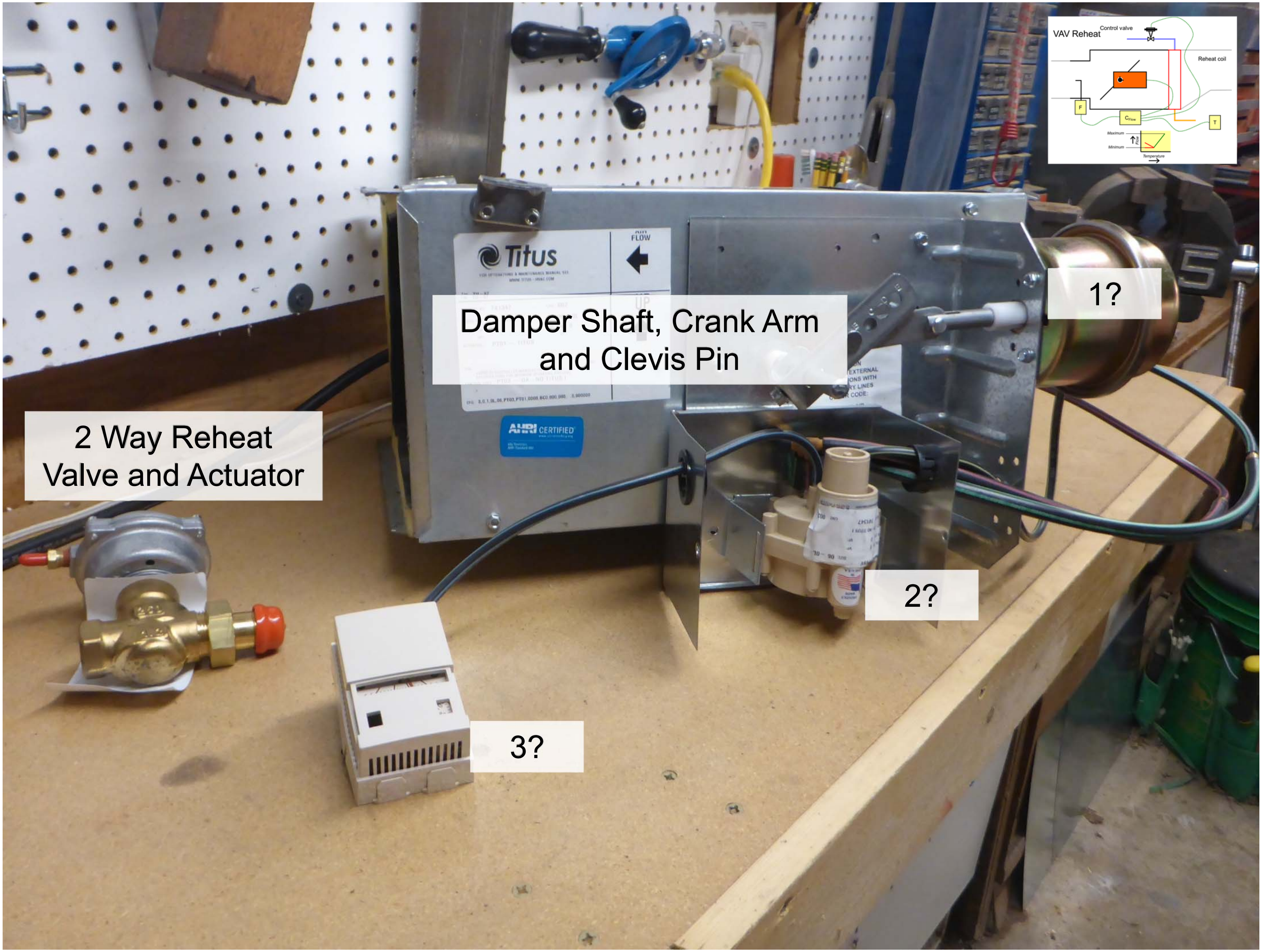

VAV Reheat
Control valve
Reheat coil
F
C_{Flow}
T
Maximum
Minimum
Flow
Temperature
7?
Flow Sensor

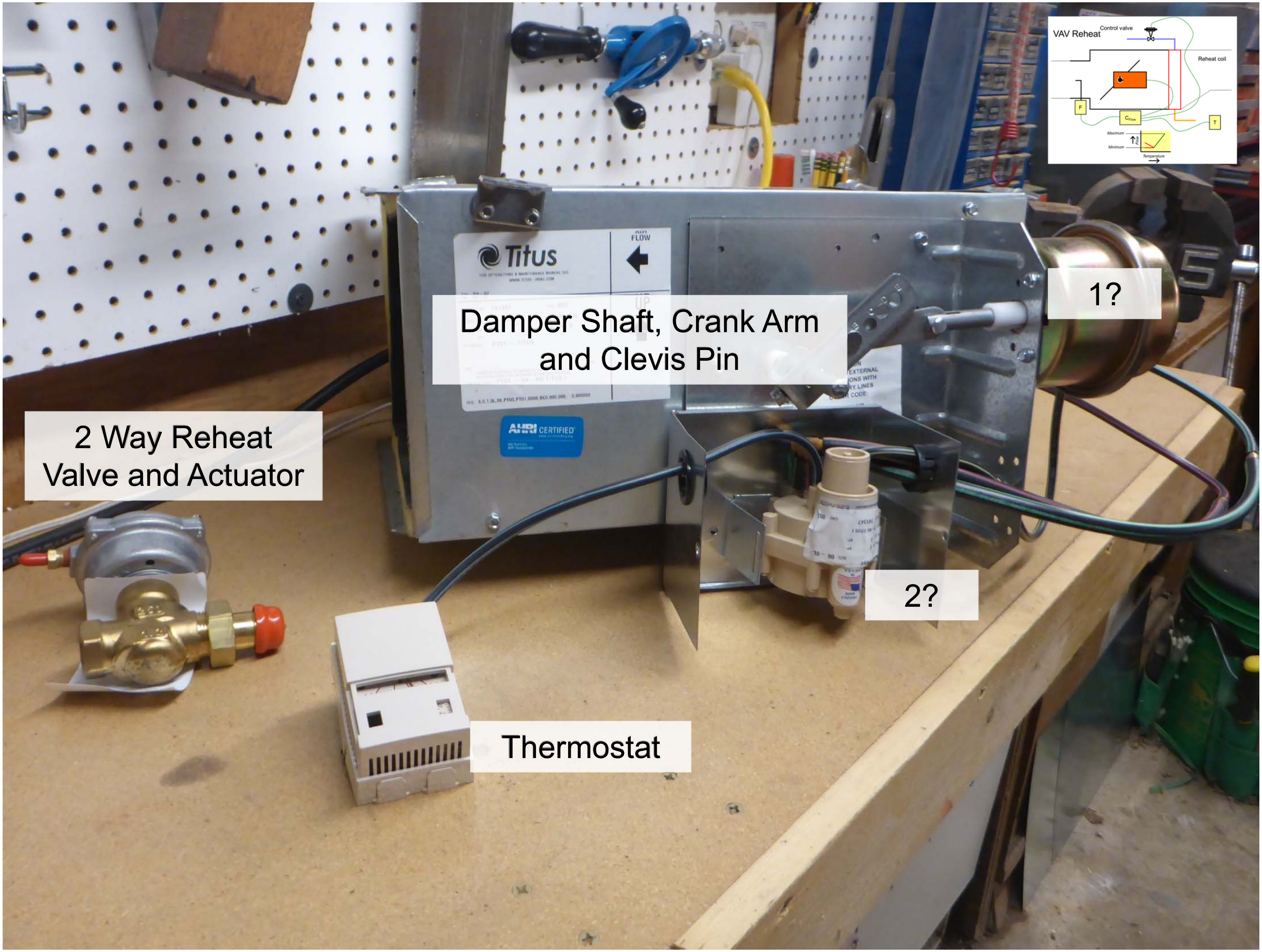

VAV Reheat
Control valve
Reheat coil
Damper
Flow Sensor

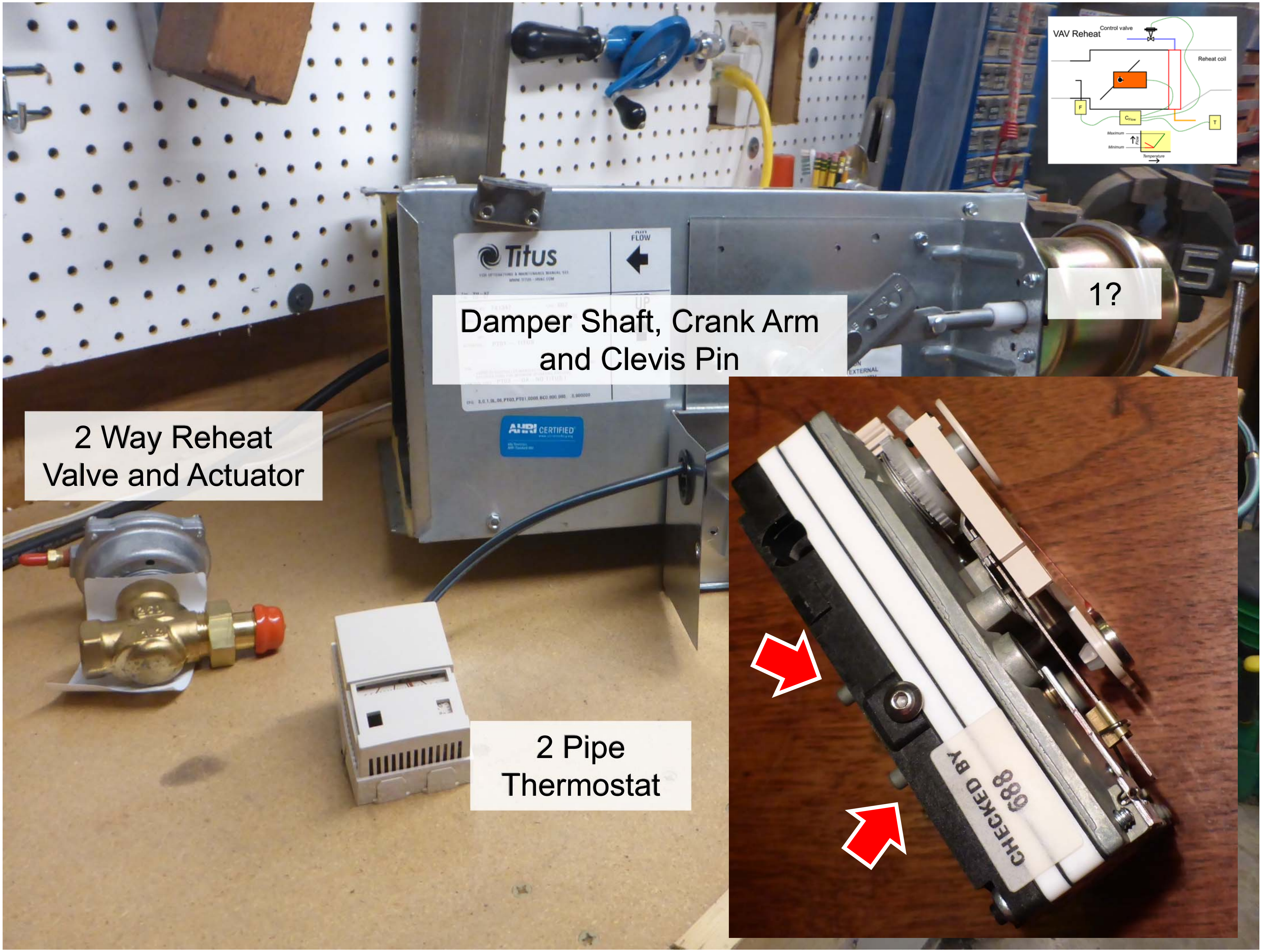


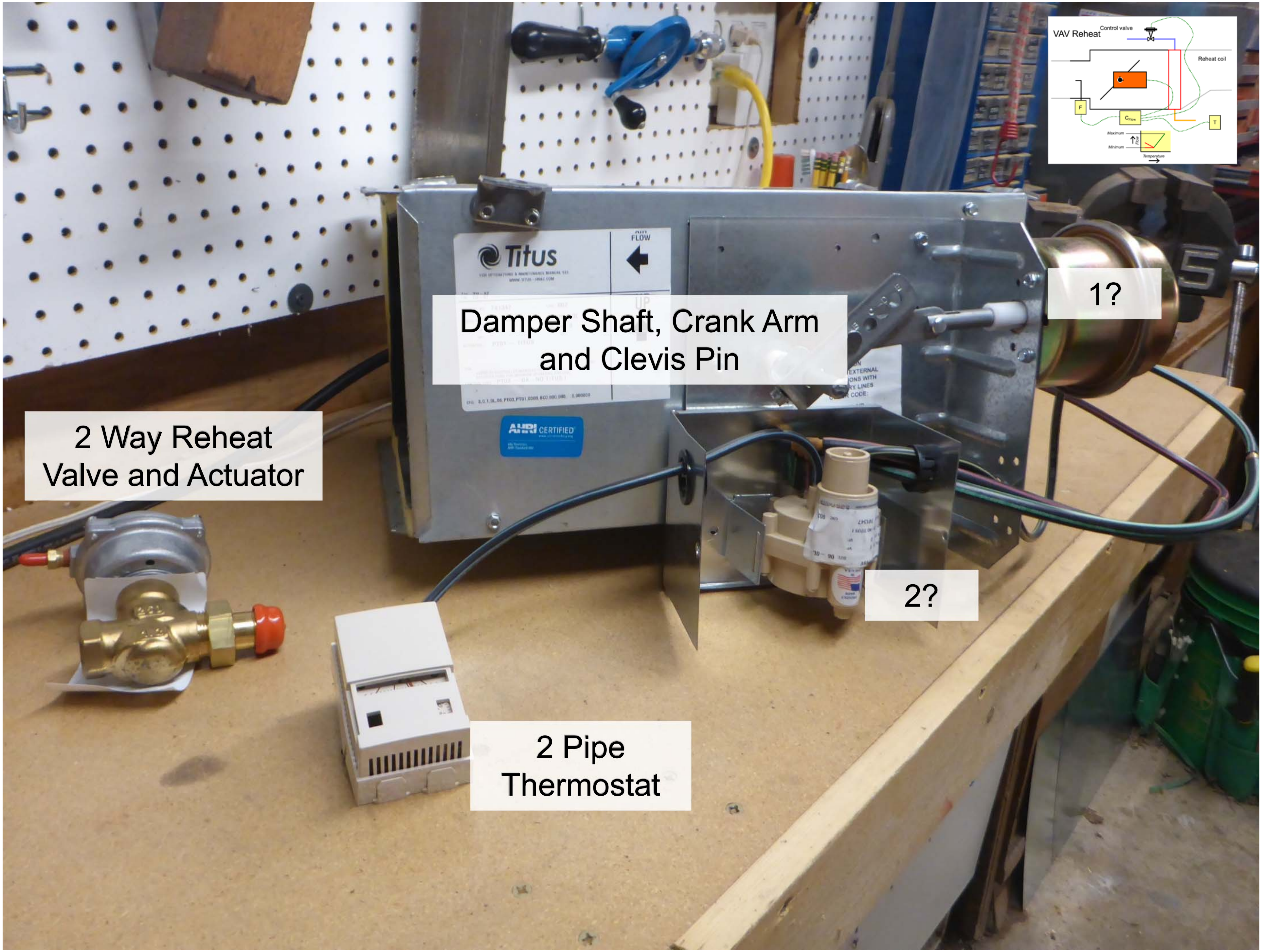
VAV Reheat
Control valve
Reheat coil
Titus
FLOW
UP
AHRI CERTIFIED
1?
2?
3?
4?
5?


Damper Shaft, Crank Arm and Clevis Pin
1?
2?
3?
4?
Titus
FLOW
AHRI CERTIFIED
VAV Reheat
Control valve
Reheat coil

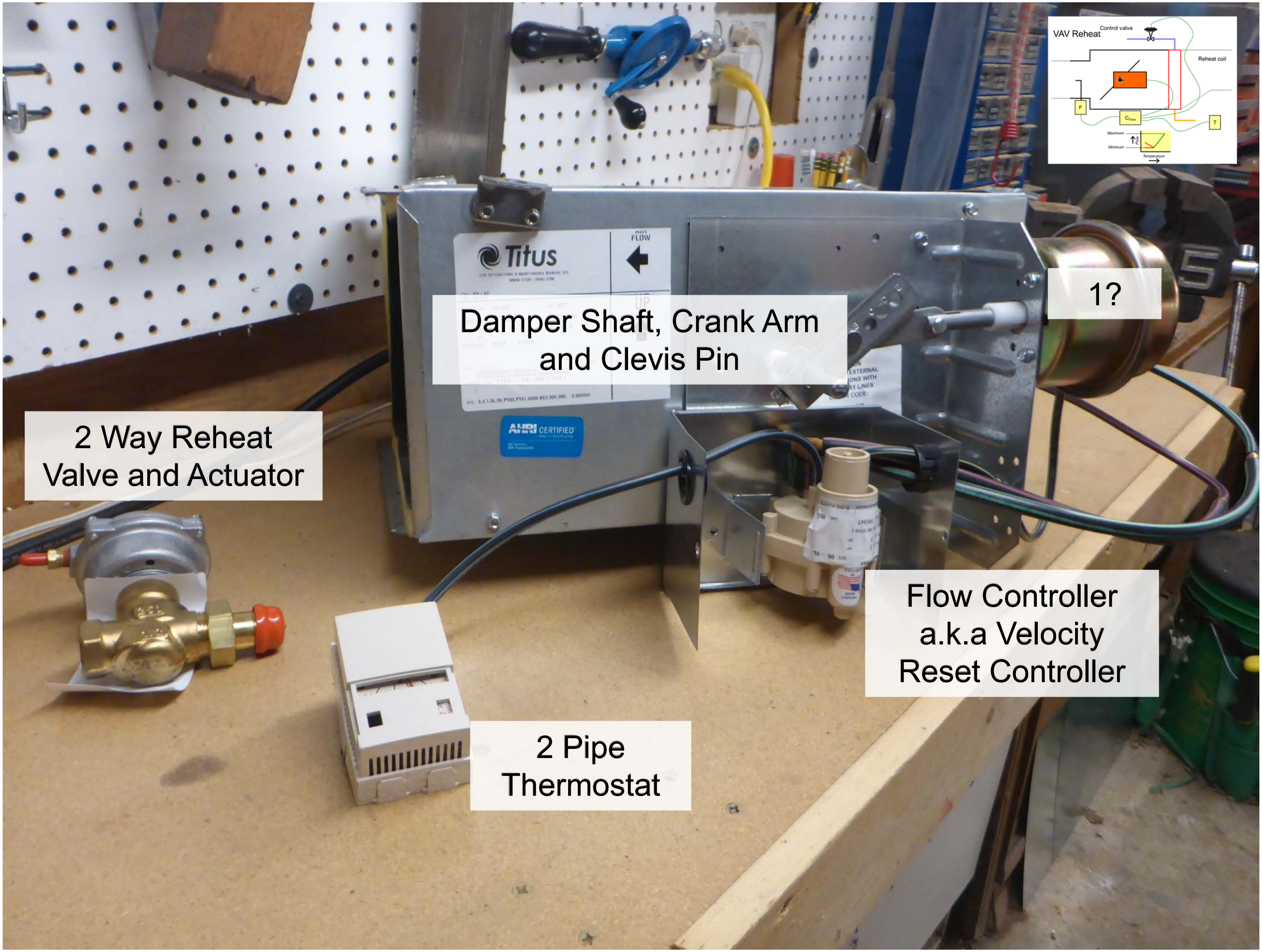

VAV Reheat
Control valve
Reheat coil
Titus
FLOW
Damper Shaft, Crank Arm and Clevis Pin
1?
2 Way Reheat Valve and Actuator
AHRI CERTIFIED
2?
3?


VAV Reheat
Control valve
Reheat coil
Damper Shaft, Crank Arm and Clevis Pin
1?
2 Way Reheat Valve and Actuator
2?
Thermostat
Titus
AIR FLOW

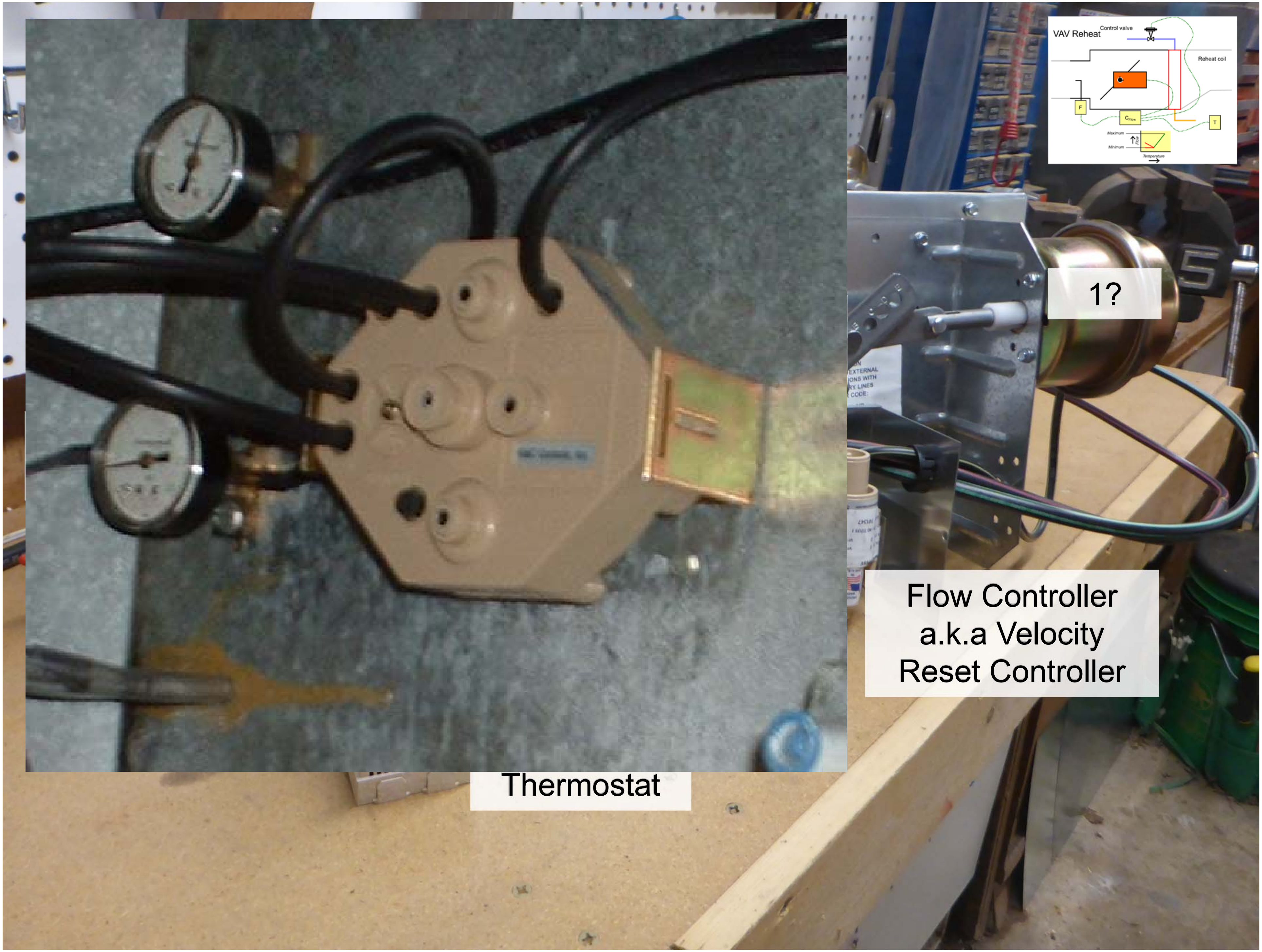

VAV Reheat
Control valve
Reheat coil
1?
Damper Shaft, Crank Arm and Clevis Pin
2 Way Reheat Valve and Actuator
2 Pipe Thermostat
Titus
CHECKED BY 688

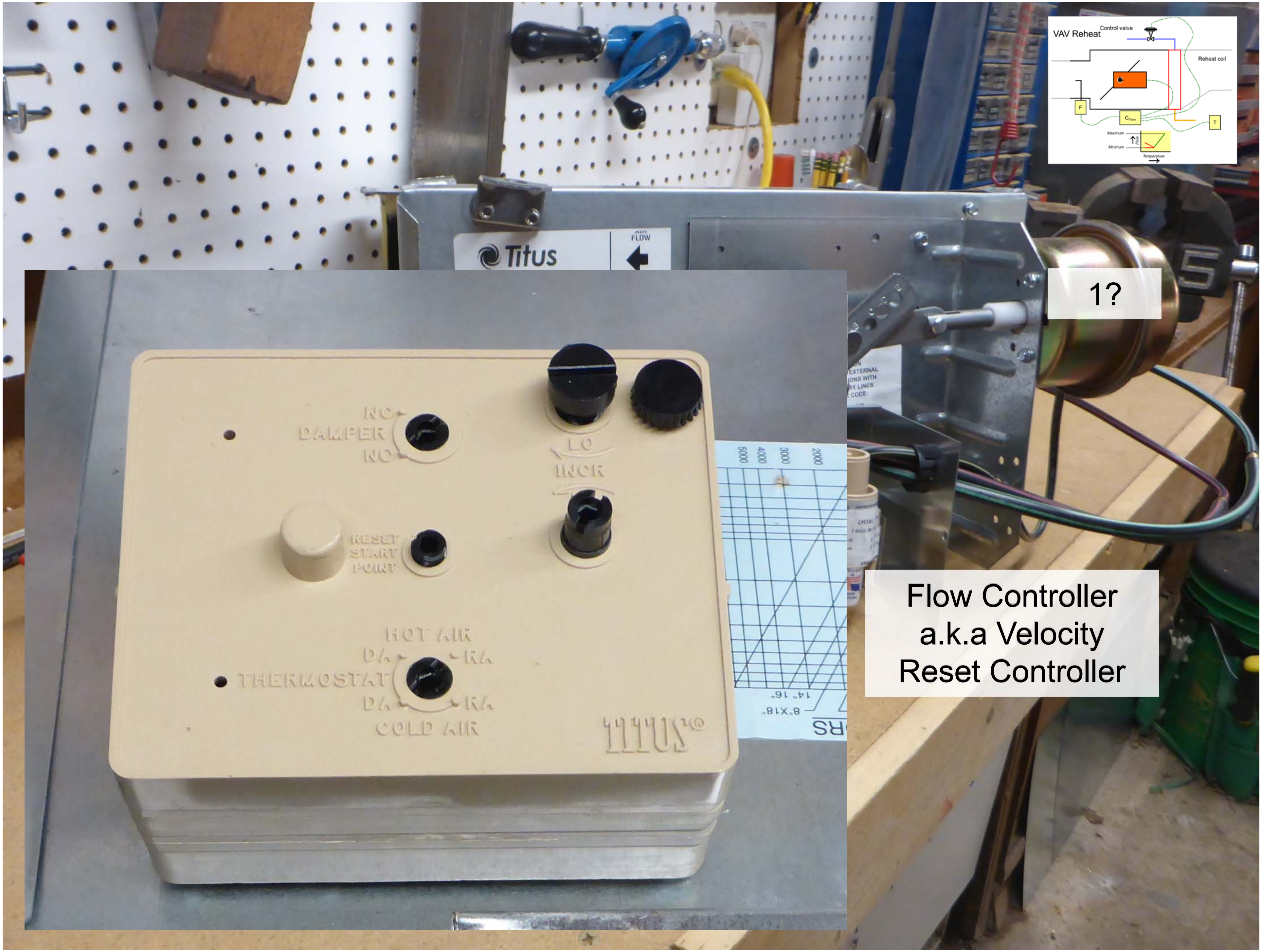


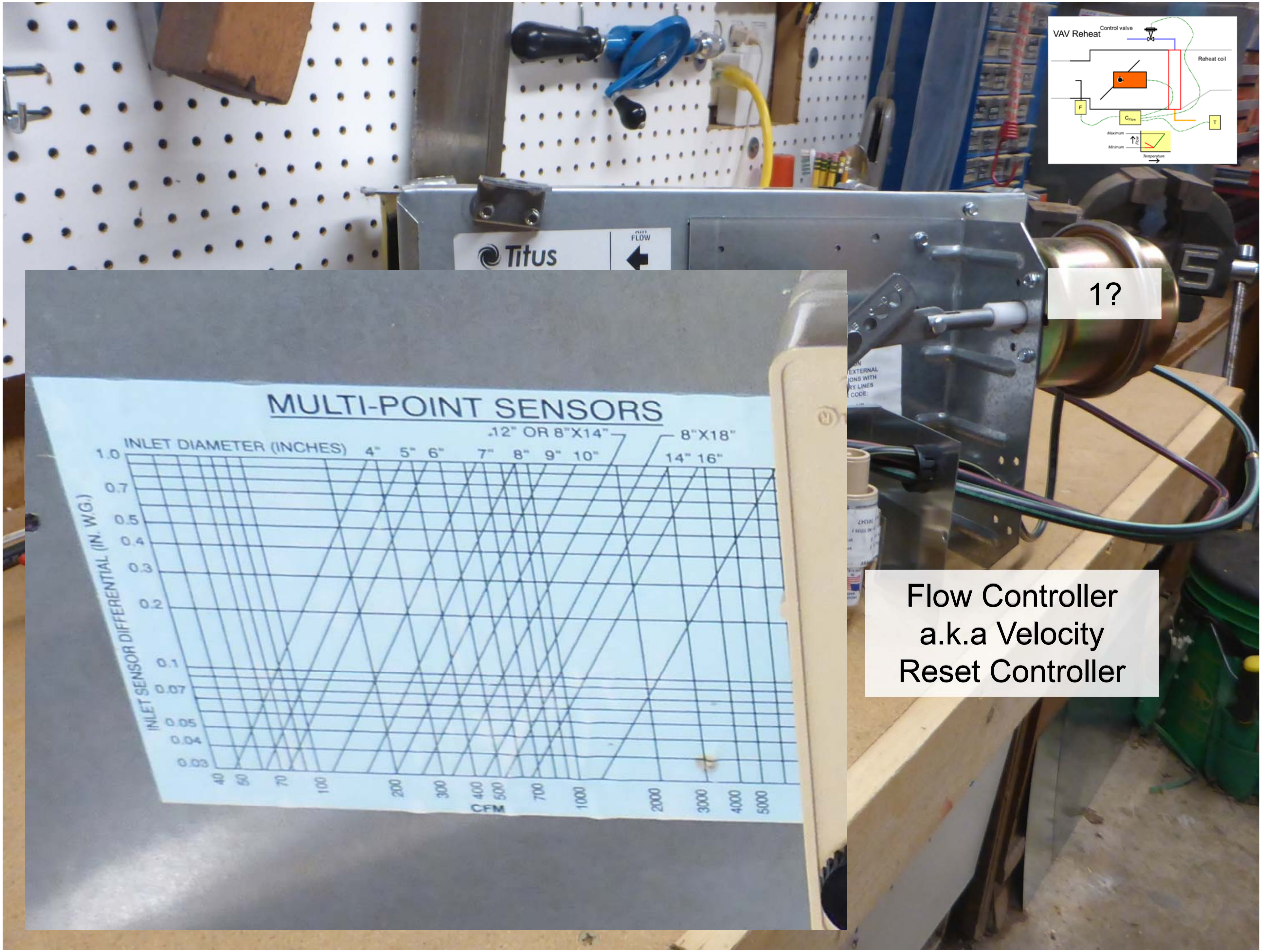
VAV Reheat
Control valve
Reheat coil
Maximum
Minimum
Temperature
Titus
AIR FLOW
AHRI CERTIFIED
Damper Shaft, Crank Arm
and Clevis Pin
1?
2 Way Reheat
Valve and Actuator
2?
2 Pipe
Thermostat

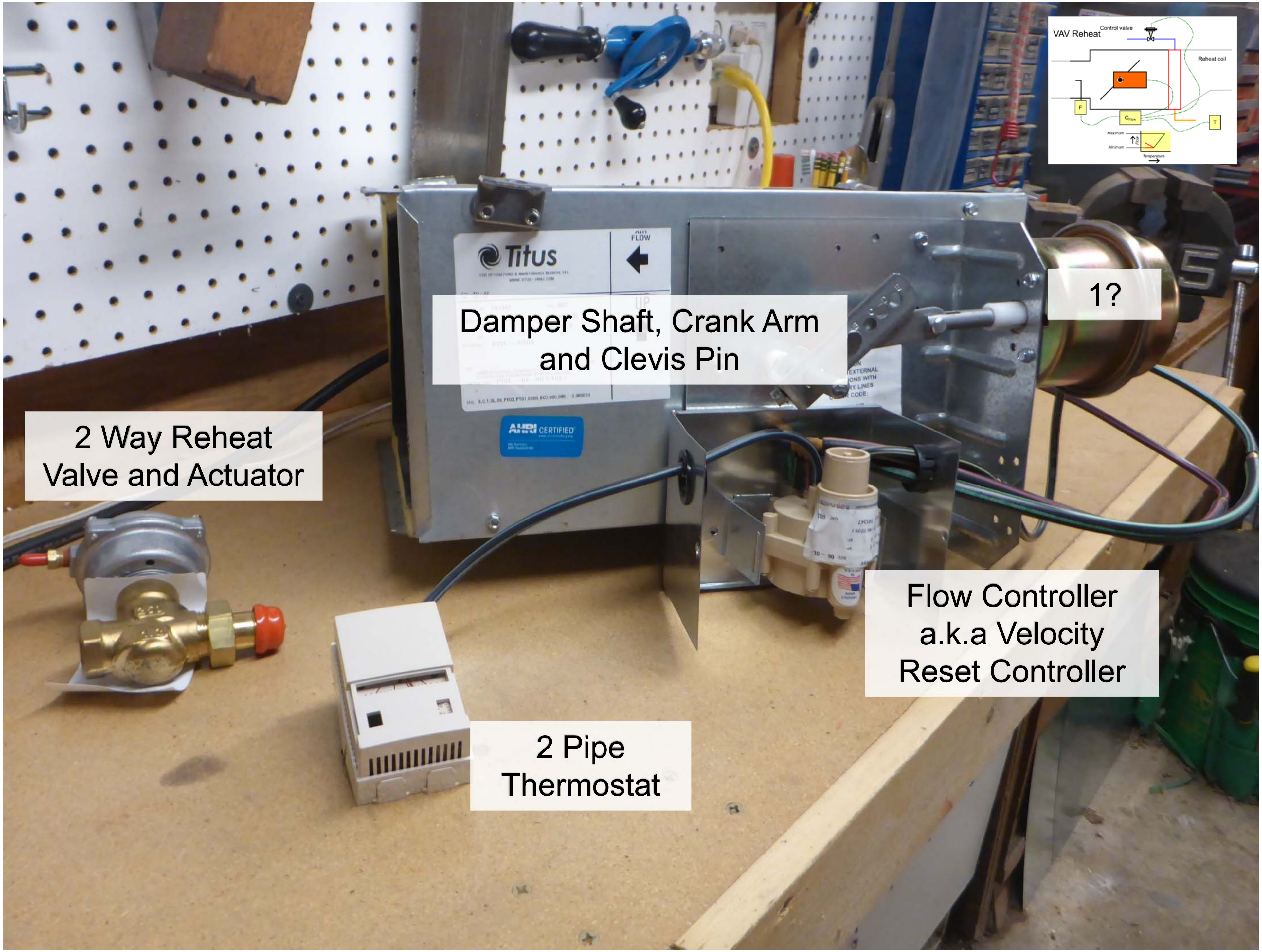


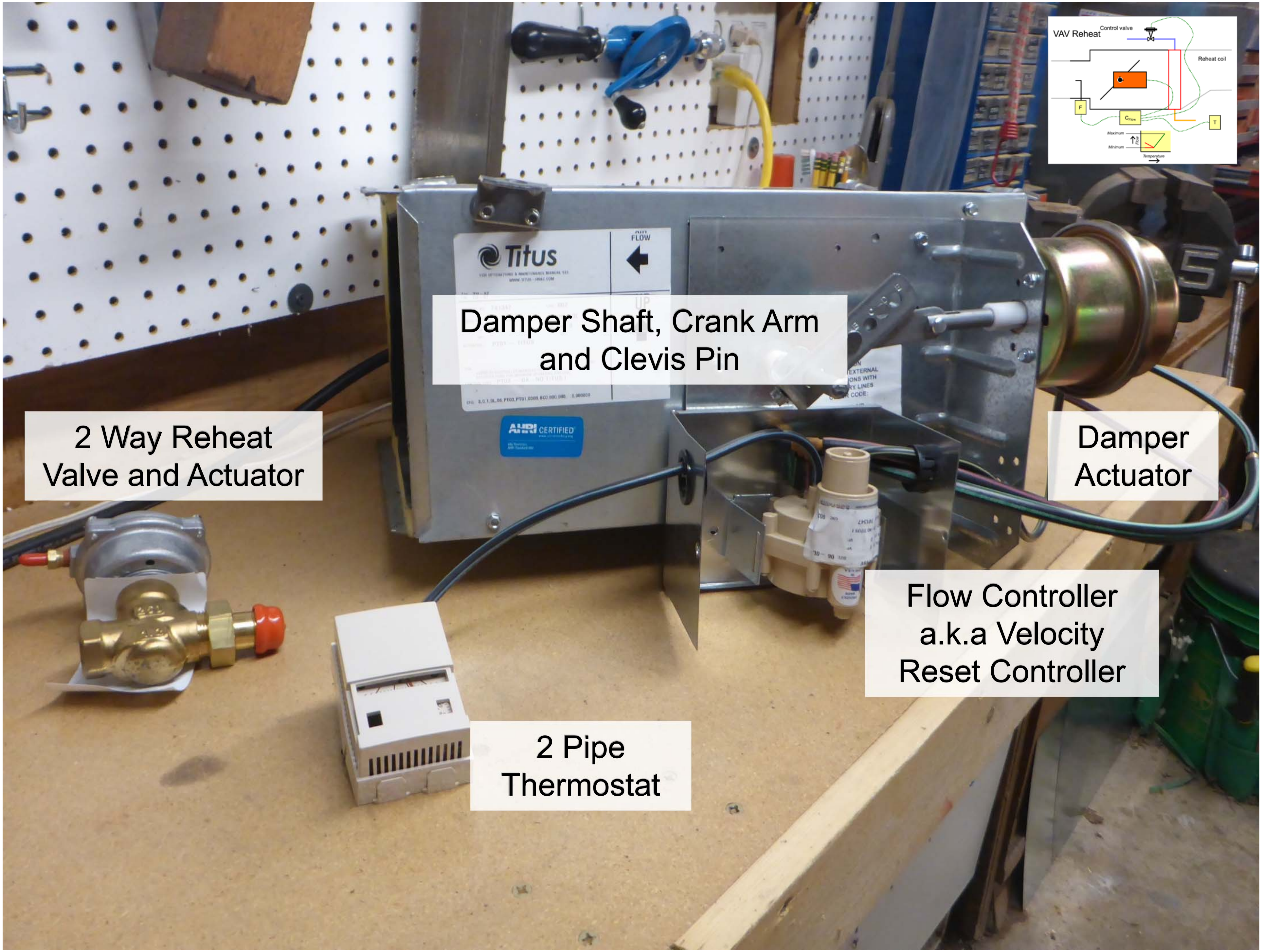
VAV Reheat
Control valve
Reheat coil
Damper Shaft, Crank Arm and Clevis Pin
1?
2 Way Reheat Valve and Actuator
Flow Controller a.k.a Velocity Reset Controller
2 Pipe Thermostat
Titus
AIR FLOW


VAV Reheat
Control valve
Reheat coil
1?
Flow Controller
a.k.a Velocity
Reset Controller
Thermostat


VAV Reheat
Control valve
Reheat coil
F
T
Maximum
Minimum
Temperature
Titus
FLOW
1?
NC
DAMPER
NO
LO
INCR
RESET
START
POINT
HOT AIR
DA
RA
THERMOSTAT
DA
RA
COLD AIR
TITUS®
Flow Controller
a.k.a Velocity
Reset Controller


VAV Reheat
Control valve
Reheat coil
Titus
FLOW
1?
MULTI-POINT SENSORS
INLET DIAMETER (INCHES)
4" 5" 6" 7" 8" 9" 10"
12" OR 8"X14"
8"X18"
14" 16"
INLET SENSOR DIFFERENTIAL (IN. W.G.)
1.0 0.7 0.5 0.4 0.3 0.2 0.1 0.07 0.05 0.04 0.03
40 50 70 100 200 300 400 500 700 1000 2000 3000 4000 5000
CFM
Flow Controller
a.k.a Velocity
Reset Controller


VAV Reheat
Control valve
Reheat coil
Titus
FLOW
1?
Damper Shaft, Crank Arm and Clevis Pin
AHRI CERTIFIED
2 Way Reheat Valve and Actuator
Flow Controller a.k.a Velocity Reset Controller
2 Pipe Thermostat


VAV Reheat
Control valve
Reheat coil
Titus
FLOW
AHRI CERTIFIED
Damper Shaft, Crank Arm
and Clevis Pin
2 Way Reheat
Valve and Actuator
Damper
Actuator
Flow Controller
a.k.a Velocity
Reset Controller
2 Pipe
Thermostat

Bottom Line

A pressure independent VAV box control process is a flow control process that is:

- Reset between a minimum and maximum flow based on the deviation of space temperature from set point
- Sequences reheat and heat as needed once the terminal unit is at its minimum flow condition
- *May* increase the flow again during the heating/reheating cycle
  - More common with DDC systems
  - Not as good a plan as it may seem

Heating vs. Reheat

Definitions

- Heating

  A process that adds energy. For a space, this is often accomplished by circulating air through it at a temperature above the required set point. For an airstream, this is often accomplished by passing it over a surface that is above the required supply temperature.

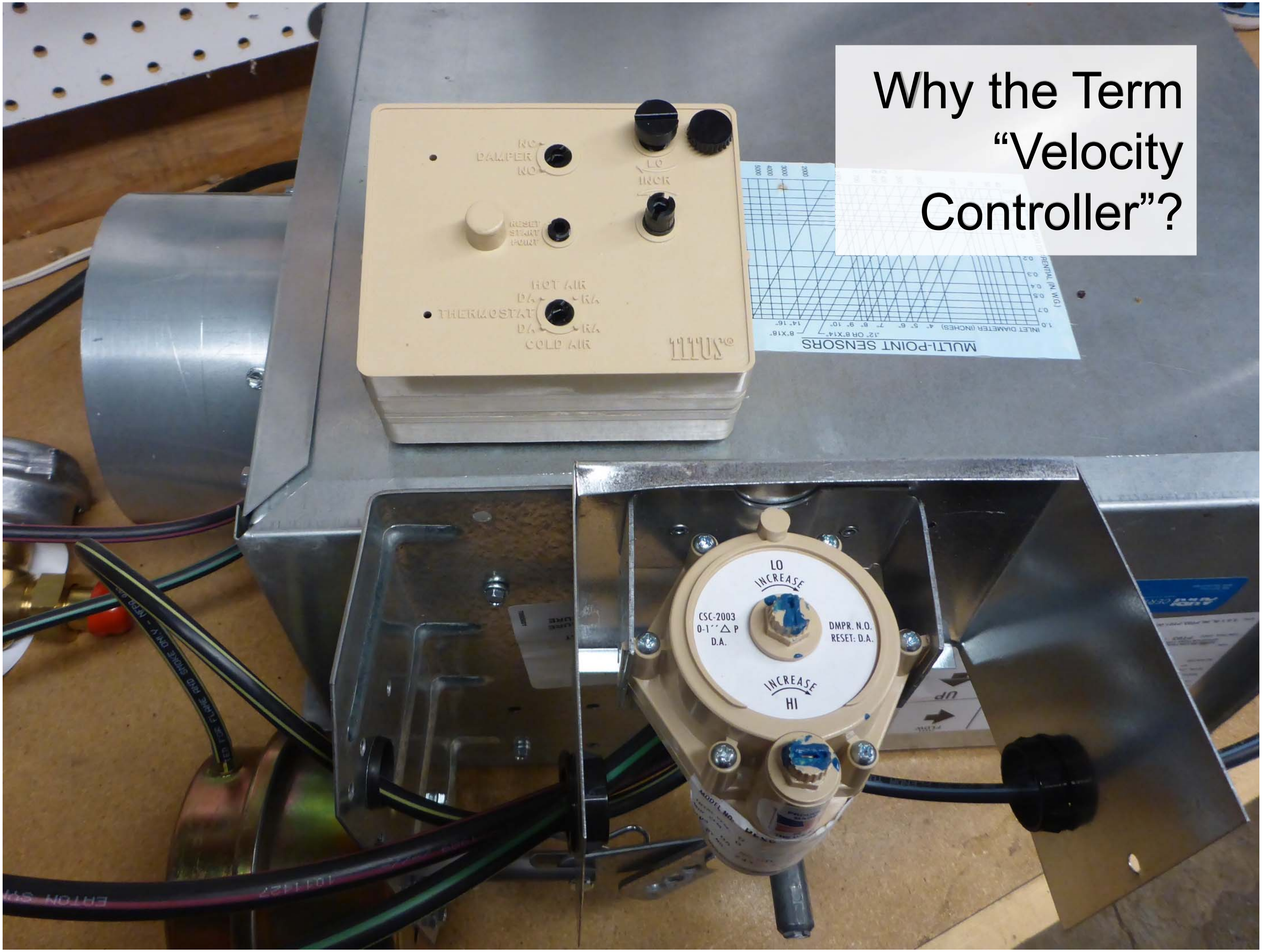
Heating vs. Reheat

Definitions

- Reheat

    A process that uses heat to warm air being delivered to a zone to prevent over cooling. The temperature of the air was set by the need to hit a dehumidification target or by the requirements of another zone, so it can not be raised at the central system. The volume can not be reduced because it has been set to assure proper ventilation (contaminant control). In the limit, reheat will raise the supply temperature to the zone temperature but not above it.

Why the Term "Velocity Controller"?



The Relationship Between Flow and Velocity

$$Q = VA$$

Where:

Q = Flow rate in cubic feet per minute

V = Velocity in feet per minute

A = Cross sectional area in square feet

The Relationship Between Velocity and Velocity Pressure

$$V = 4{,}005\sqrt{VP}$$

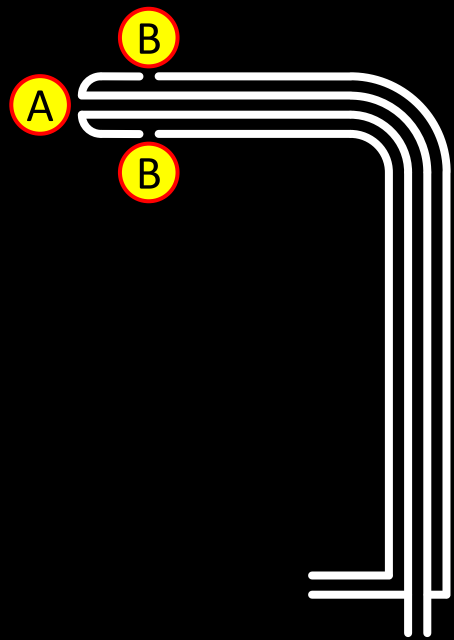
Where :

V = Velocity in feet per minute

$4{,}005$ = A units conversion constant

VP = Velocity pressure in inches w.c.

Flow Sensors are Typically a Form of Pitot Tube



Pitot tubes are designed to measure velocity pressure

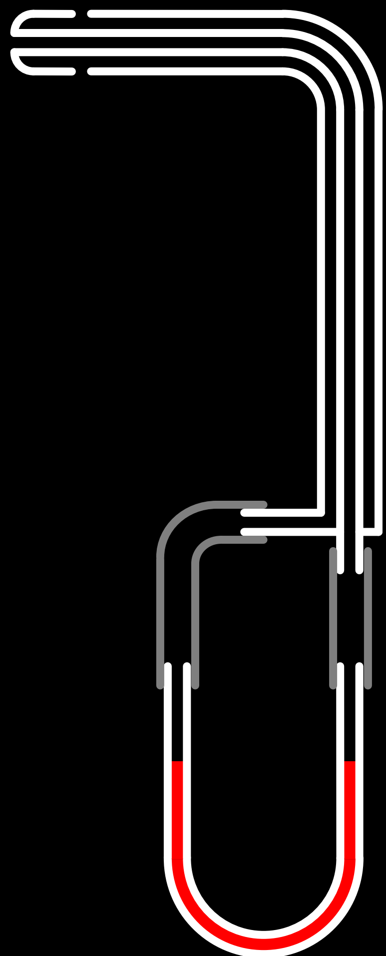
A tube inside a tube

- Inner tube open at the tip A
- Outer tube open through ports on the side B

In a moving air stream:

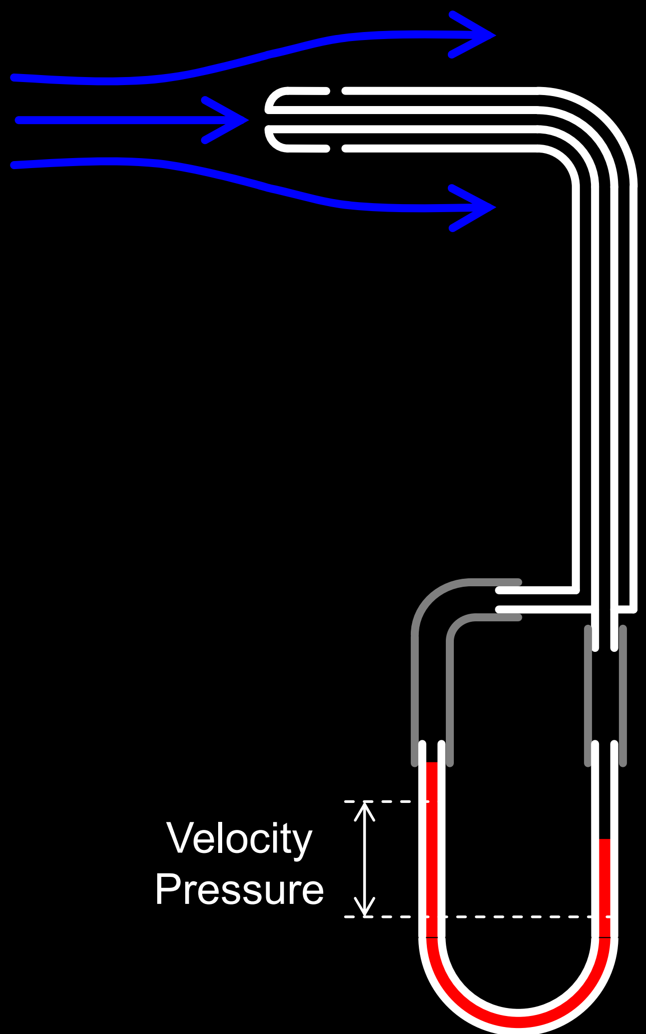
- The ports on the side (B) are exposed to only the ambient static pressure
- The port on the tip (A) is exposed to both the static pressure and the pressure created by the air being stopped; a.k.a. total pressure.
- The air is stopped because the tube dead ends on the measurement device
- The pressure associated with the moving air is called velocity pressure

Flow Sensors are Typically a Form of Pitot Tube



Connecting a U shaped glass tube filled with a liquid like oil or water – called a manometer – to the pitot tube allows velocity pressure to be measured

Flow Sensors are Typically a Form of Pitot Tube



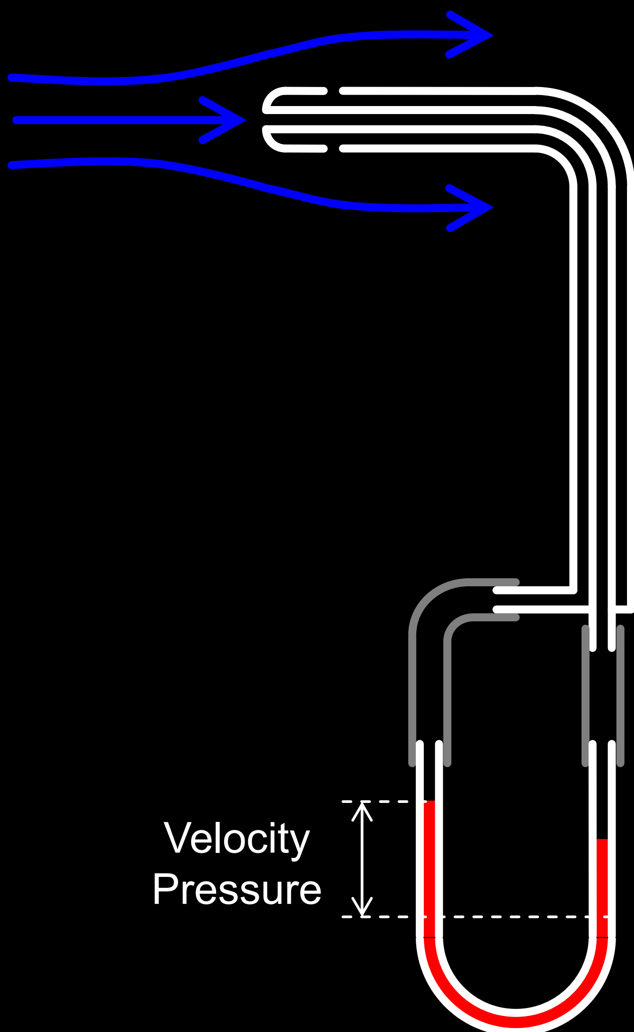
With no air flow, the pressure at both ports is the same and the level in each “leg” of the U tube is the same.

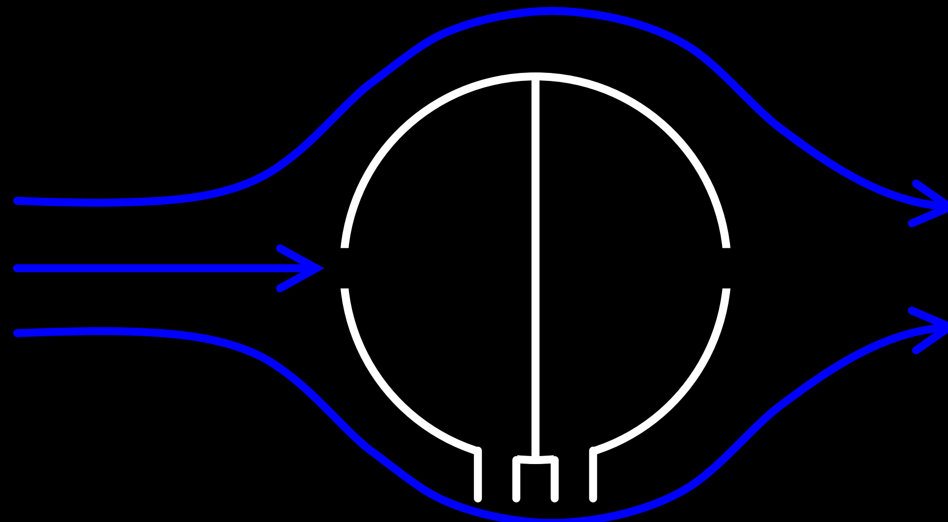
In a moving air stream, the total pressure port pushes the manometer liquid down in the tube it is connected to

But the static pressure pushes back, canceling out the static pressure portion of the total pressure signal

The resulting level difference is a measure of the velocity pressure

Flow Sensors are Typically a Form of Pitot Tube

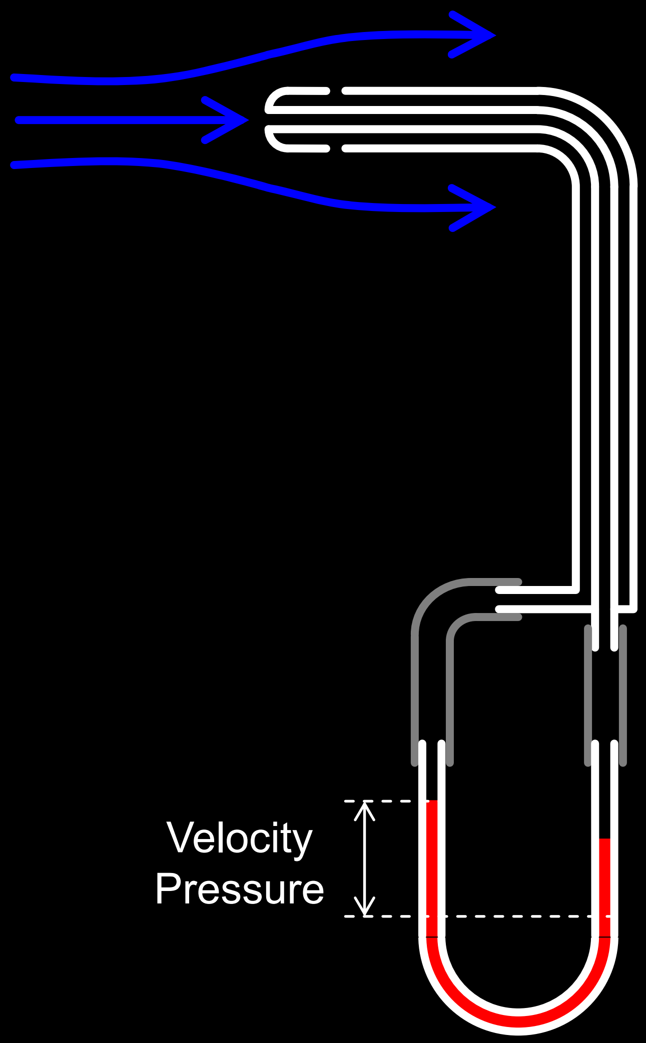


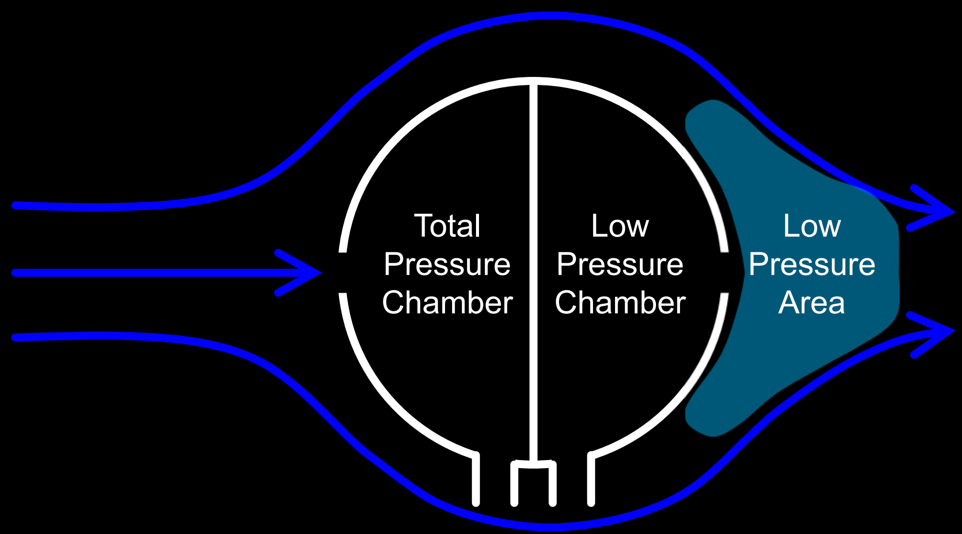


Terminal unit flow sensors are typically tubes that are divided down the center, creating two chambers

- One chamber has a port facing into the air flow
- The other has a port facing away from the air flow

Flow Sensors are Typically a Form of Pitot Tube

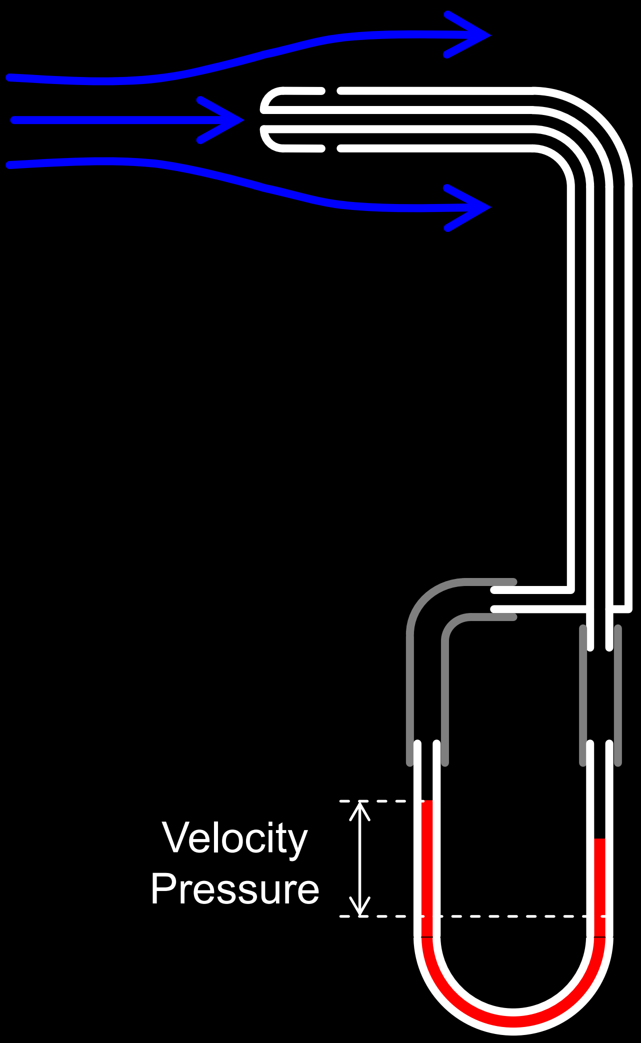


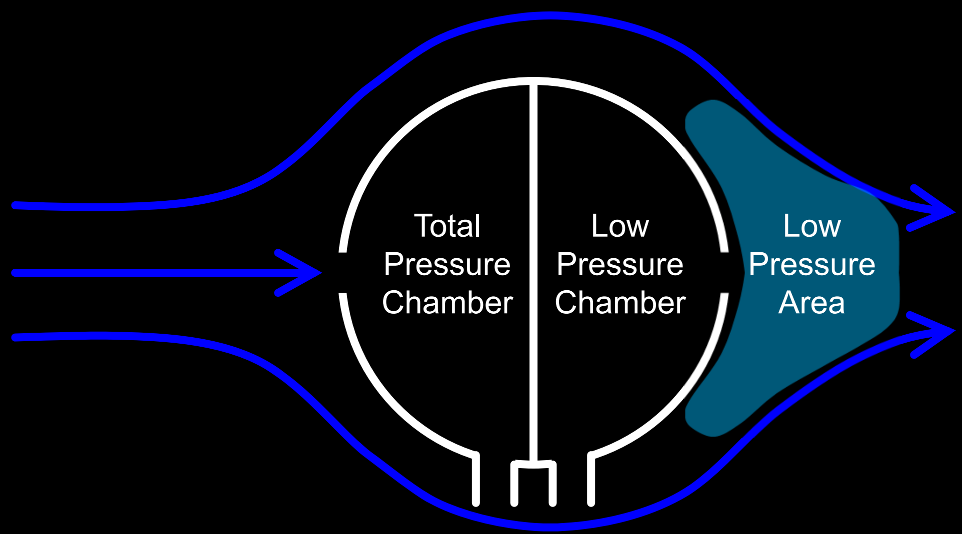


The chamber facing the air flow sees total pressure

The chamber facing away from the air flow sees a low pressure area in the wake of the flow around the tube

Flow Sensors are Typically a Form of Pitot Tube





The difference between the two pressures is an "amplified velocity" pressure signal

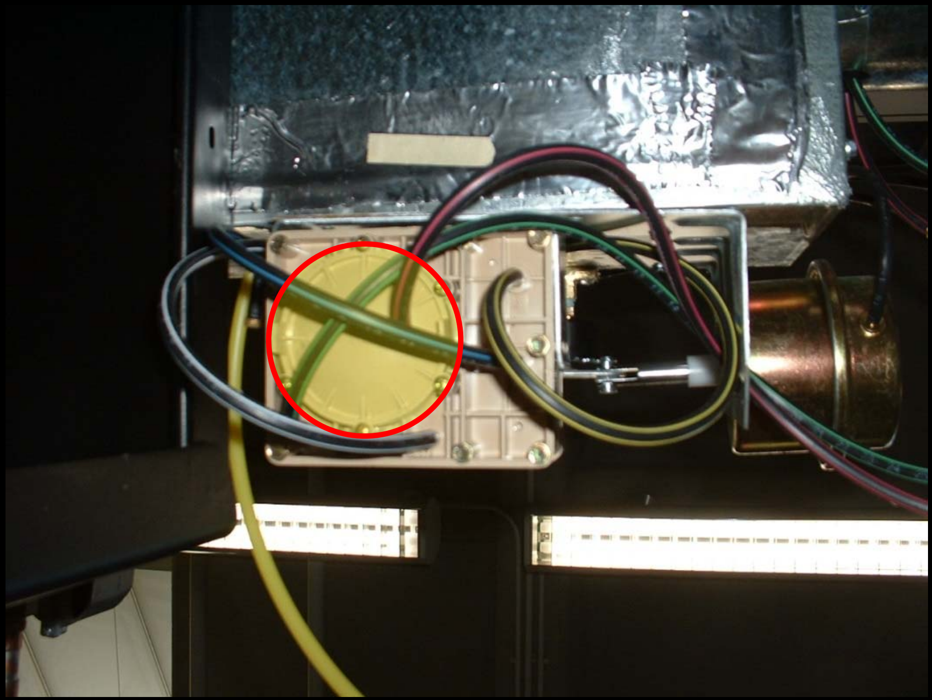
The "amplification" allows the VAV box controller to work at lower flows than would be possible if actual velocity pressure were sensed

The Relationship Between Velocity and Velocity Pressure

12 inch VAV Box

- Maximum flow
  - 2,000 cfm
  - VP = 0.2494 in.w.c.

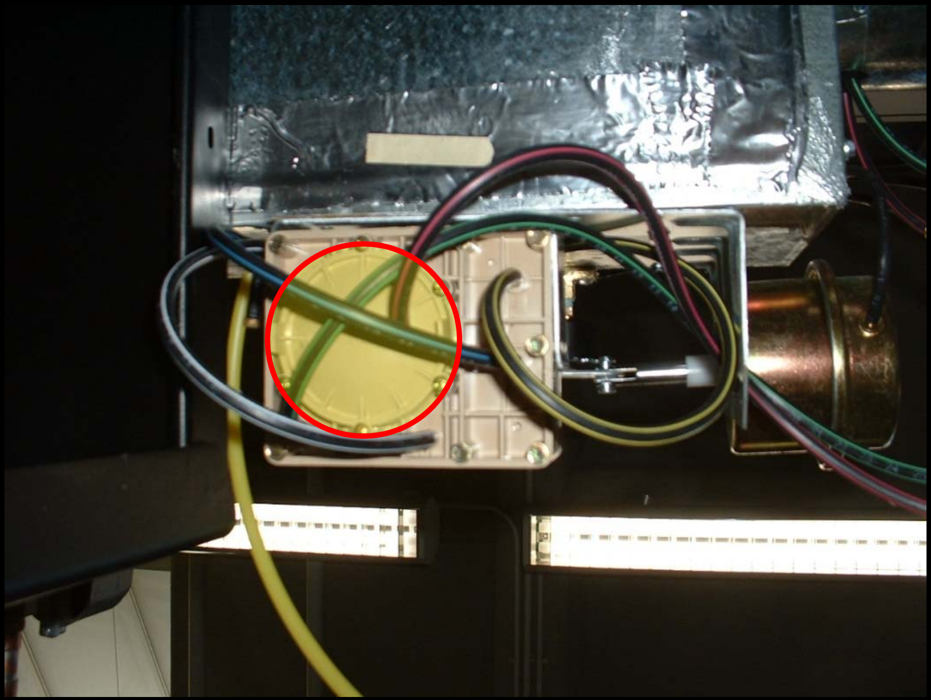
- Minimum flow
  - 325 cfm
  - VP = 0.0066 in.w.c.



The Relationship Between Velocity and Velocity Pressure

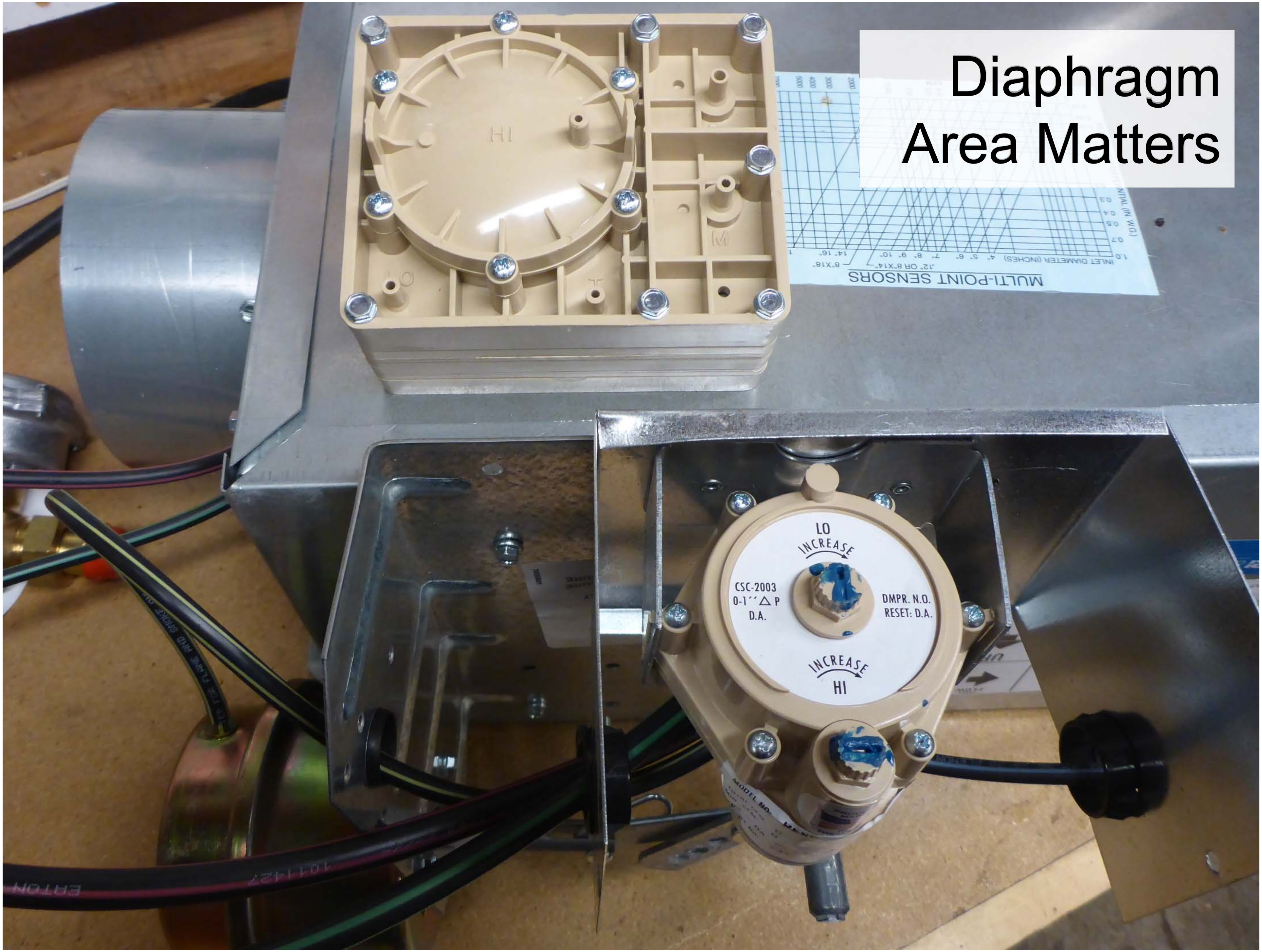
12 inch VAV Box

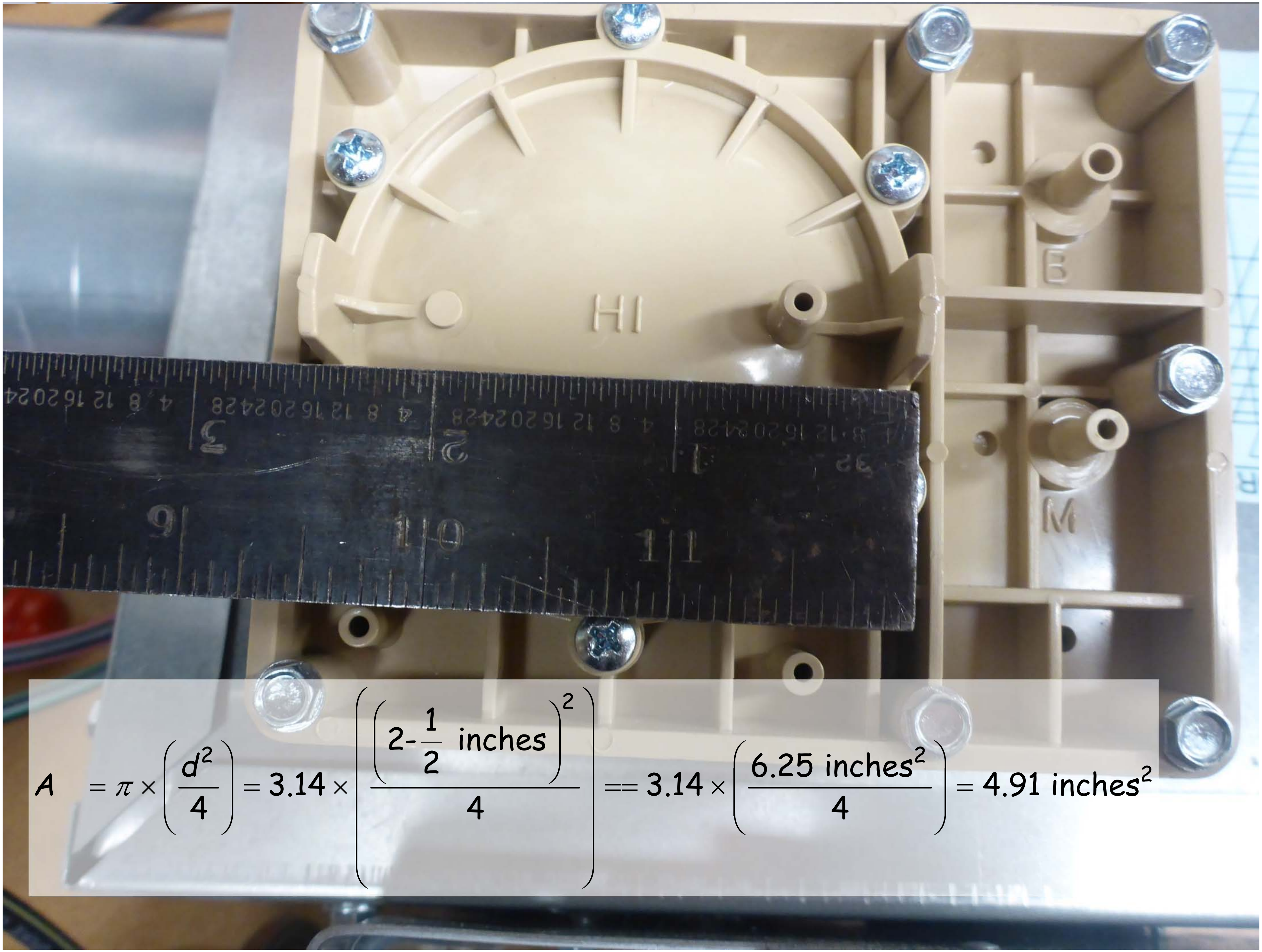
- Maximum flow
  - 2,000 cfm
  - VP = 0.2494 in.w.c.
  - Force = 0.0442 lb
  - Force = 0.7066 oz
- Minimum flow
  - 325 cfm
  - VP = 0.0066 in.w.c.
  - Force = 0.0012 lb
  - Force = 0.0187 oz



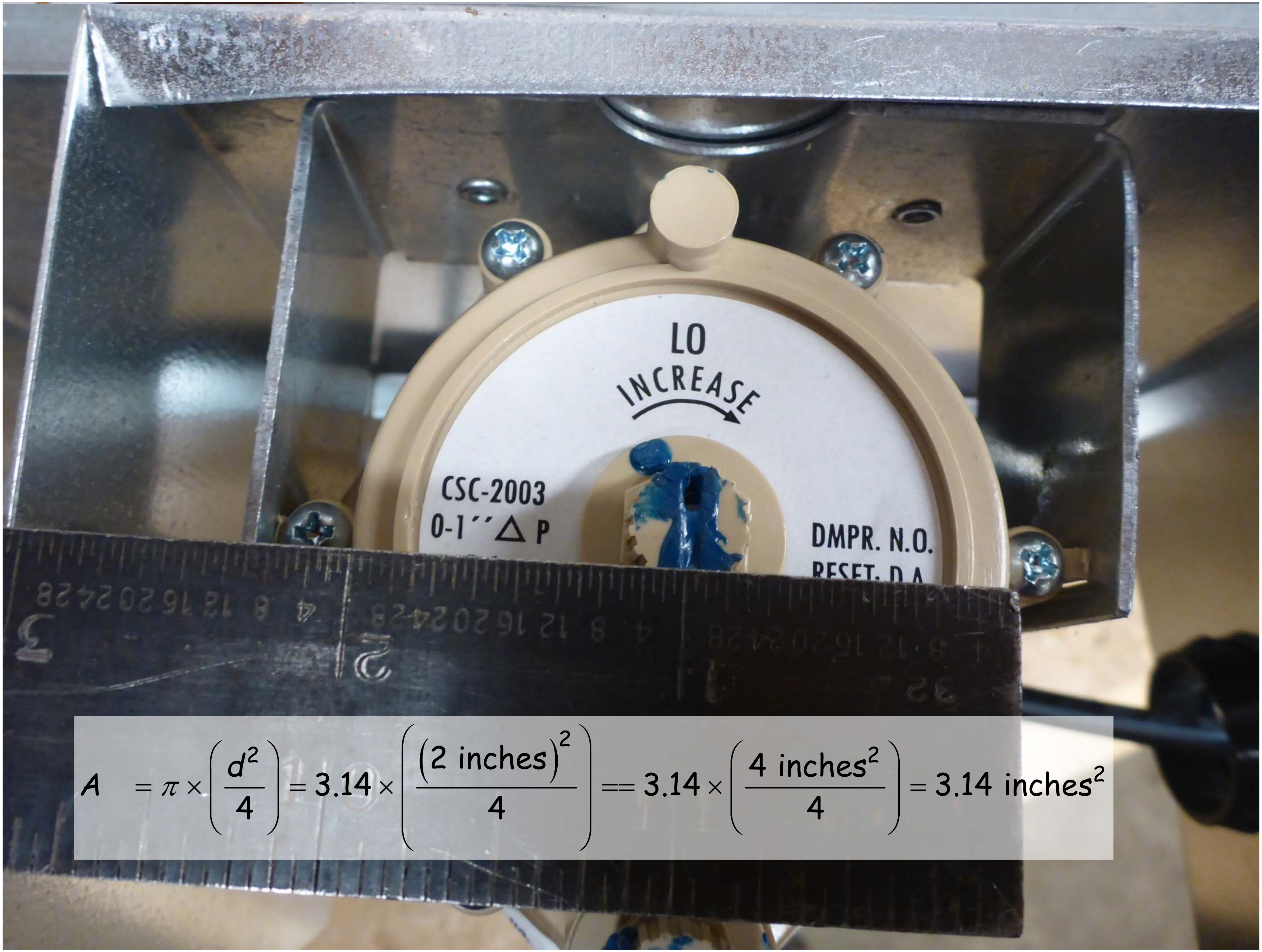
Frame of reference; a letter in an envelop weighs about 1 oz.

Diaphragm Area Matters



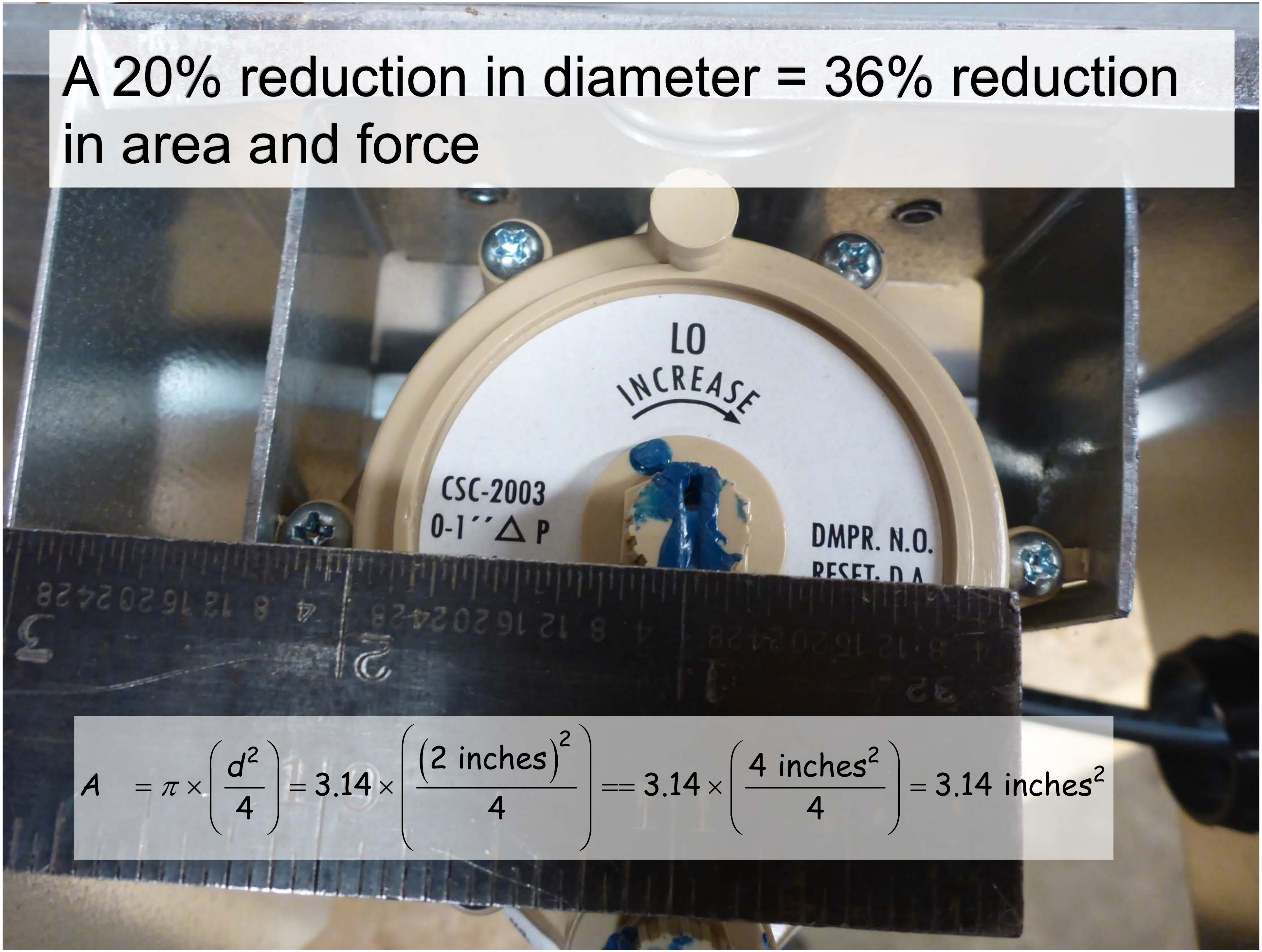


$$A = \pi \times \left(\frac{d^2}{4}\right) = 3.14 \times \left(\frac{\left(2\text{-}\frac{1}{2}\ \text{inches}\right)^2}{4}\right) == 3.14 \times \left(\frac{6.25\ \text{inches}^2}{4}\right) = 4.91\ \text{inches}^2$$



$$A = \pi \times \left(\frac{d^2}{4}\right) = 3.14 \times \left(\frac{(2\ \text{inches})^2}{4}\right) == 3.14 \times \left(\frac{4\ \text{inches}^2}{4}\right) = 3.14\ \text{inches}^2$$

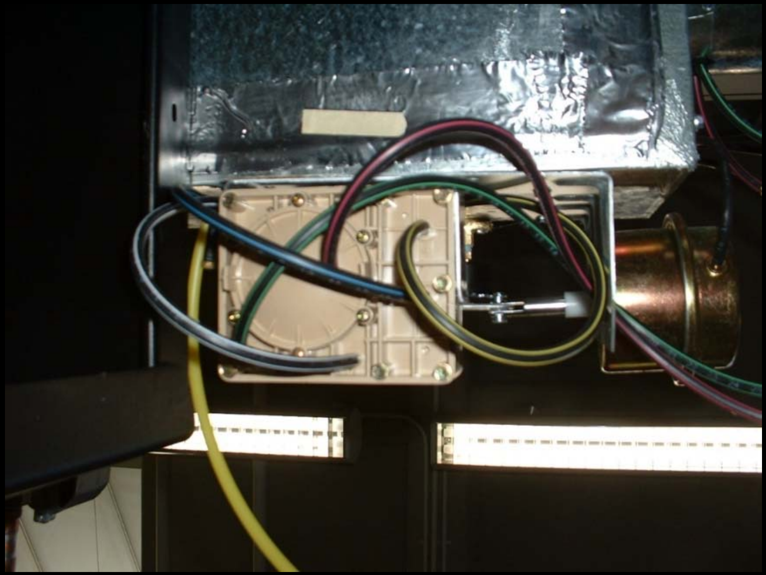
A 20% reduction in diameter = 36% reduction in area and force



$$A = \pi \times \left(\frac{d^2}{4}\right) = 3.14 \times \left(\frac{(2\text{ inches})^2}{4}\right) == 3.14 \times \left(\frac{4\text{ inches}^2}{4}\right) = 3.14\text{ inches}^2$$

Pneumatic Terminal Failure Modes

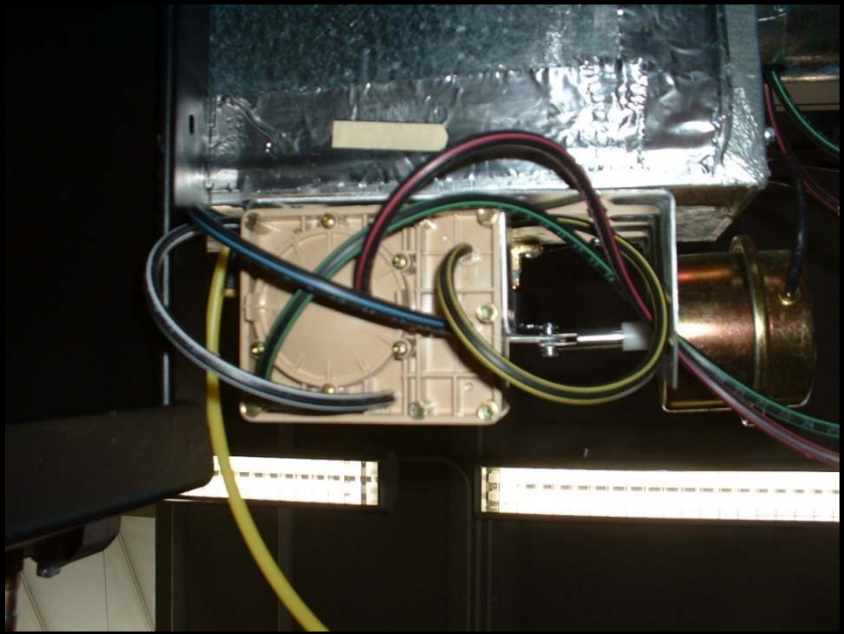
- Flow set points drift up
- Recent experience
  - Sample 10 of 45 pneumatic zones
  - Three years since last service effort



- Many of the controllers worked
- Many thermostats were out of calibration
- 0 (zero) zones were regulating at the required flow
- Many zones were wide open
- Some reheat valves were leaking through

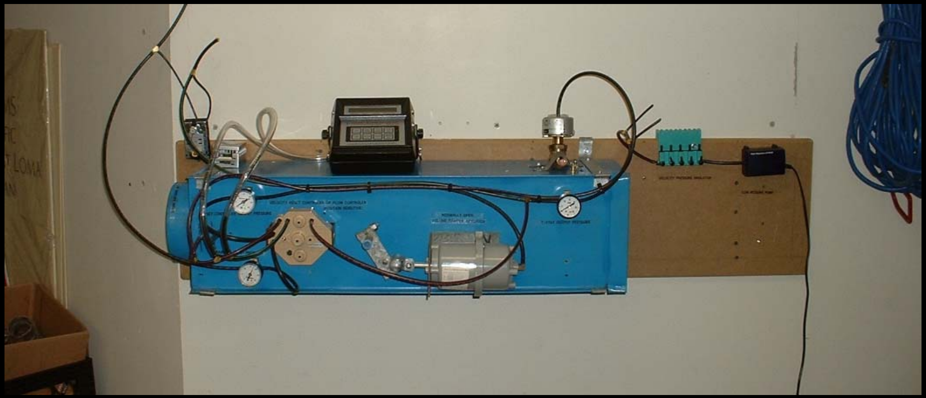
Pneumatic Terminal Bottom Lines

- Pneumatic terminals are common in existing buildings
- Pneumatic terminals are still being installed in “match existing” tenant improvement projects

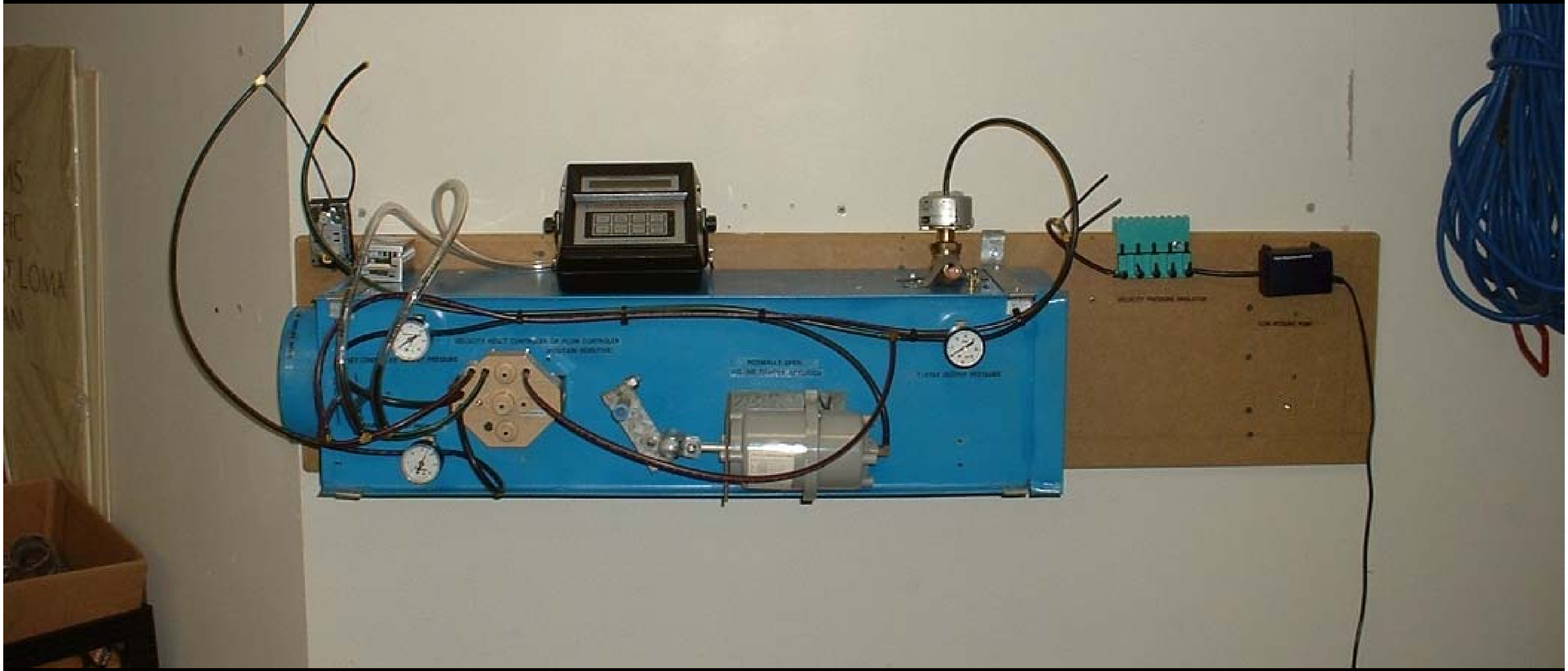


Pneumatic Terminal Bottom Lines

- Pneumatic terminals are common in existing buildings
- Pneumatic terminals are still being installed in “match existing” tenant improvement projects
- Pneumatic terminals represent an opportunity for mechanically minded folks to make a big impact on building performance and efficiency



The Real Challenge:
Creating an in.w.c. test signal



The Real Challenge:
Creating an in.w.c. test signal

Elegant but Expensive

The Real Challenge:

Creating an in.w.c. test signal

Less Elegant, but Less Expensive (and Kind of Clever)

The Real Challenge:

Creating an in.w.c. test signal

Elegant but Expensive

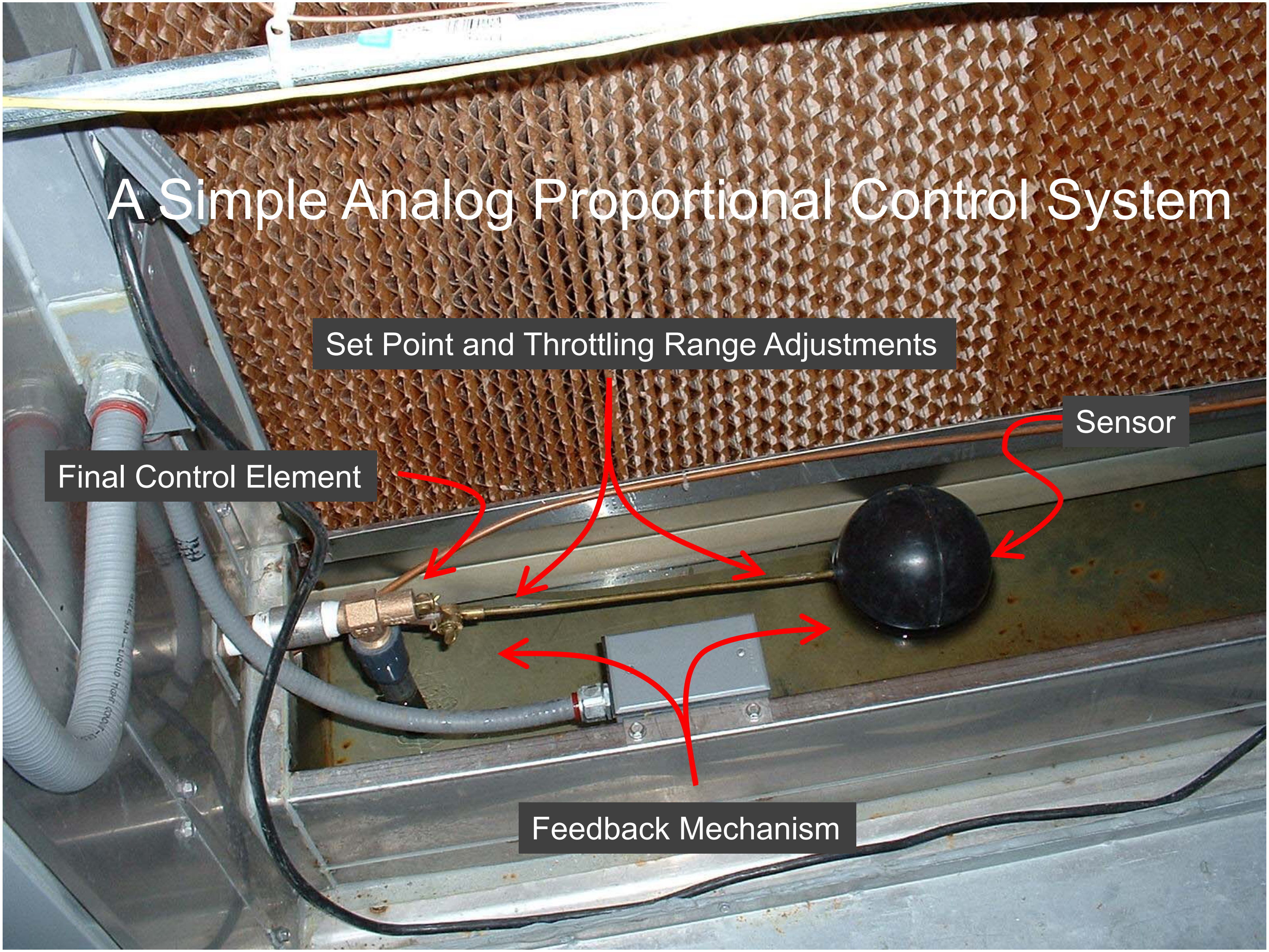
Less Elegant, but Less Expensive (and Kind of Clever)

Instructions at: https://av8rdas.wordpress.com/2013/10/14/simulating-small-pressures-my-inch-water-column-simulator/

Proportional Control

A Fundamental Pneumatic Control System Principle

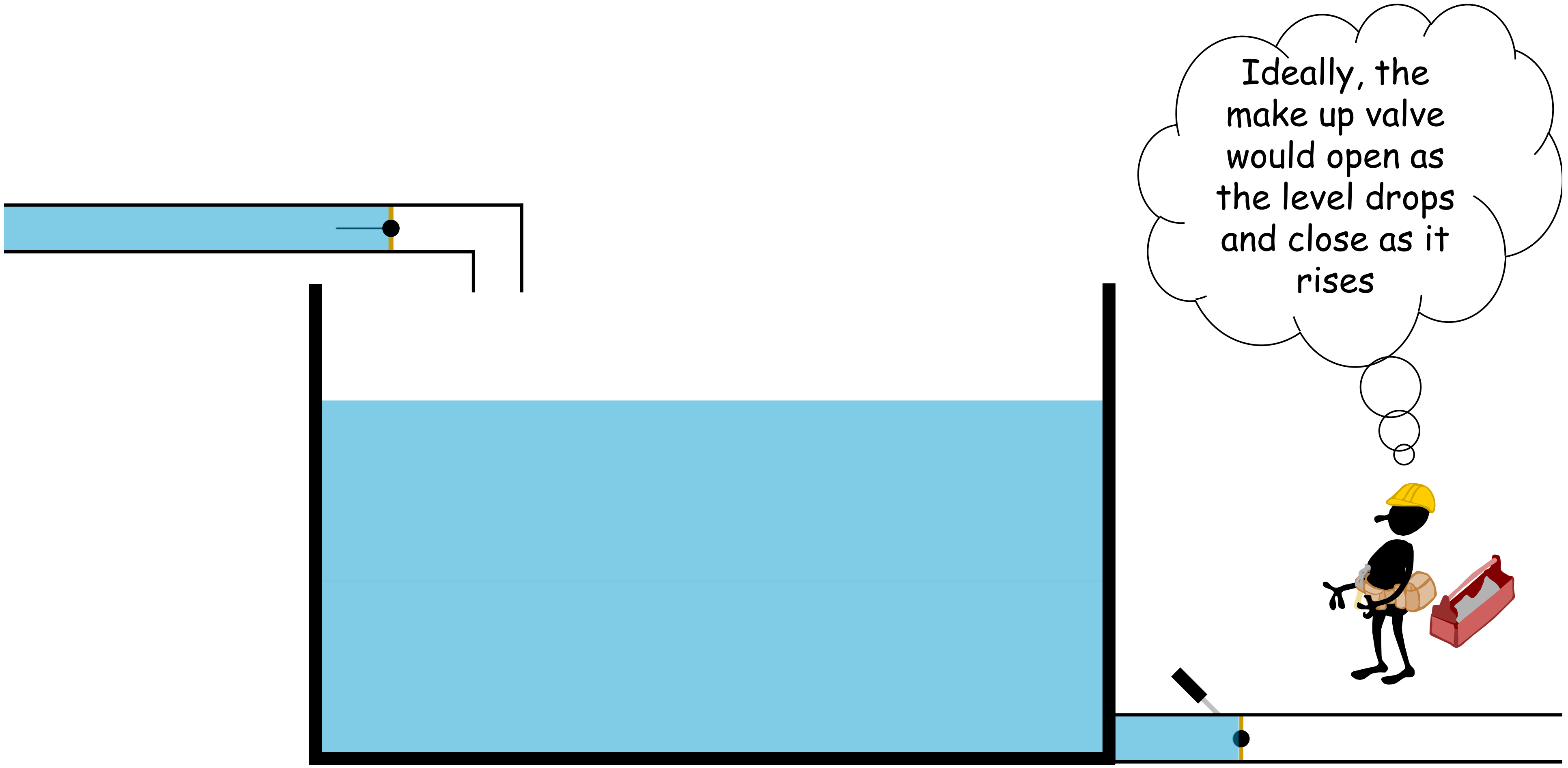
A Simple Analog Proportional Control System



A Simple Control System

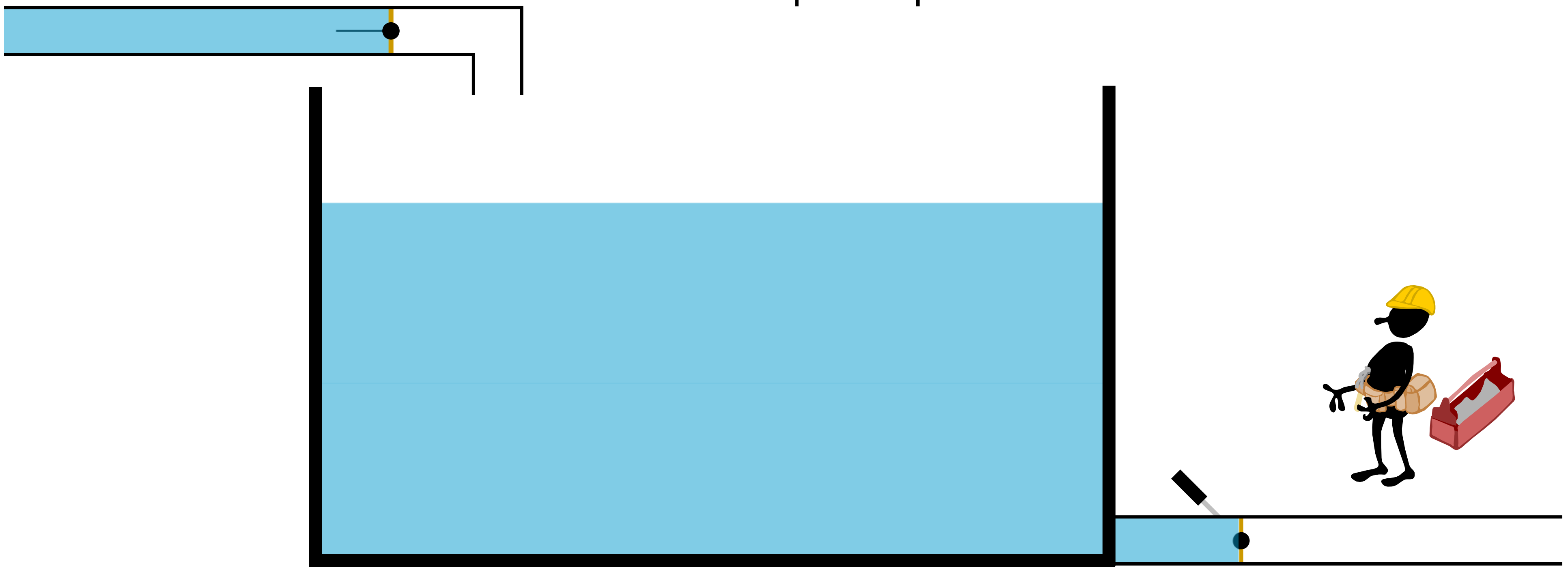
The make up valve is the
device to be controlled; a.k.a.
the *Controlled Variable*

A Simple Control System

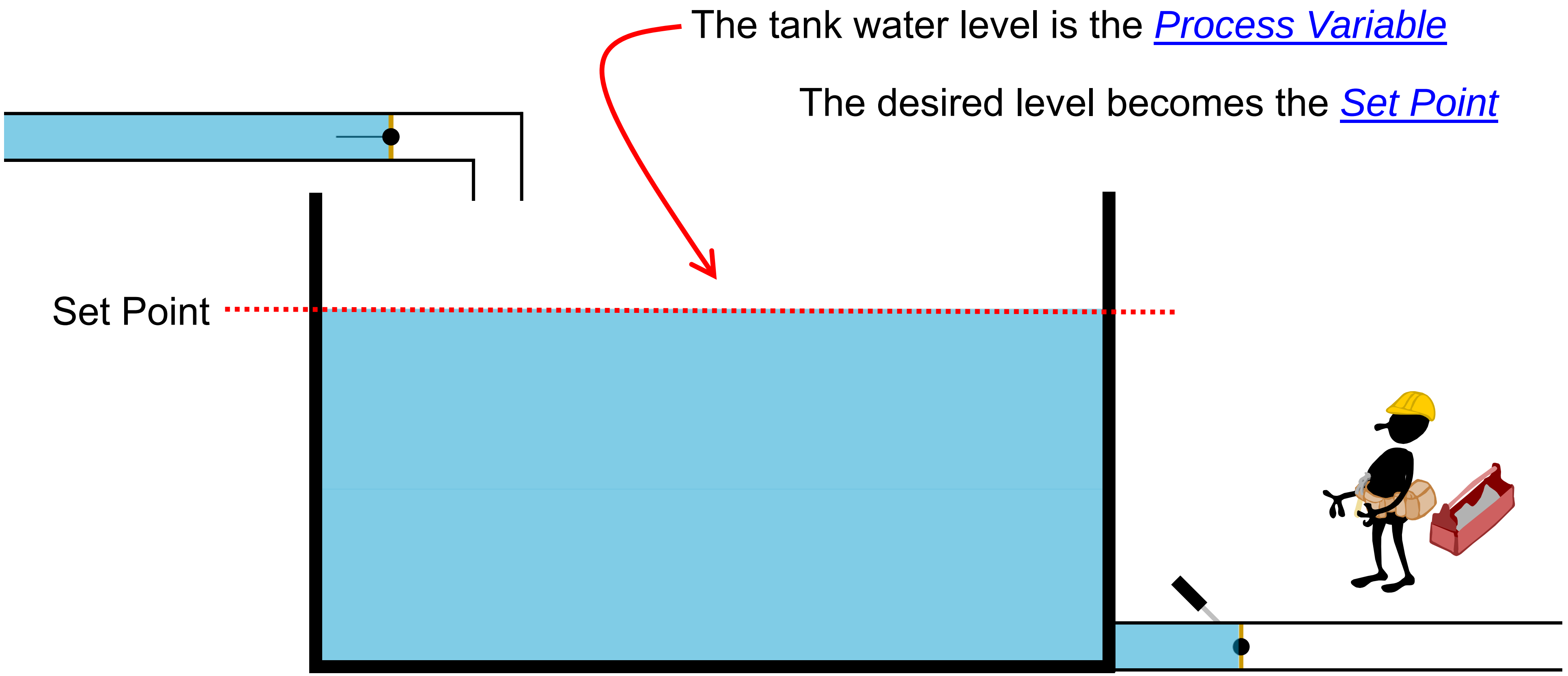


A Simple Control System

Monitoring the tank water level will allow us to gauge how much make up we need to add as demand picks up

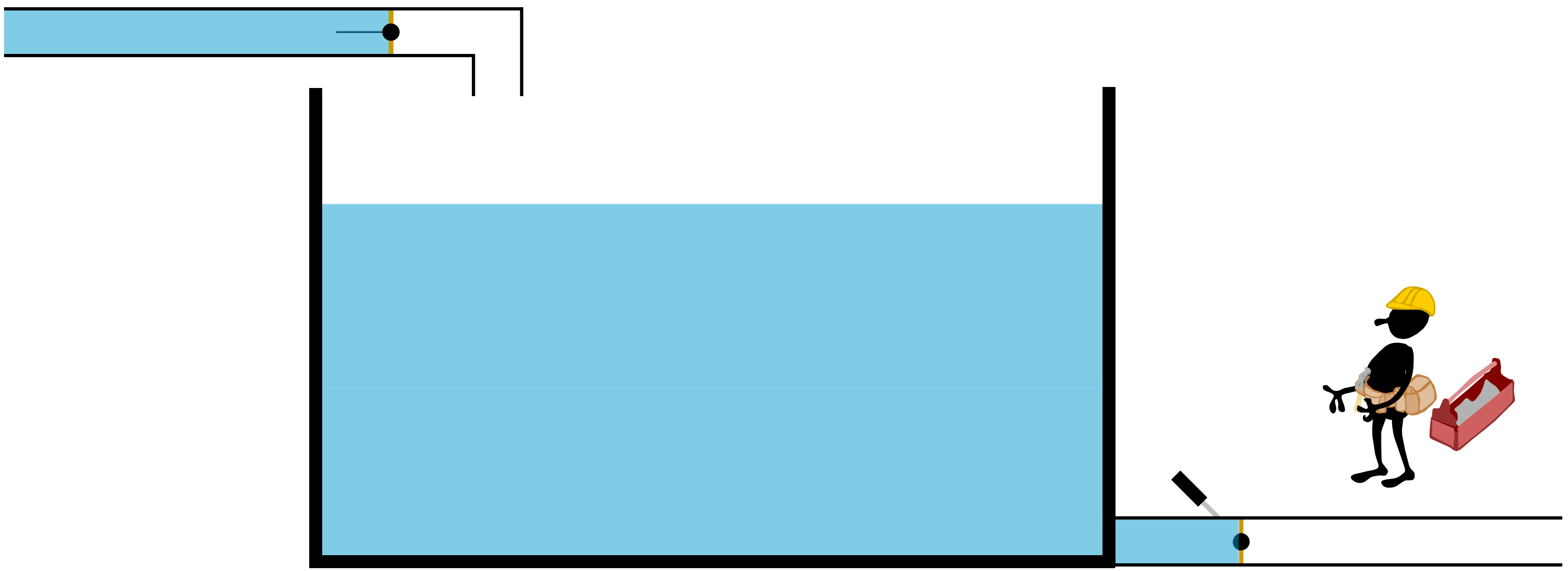


A Simple Control System

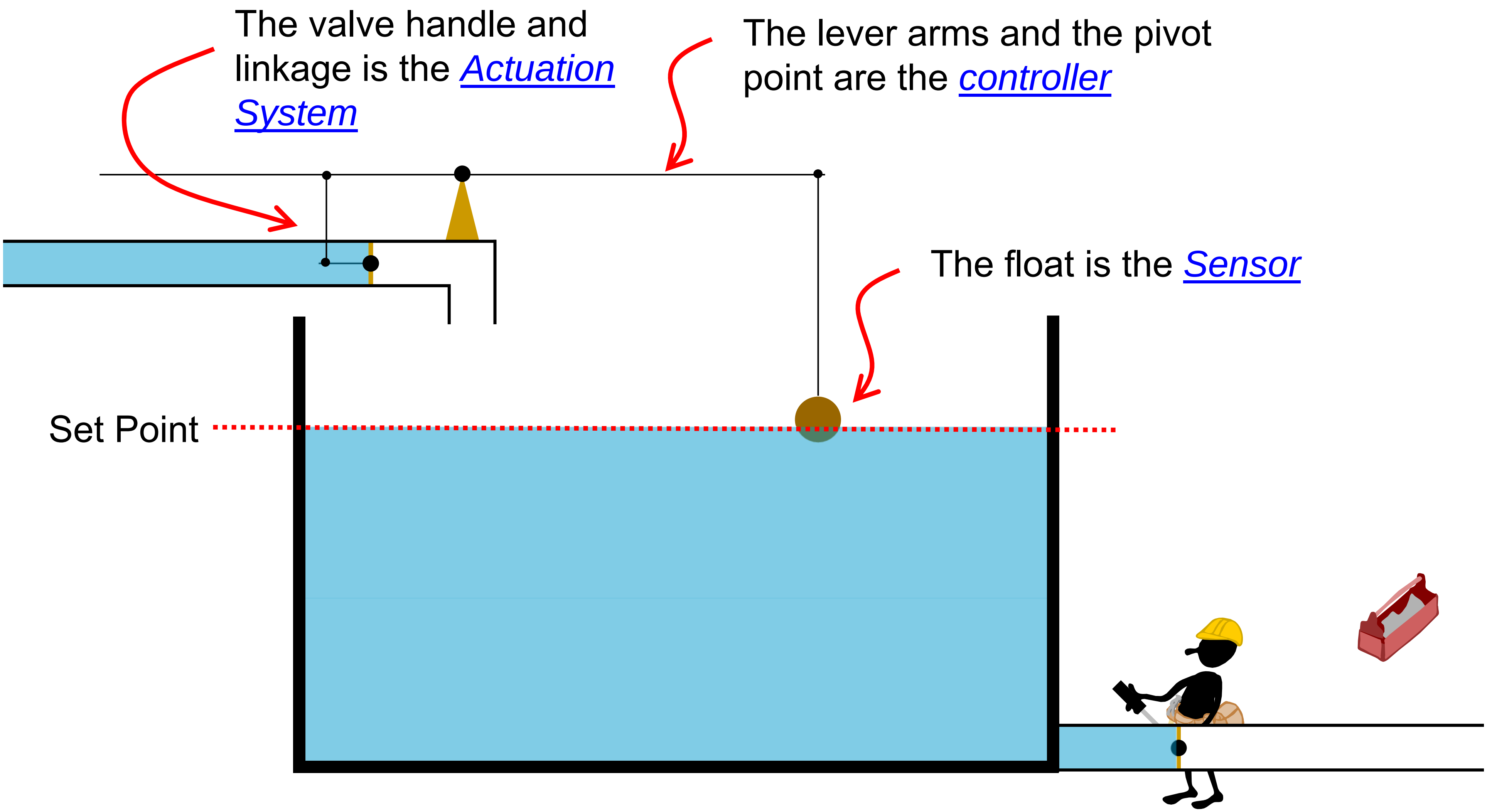


A Simple Control Requirement

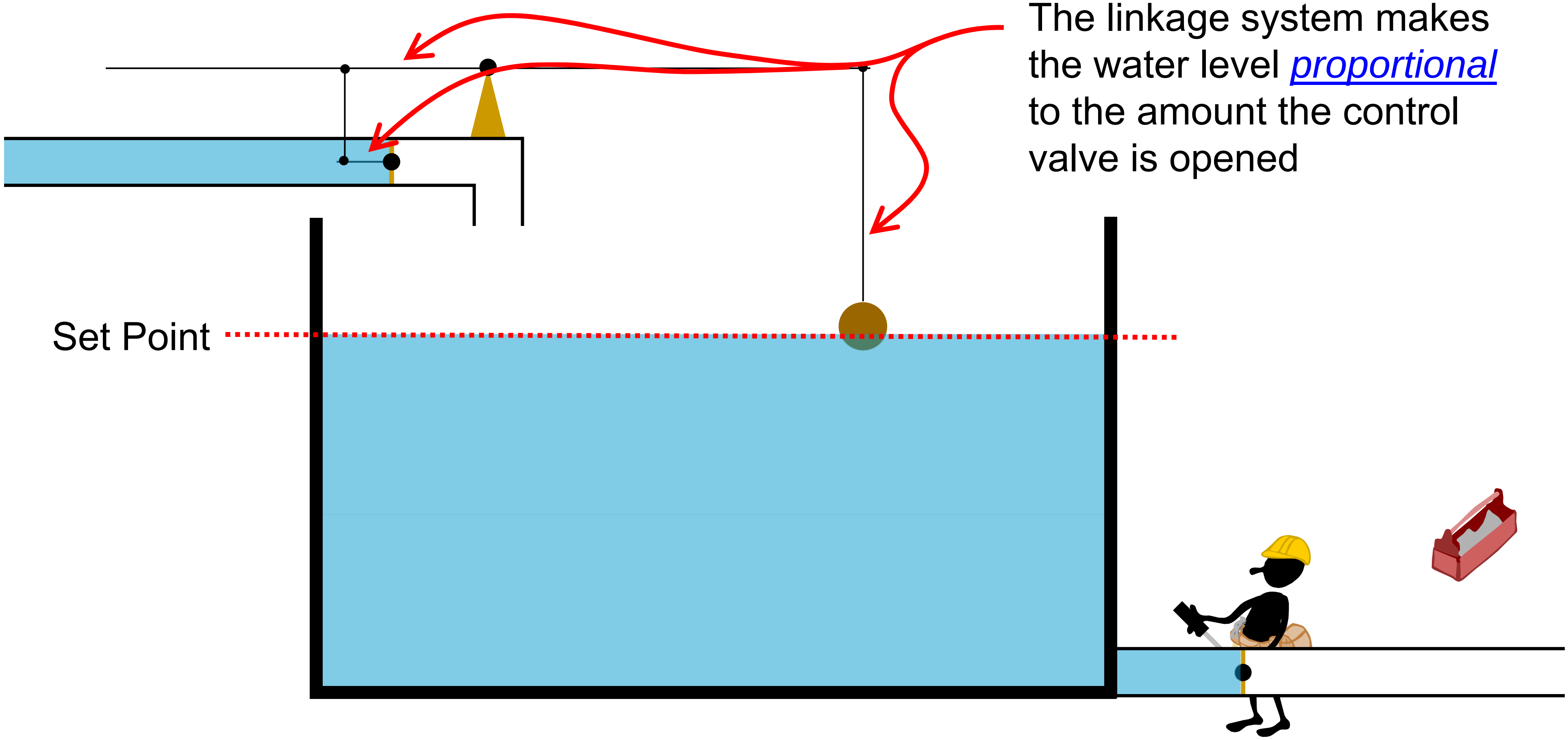
The make up valve is the device to be controlled; a.k.a. the *Controlled Variable* or *Final Control Element*



A Simple Proportional Control System

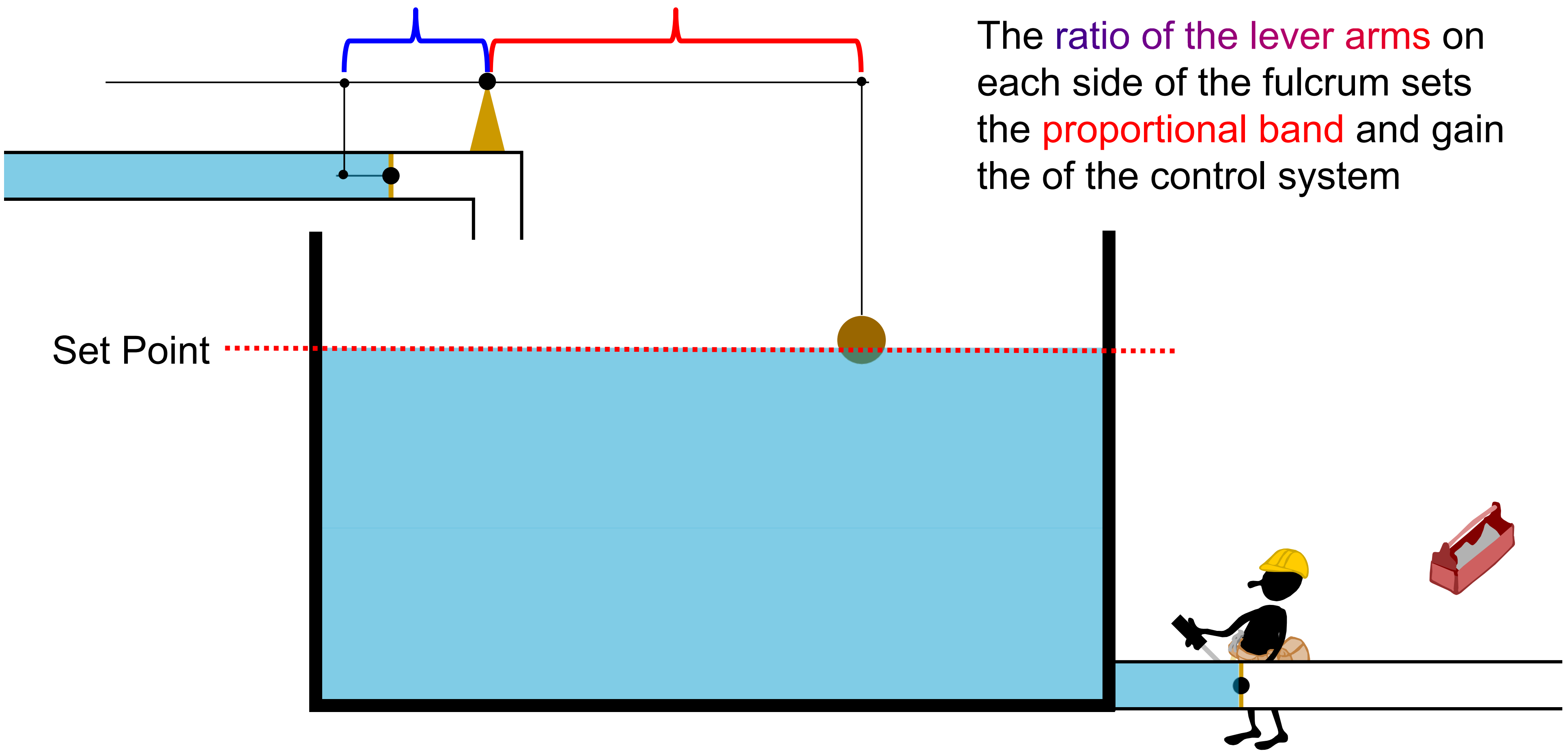


A Simple Proportional Control System



The linkage system makes the water level *proportional* to the amount the control valve is opened

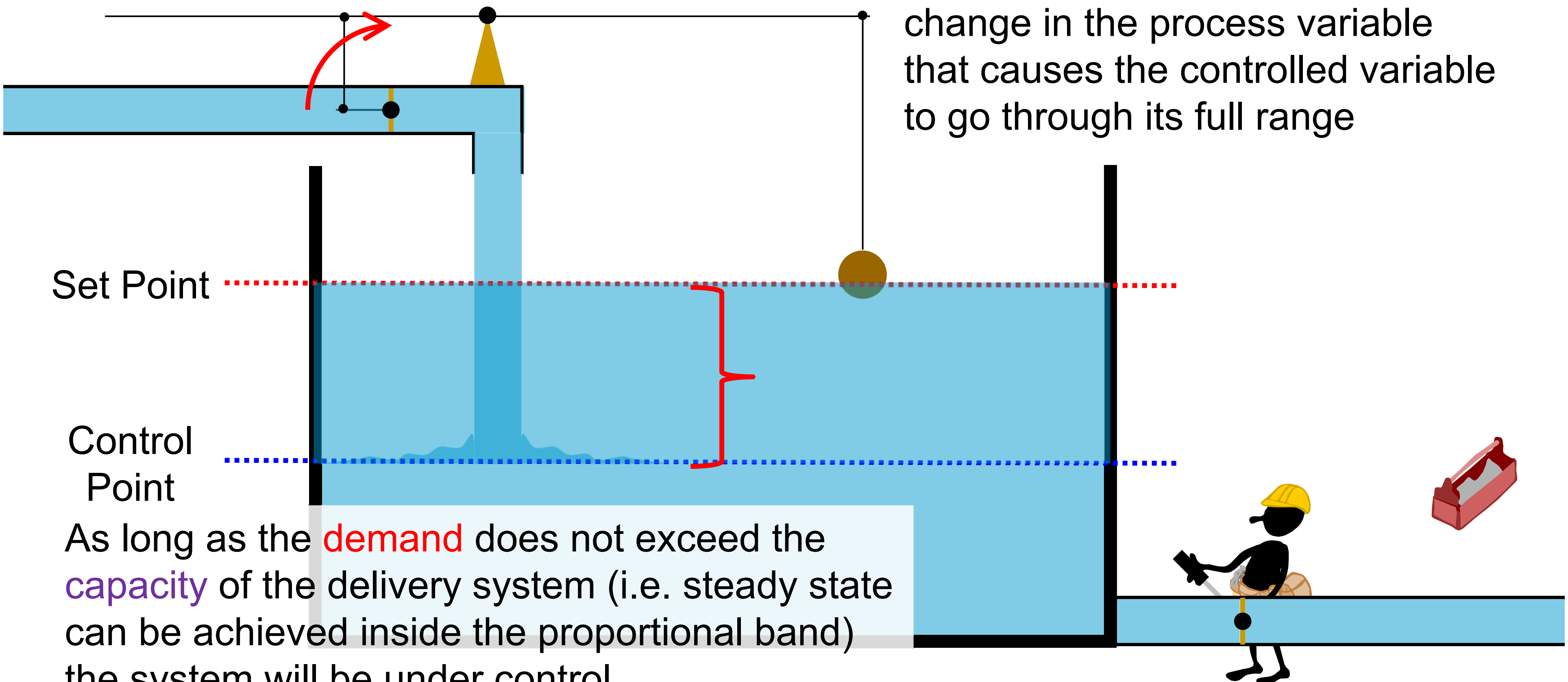
A Simple Proportional Control System



The ratio of the lever arms on each side of the fulcrum sets the proportional band and gain the of the control system

A Simple Proportional Control System

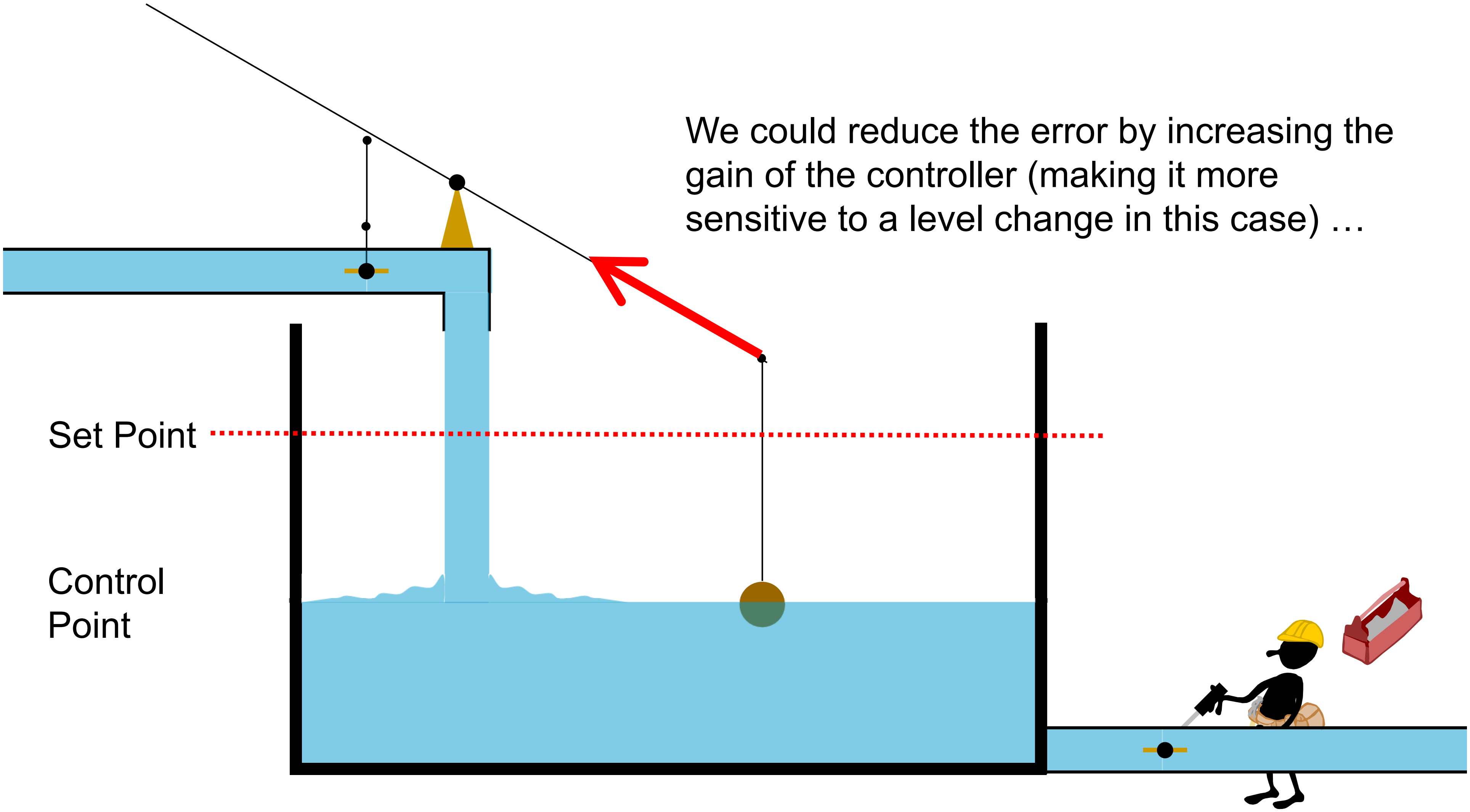
The proportional band is the change in the process variable that causes the controlled variable to go through its full range



As long as the demand does not exceed the capacity of the delivery system (i.e. steady state can be achieved inside the proportional band) the system will be under control

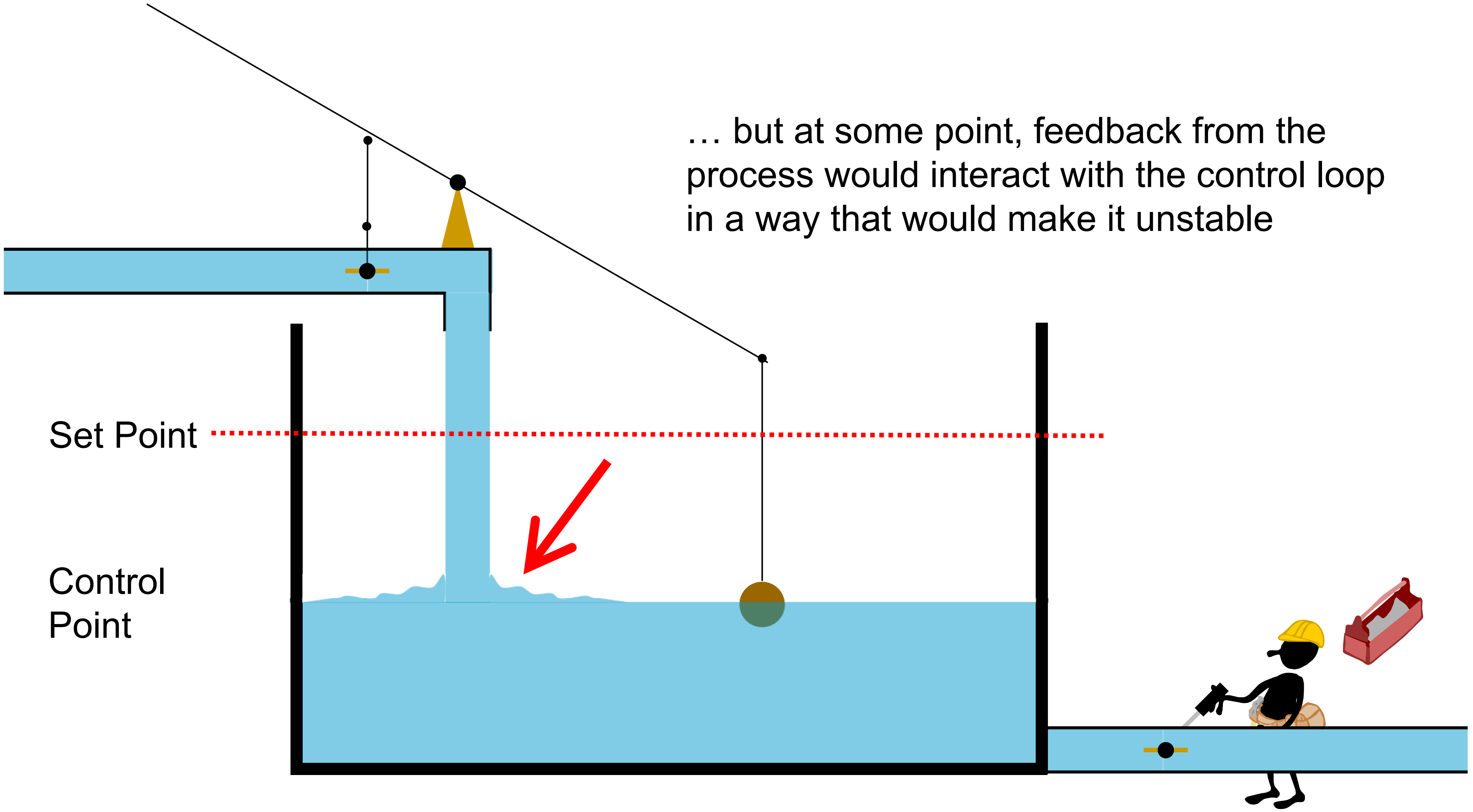
A Simple Proportional Control System

We could reduce the error by increasing the gain of the controller (making it more sensitive to a level change in this case) …



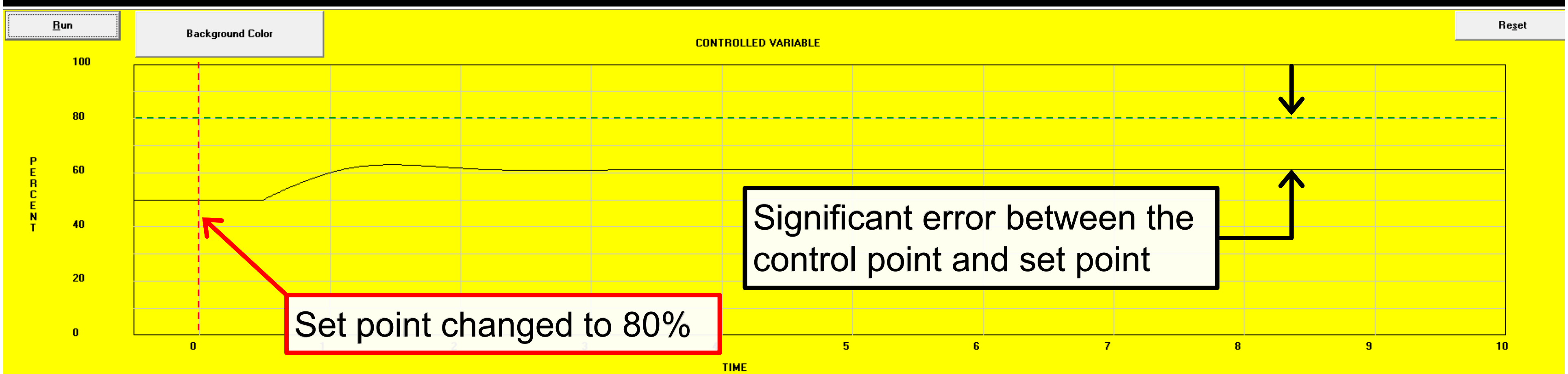
A Simple Proportional Control System

… but at some point, feedback from the process would interact with the control loop in a way that would make it unstable



The Impact of Narrowing Throttling Range

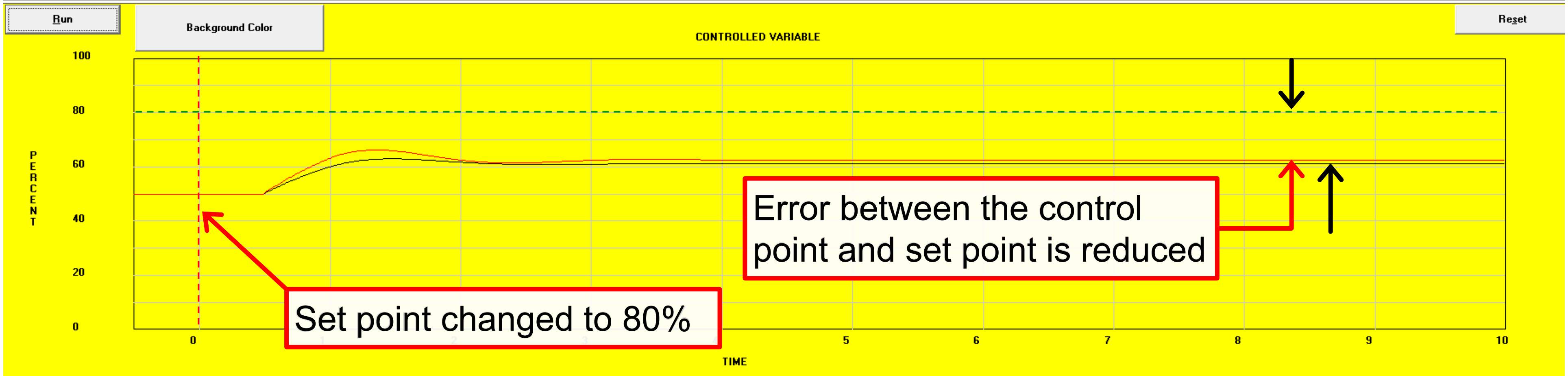
Proportional band =400% and set point changed to 80% (black line)



The Impact of Narrowing Throttling Range

Proportional band =400% (black line)

Proportional band =300% and set point changed to 80% (red line)

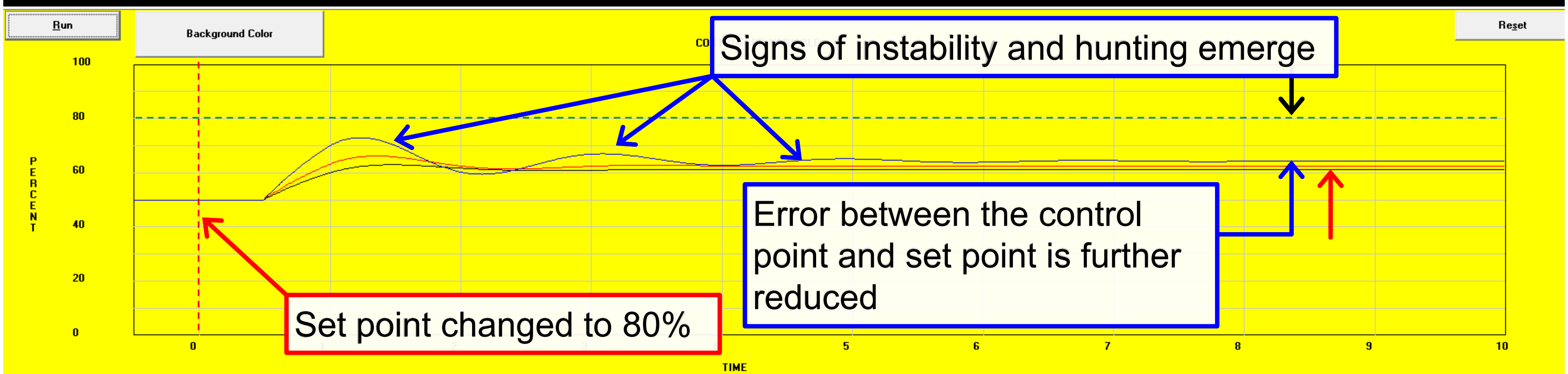


The Impact of Narrowing Throttling Range

Proportional band =400% (black line)

Proportional band =300% (red line)

Proportional band =200% and set point changed to 80% (blue line)



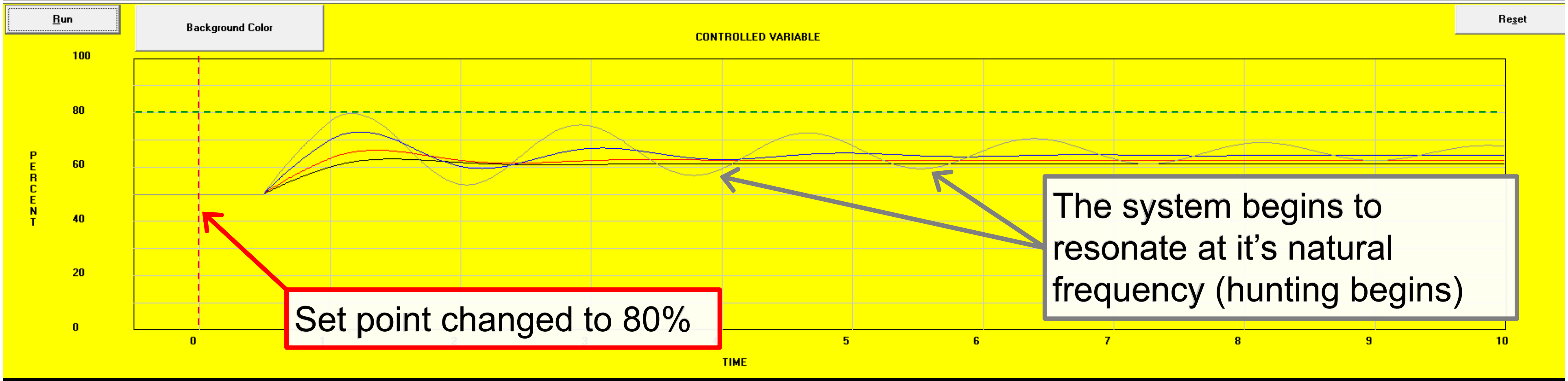
The Impact of Narrowing Throttling Range

Proportional band =400% (black line)

Proportional band =300% (red line)

Proportional band =200% (blue line)

Proportional band =150% and set point changed to 80% (gray line)



The Impact of Narrowing Throttling Range

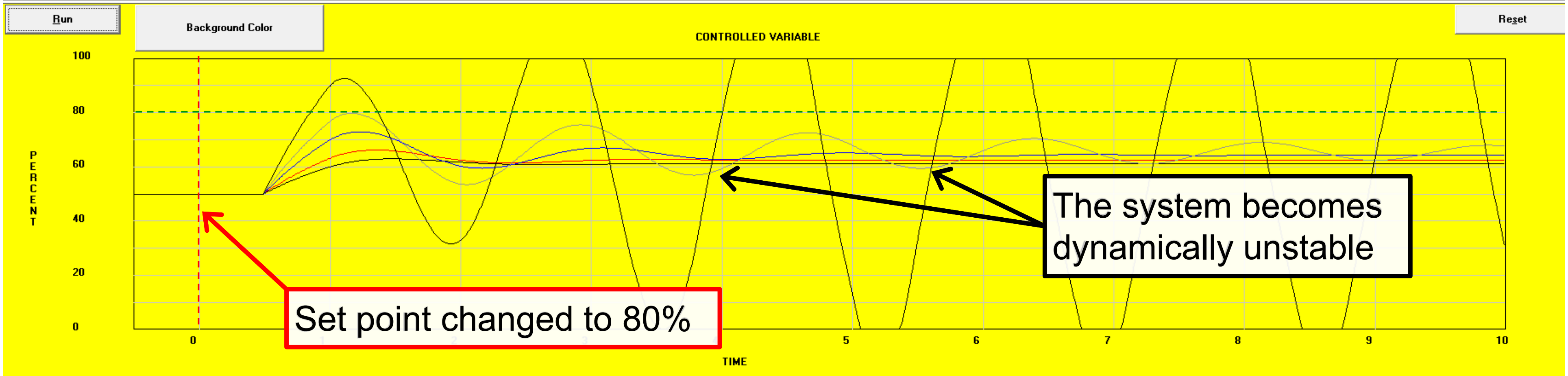
Proportional band =400% (black line)

Proportional band =300% (red line)

Proportional band =200% (blue line)

Proportional band =150% ((gray line)

Proportional band =100% and set point changed to 80% (second black line)



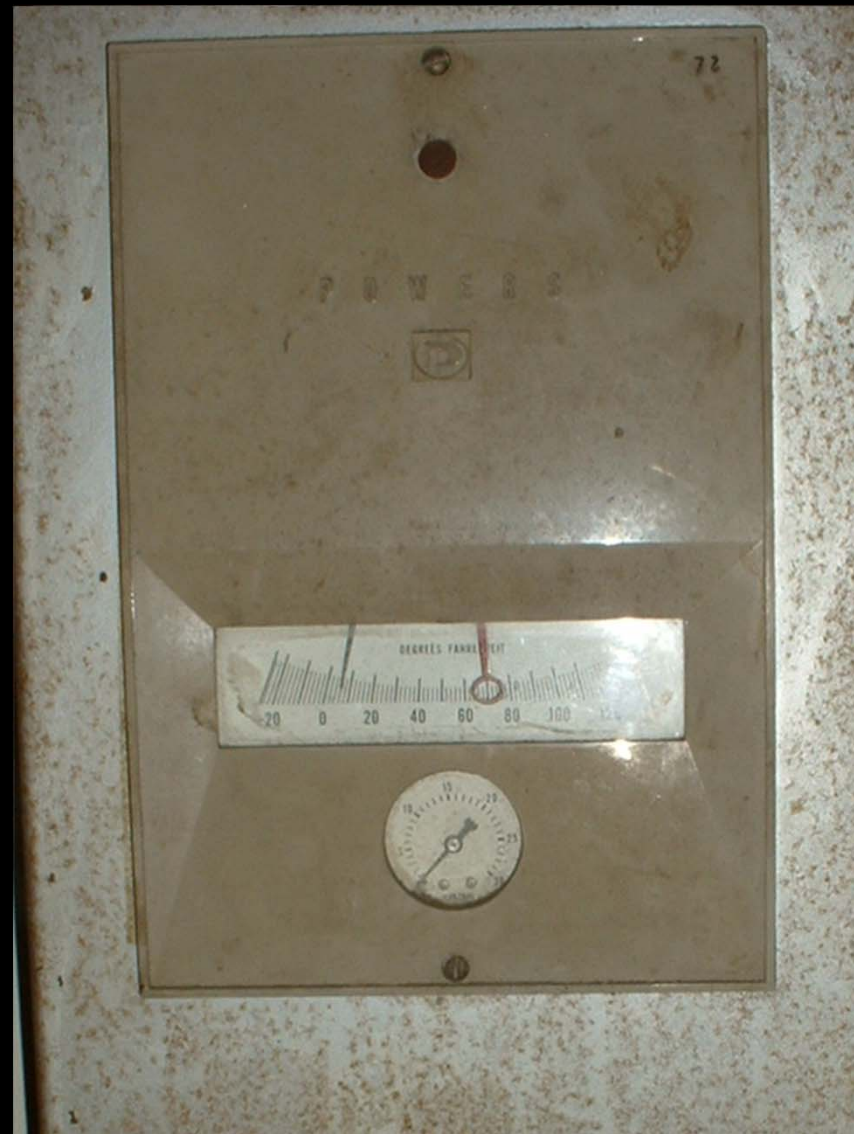
Bottom Lines On Proportional Control

1. All proportional control processes will show a difference between set point and control point (a.k.a. error) under all operating conditions other than one very specific condition
2. The error can be reduced by narrowing down the throttling range
3. There is a limit to how much you can narrow the throttling range with out hunting
4. The limit is a function of the physics of the control system; things like lags, play in the linkage system, the nature of the process, etc.

Bottom Lines On Proportional Control

Integral and Derivative (the I and D in PID) can help address proportional error and large swings from set point during transients

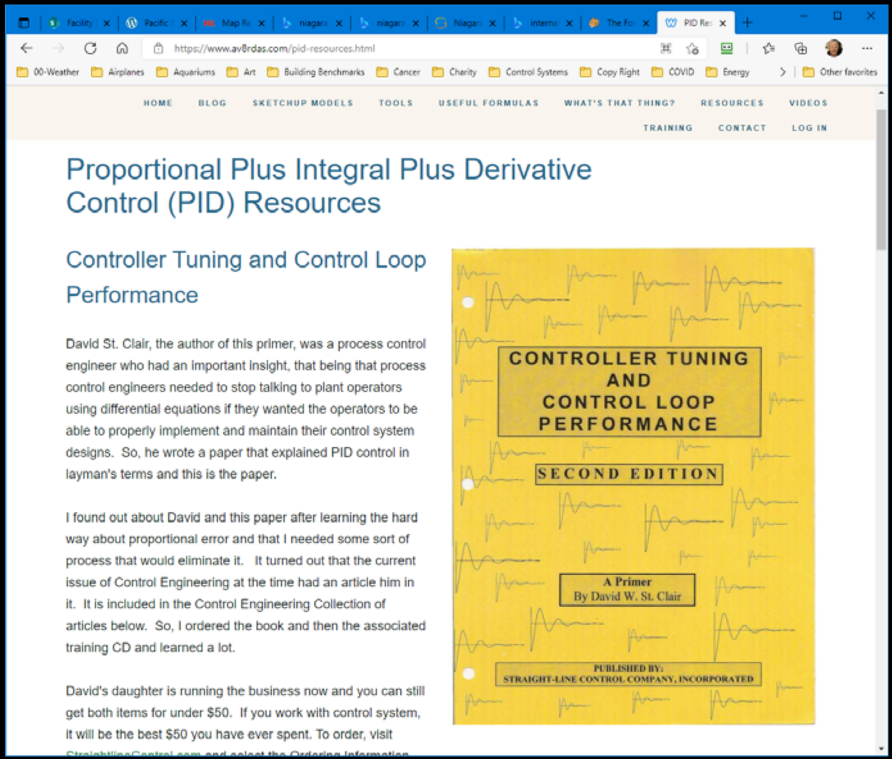
- There are pneumatic PID controllers



Bottom Lines On Proportional Control

Integral and Derivative (the I and D in PID) can help address proportional error and large swings from set point during transients

- There are pneumatic PID controllers
- Additional information on PID can be found at https://www.av8rdas.com/pid-resources.html



Set Points

Control System Building Blocks

Automatically adjust a piece of machinery to give us what we want by comparing what is going on to what we want to go on and making appropriate adjustments to the process we want to control

Inputs	Measure the process variable
Outputs	Adjust the controlled variable
Control Process	Logic and algorithms that tries to bring the controlled variable into agreement with the set point
Set Point	Our requirements for the process that is under control, which can be fixed or variable

Control System Building Blocks

Automatically adjust a piece of machinery to give us what we want by comparing what is going on to what we want to go on and making appropriate adjustments to the process we want to control

Inputs	Measure the process variable
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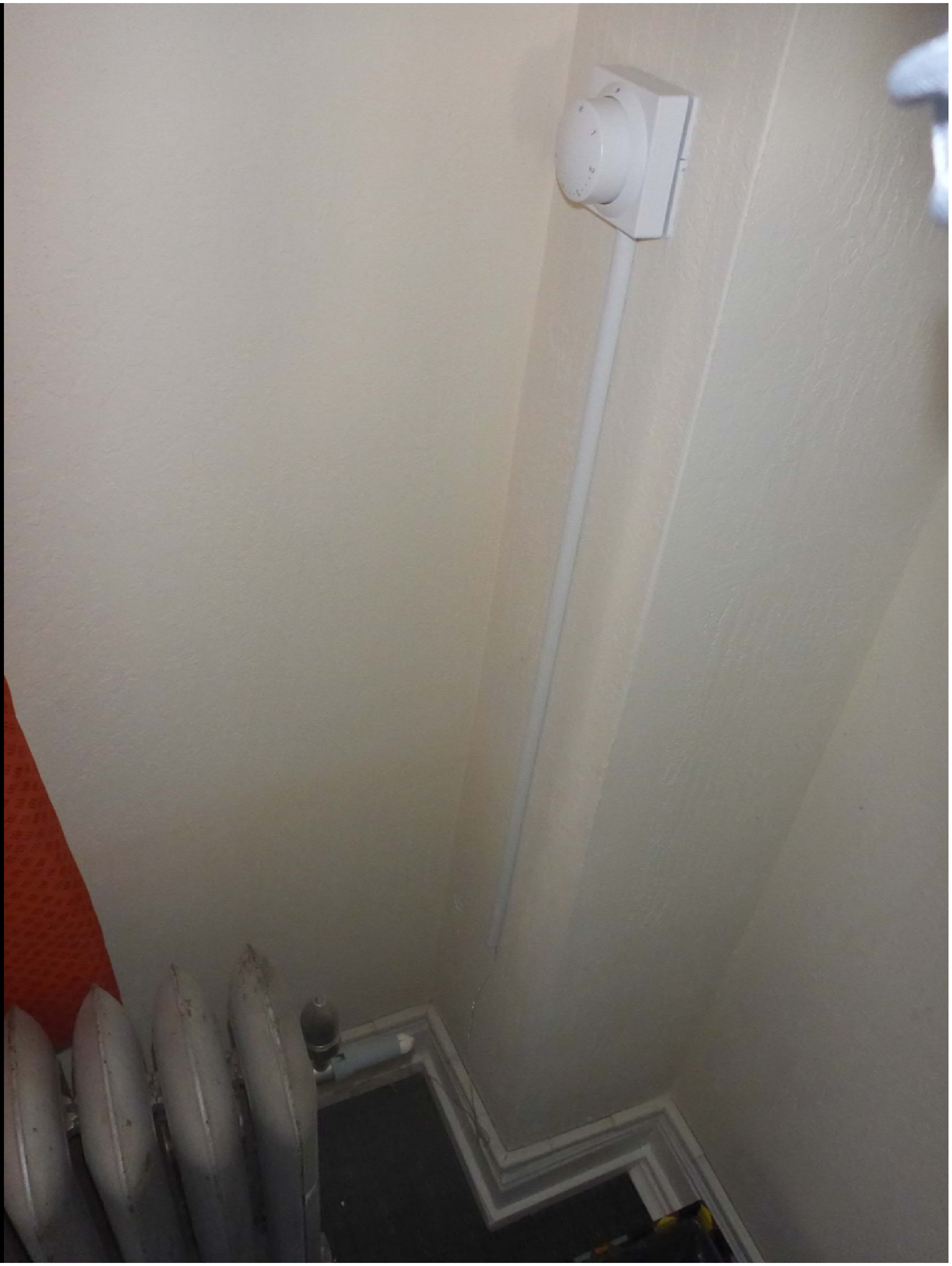
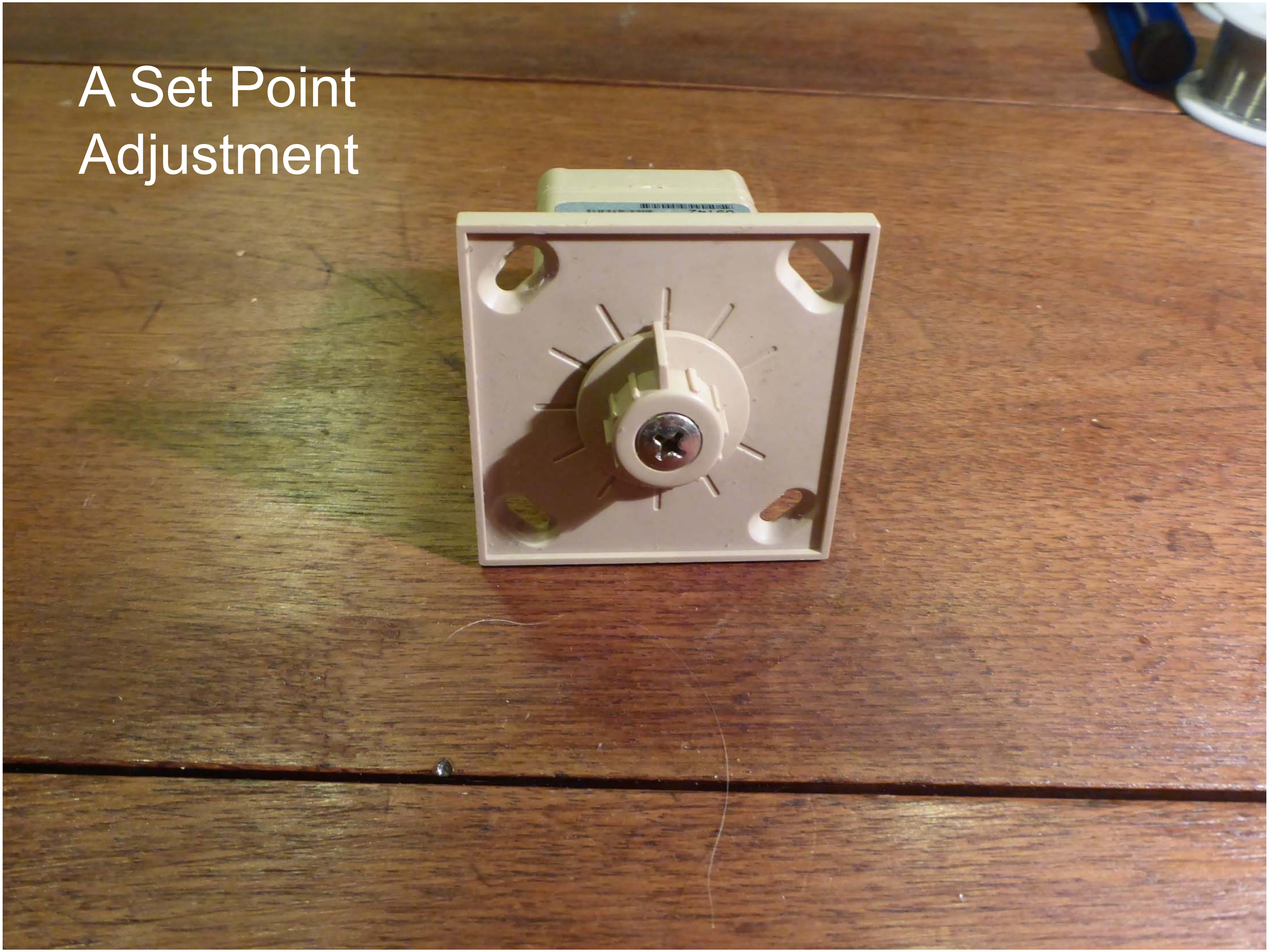
Control Process	Logic and algorithms that tries to bring the controlled variable into agreement with the set point
Set Point	Our requirements for the process that is under control, which can be fixed or variable

A Set Point Adjustment




A Set Point
Adjustment

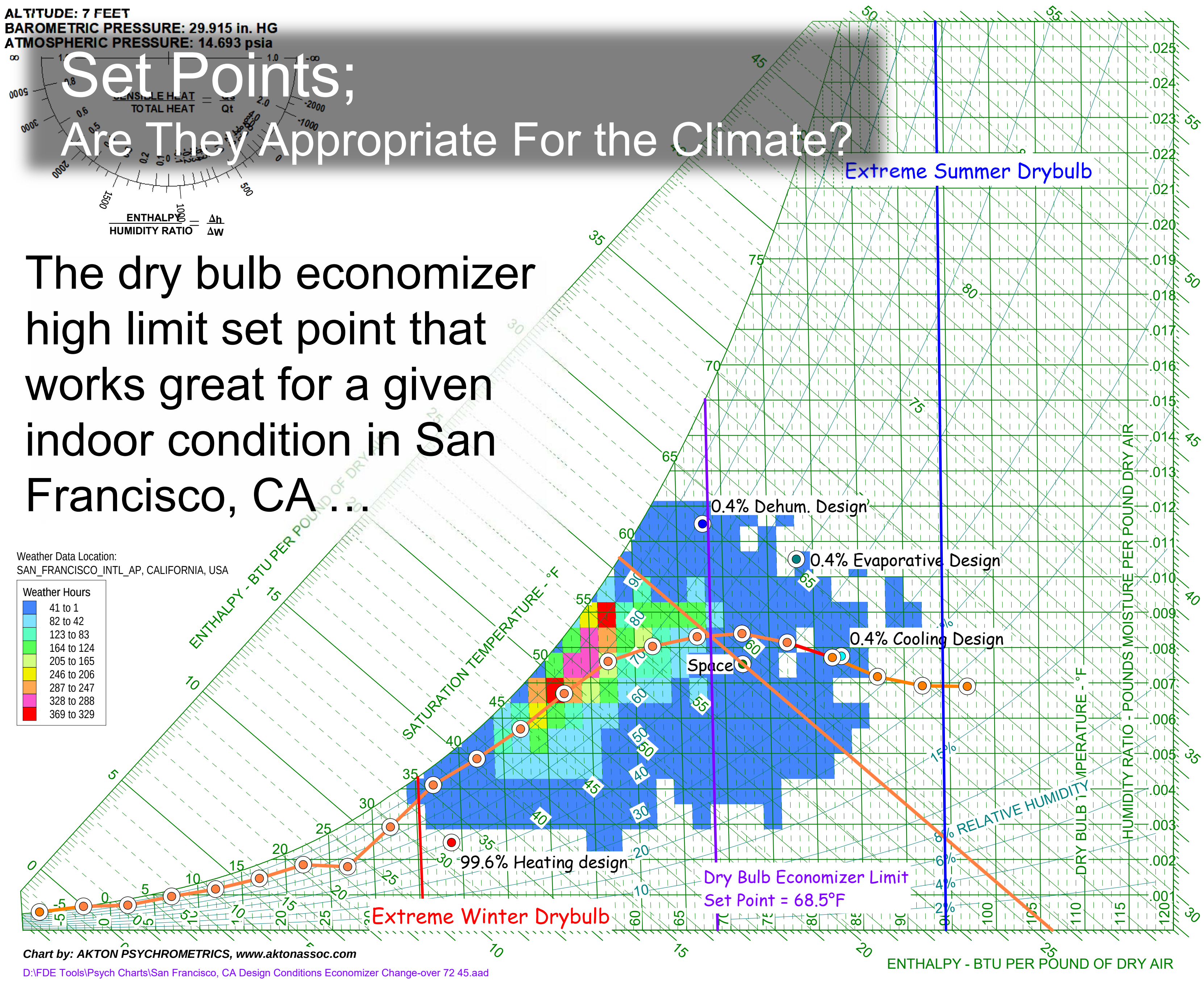

David Sellers
Facility Dynamics NW
8560 North Buchanan Ave.
Portland, OR 97203; Cell 503-320-

Set Points

Are They Appropriate for the Climate?

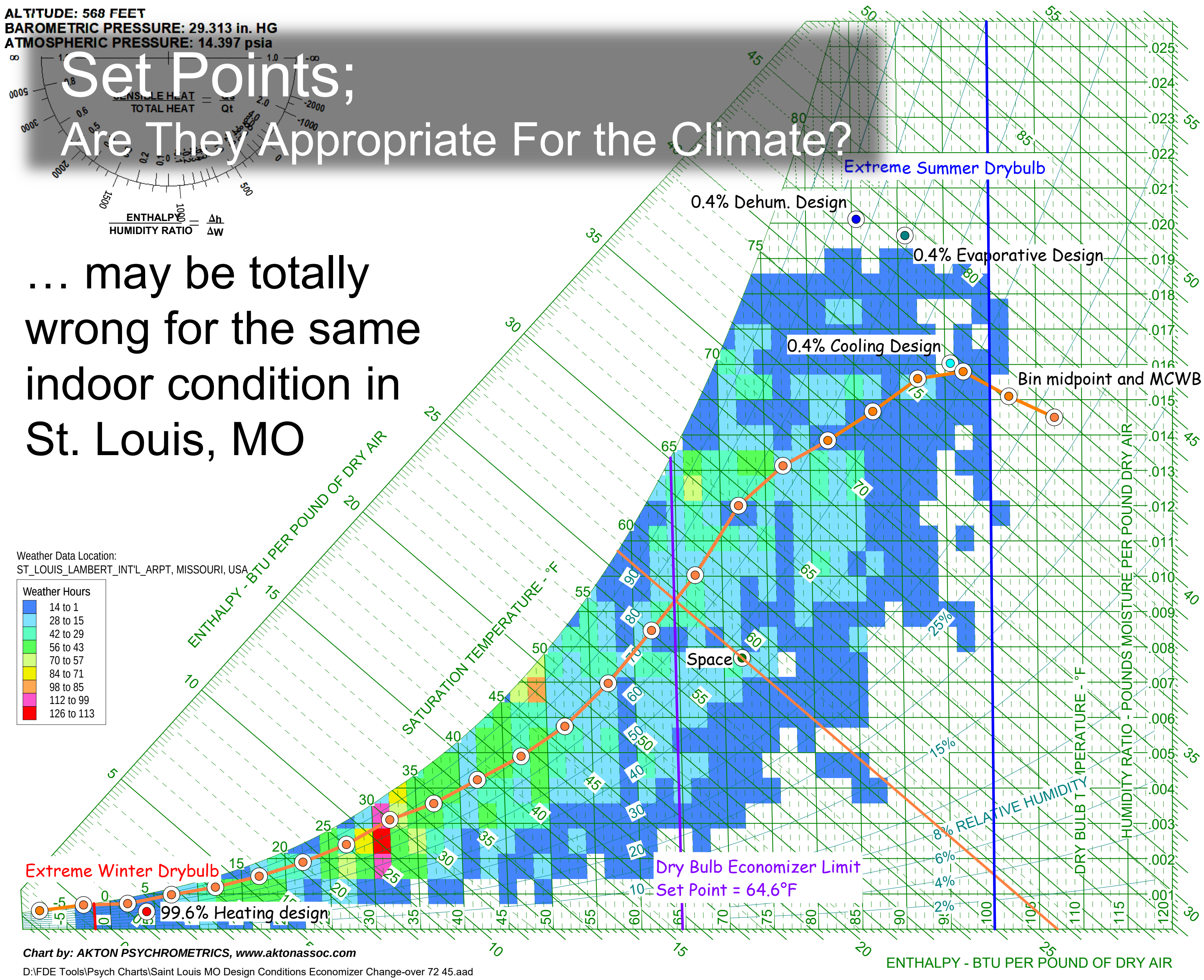
Set Points;
Are They Appropriate For the Climate?

The dry bulb economizer high limit set point that works great for a given indoor condition in San Francisco, CA …



Set Points;
Are They Appropriate For the Climate?

… may be totally wrong for the same indoor condition in St. Louis, MO

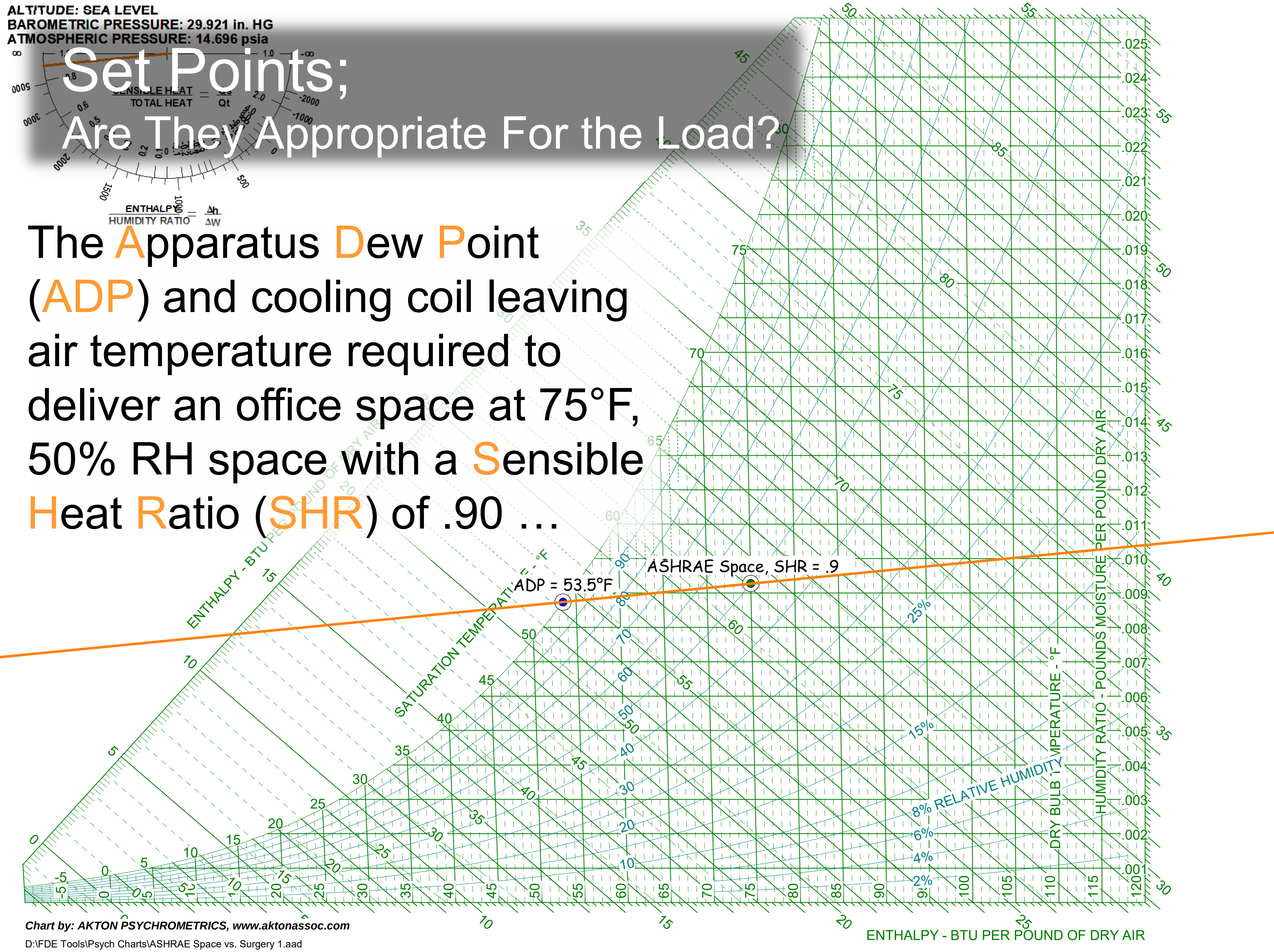


Set Points

Are They Appropriate for the Load?

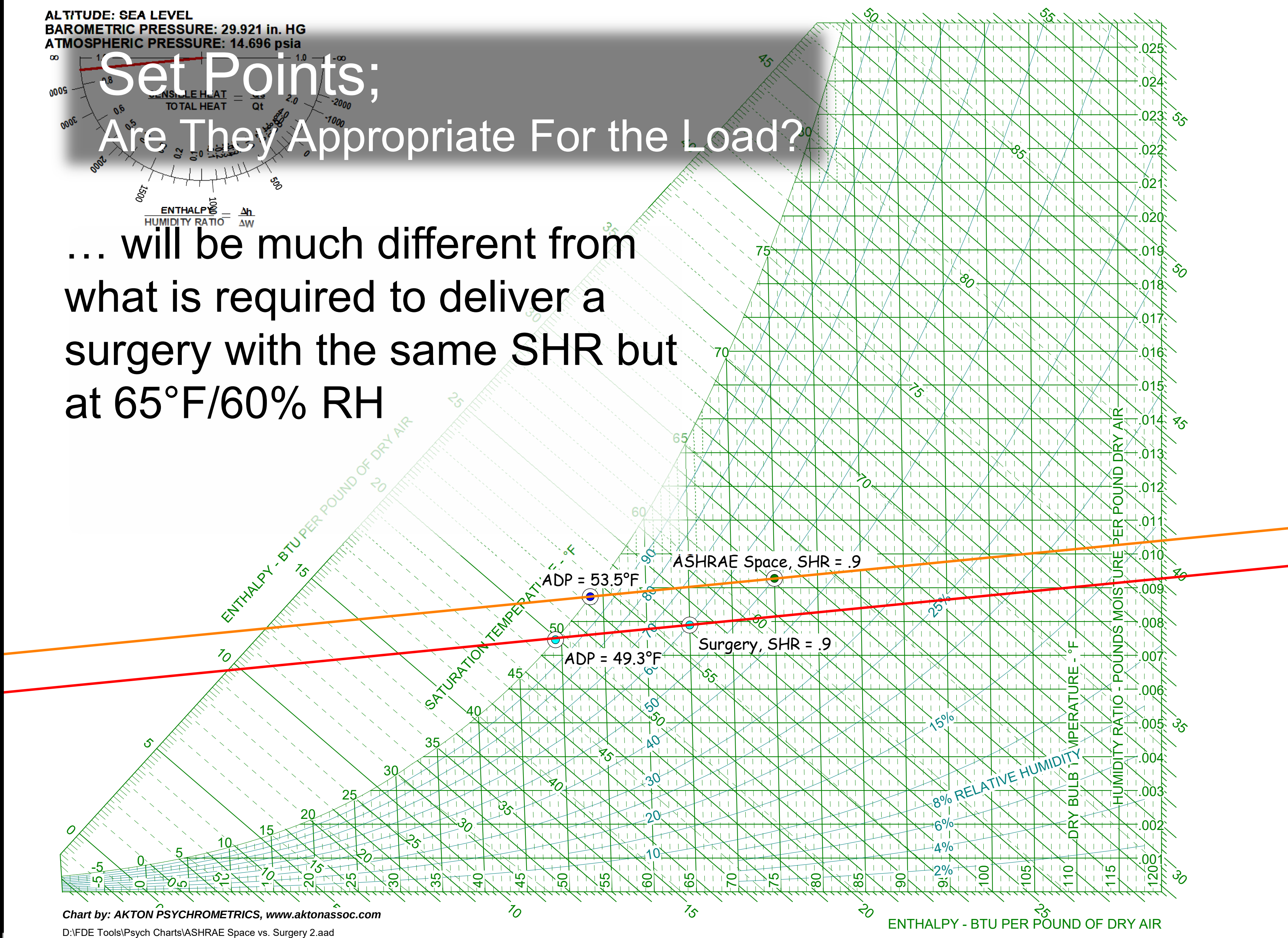
Set Points;
Are They Appropriate For the Load?

The Apparatus Dew Point (ADP) and cooling coil leaving air temperature required to deliver an office space at 75°F, 50% RH space with a Sensible Heat Ratio (SHR) of .90 …



Set Points;
Are They Appropriate For the Load?

… will be much different from what is required to deliver a surgery with the same SHR but at 65°F/60% RH



Set Points;

Set Point Reset; Not 1 Size Fits All?

- In the San Francisco Bay area, it is not uncommon to see Air Handling Unit (AHU) Leaving Air Temperature (LAT) reset schedules that reset the LAT to 65°F (or higher) under low load conditions
- The same reset schedule may be a really bad idea in hot and humid climates like St. Louis, Missouri or Honolulu Hawaii

Set Points

Are They Appropriate for the Equipment Selections?

Set Points;

Are They Appropriate for the Equipment Selection?

Two Cooling Towers Selected for the Same Load Requirement

- Best first cost tower
  - 60 bhp
  - 69.5 gpm/hp
  - $7,230 per year for fan energy
- Best life cycle cost tower
  - 40 bhp
  - 105.8 gpm/hp
  - $4,810 per year for fan energy
  - Fan energy savings = $2,420 per year

UPDATE™ Version 5.2.0
Product Data: 11/14/2016 (Current)

11/26/2016 12:54:44 PM

Job Information

Region	North America
Product Type	Cooling Towers
Electrical Source	60 Hz
Labor Rate	50 USD/h

Selected By

Facility Dynamics Engineering
NW Satellite Office
8560 North Buchanan Avenue
DSellers@FacilityDynamics.com
David Sellers
Tel 503-286-1494

SPX Cooling Technologies Contact

TraneOregon
7257 SW Kable Lane
Portland, OR
ddriver@trane.com
Tel 503-620-8031

Design Conditions

Solve For	Capacity
Tolerance Under Design	5 %
Number of Cells	2
Tower Water Flow	3450 gpm
Hot Water Temperature	86 °F
Cold Water Temperature	76 °F
Total Heat Load	17216000 Btu/h
Wet-Bulb Temperature	66 °F

Evaluation Parameters

Energy Cost	0.08 $/kWh
Annual Operating Time	2000 h
Evaluation Period	1 years
Interest Rate	10 %
Cold Water Set Point	76 °F
Average Wet-Bulb	66 °F
Range at Avg. Wet-Bulb	10 °F
Maximum Wet-Bulb	66 °F
Wet-Bulb Profile	Linear
Fan Operation	Single-Speed
Motor Efficiency	90 %

Advanced

Sound Requirements

Calculation	Single Cell
Location	Air Inlet
Distance from Product	5 ft
Maximum SPL	NA

Product
NC Steel

Sound Location
Air Inlet Face

Selections

Model	Cells	Status	Fan Motor Output BHp	Total Fan Motor Output BHp	Capacity	Cost Ratio	ASHRAE 90.1 Perf. gpm/Hp	Fan Energy Cost $	Pump Energy Cost $	dBA Single Cell
NC8405UAN2	2	Caution	50.0	100.0	99.2%	0.92	41.5	12050	1667	84
NC8405ULN2	2	Caution	50.0	100.0	97.9%	0.92	41.0	12050	1667	82
NC8405TAS2	2	Caution	40.0	80.0	99.0%	1.00	51.7	9640	1667	84
NC8405UAS2	2	CTI	50.0	100.0	103.5%	1.00	43.2	12010	1667	84
NC8405TLS2	2	Caution	40.0	80.0	97.2%	1.00	50.9	9640	1667	81
NC8405ULS2	2	CTI	50.0	100.0	102.3%	1.01	42.7	12020	1667	82
NC8407SAN2	2	CTI	30.0	60.0	100.0%	1.03	70.2	7230	1667	81
NC8407SLN2	2	Caution	30.0	60.0	99.3%	1.04	69.5	7230	1667	78
NC8407TAN2	2	CTI	40.0	80.0	109.2%	1.04	57.3	9520	1667	83
NC8407UAN2	2	CTI	50.0	100.0	117.4%	1.05	49.2	11790	1667	85
NC8407TLN2	2	CTI	40.0	80.0	105.3%	1.06	55.3	9570	1667	80
NC8407ULN2	2	CTI	50.0	100.0	115.6%	1.06	48.4	11810	1667	83
NC8407VAN2	2	CTI	60.0	120.0	123.1%	1.10	42.9	14070	1667	86
NC8407RAS2	2	Caution	25.0	50.0	98.8%	1.11	83.1	6030	1667	80
NC8407VLN2	2	CTI	60.0	120.0	121.2%	1.11	42.2	14090	1667	84
NC8407SAS2	2	CTI	30.0	60.0	104.8%	1.11	73.4	7180	1667	81
NC8407RLS2	2	Caution	25.0	50.0	97.4%	1.12	81.9	6030	1667	75
NC8407SLS2	2	CTI	30.0	60.0	106.0%	1.12	74.0	7170	1667	78
NC8407TAS2	2	CTI	40.0	80.0	114.2%	1.13	59.8	9470	1667	83
NC8409QAN2	2	CTI	20.0	40.0	100.7%	1.13	105.8	4810	1667	74

Set Points;
Are They Appropriate for the Equipment Selection?

Two Cooling Towers Selected for the Same Load Requirement

- Best first cost tower
  - 60 bhp
  - 69.5 gpm/hp
  - $7,230 per year for fan energy
- Best life cycle cost tower
  - 40 bhp
  - 105.8 gpm/hp
  - $4,810 per year for fan energy
  - Fan energy savings = $2,420 per year

Its likely that capturing the energy savings will require different set points for control processes related to the cooling tower fan operation

Set Point Bottom Lines

Control logic may be a *one size fit's all* proposition for similar system types and configurations

- The decision tree for operating a large VAV system can probably be applied to any similar system

- The decision tree for staging up the cooling towers for a variable flow, water cooled, primary only chiller plant can probably be applied to any similar system

Set Point Bottom Lines

The set points used by the *one size fit's all* decision tree will need to be tailored to the climate, load characteristics and equipment characteristics for each application

- The economizer high limit set point associated with the logic for a large VAV system in San Francisco, CA will be different for that same logic applied in St. Louis, MO

- The cooling tower staging and condenser water reset schedule will be different for a for a variable flow, water cooled, primary only chiller plant that has a mix of chiller types and sizes as compared to a plant with identical machines

Control System Building Blocks

Automatically adjust a piece of machinery to give us what we want by comparing what is going on to what we want to go on and making appropriate adjustments to the process we want to control

Inputs	Measure the process variable
Outputs	Adjust the controlled variable
Control Process	Logic and mechanisms that tries to bring the controlled variable into agreement with the set point
Set Point	Our requirements for the process that is under control, which can be fixed or variable

Control System Building Blocks

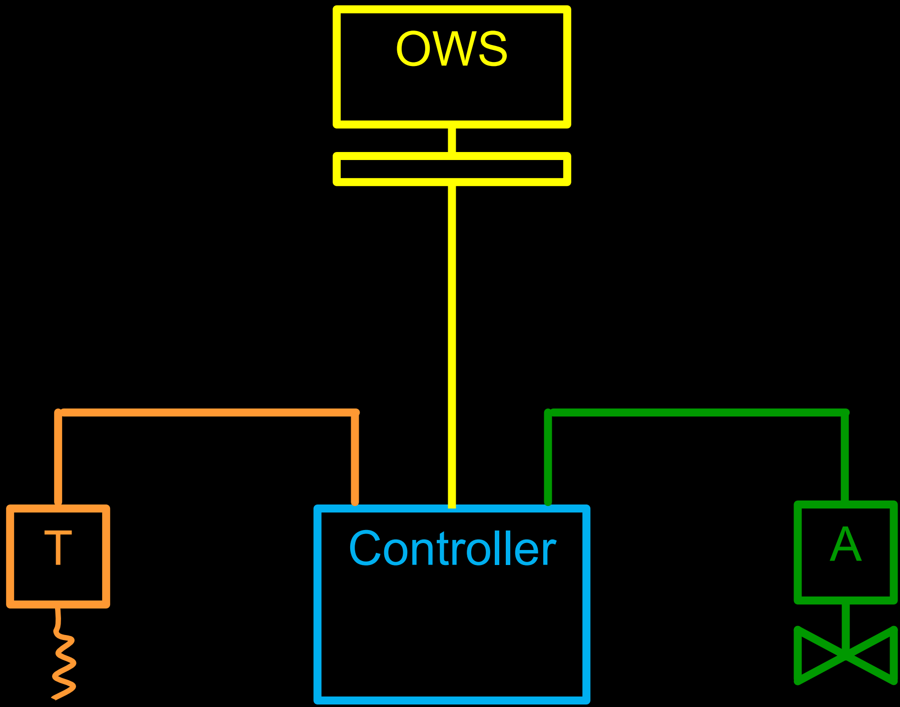
Automatically adjust a piece of machinery to give us what we want by comparing what is going on to what we want to go on and making appropriate adjustments to the process we want to control

Inputs

Outputs

Control Process

Set Point



Control System Building Blocks

Automatically adjust a piece of machinery to give us what we want by comparing what is going on to what we want to go on and making appropriate adjustments to the process we want to control

Inputs

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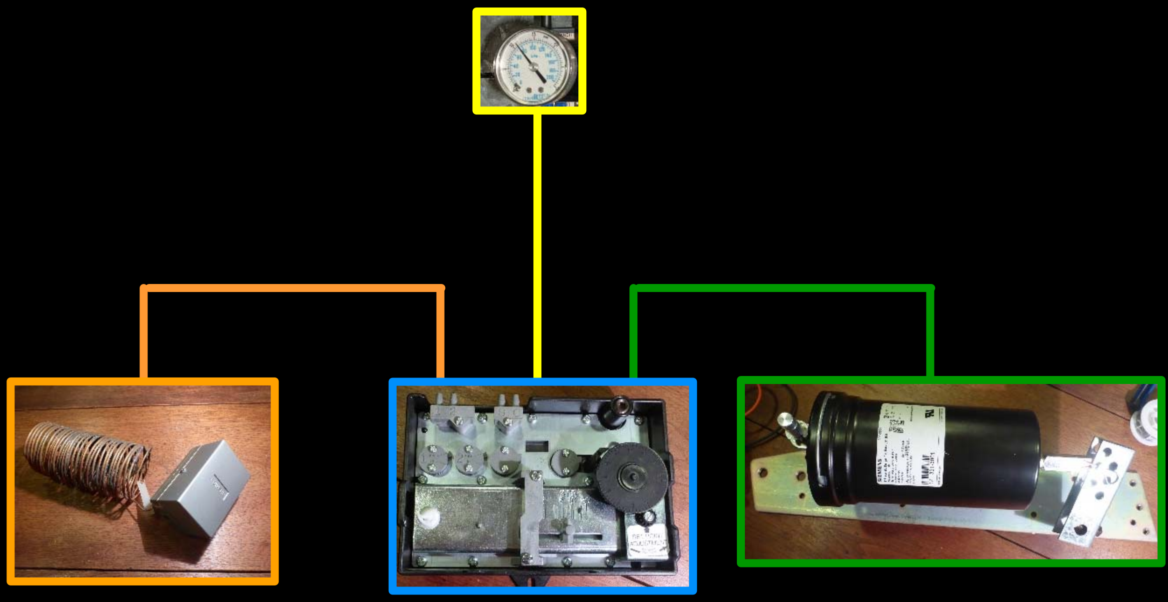
Set Point

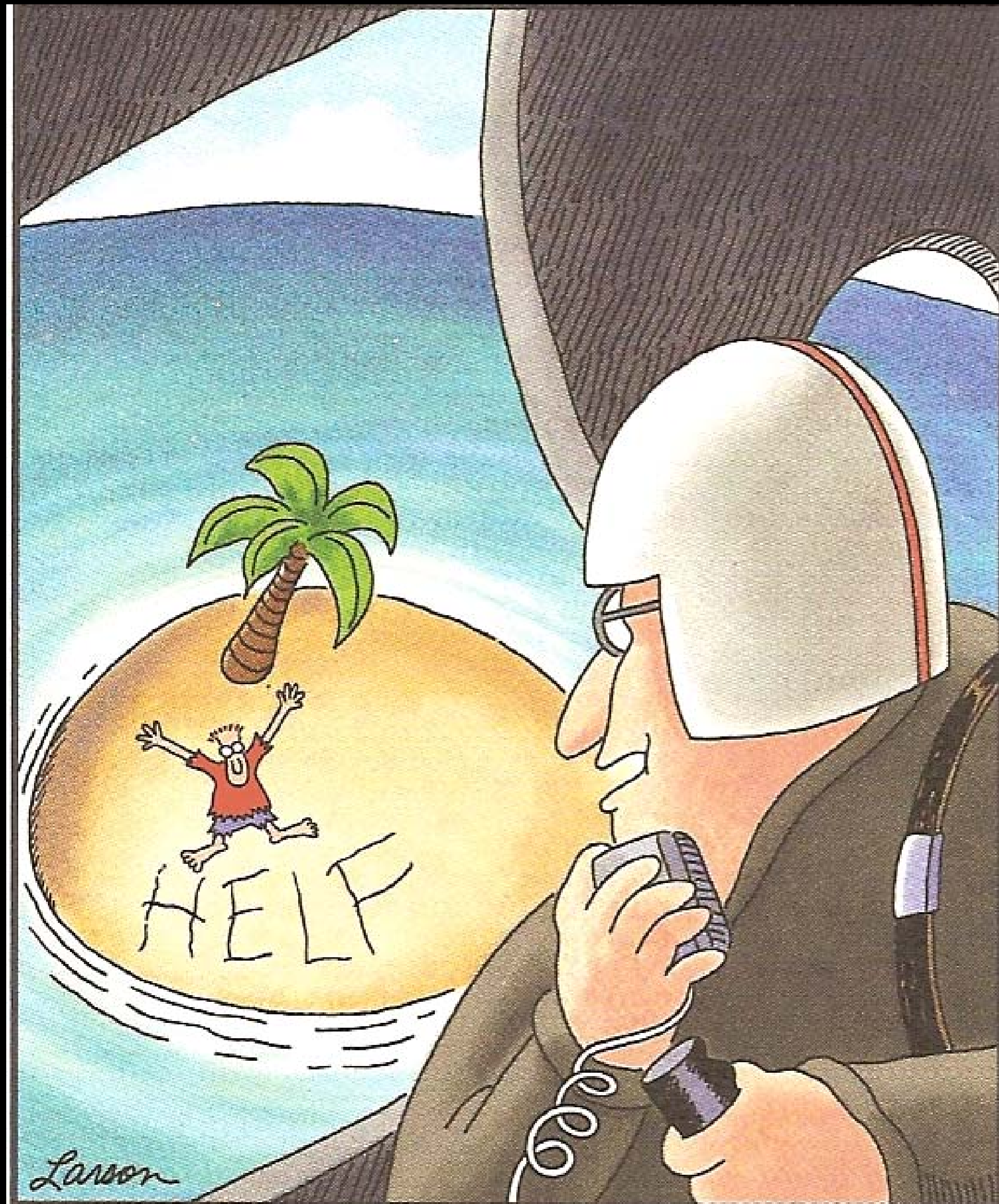


Bottom Lines

- Repeatable, Reliable, Robust control sequences and logic are essential to successfully capturing the design intent
- To be successful:
  - Capture all of the details associated with the design intent
  - Support the logic with repeatable, reliable, robust hardware
  - Support the logic with a physical configuration that will allow it to work as intended

Writing it All Down

- Documenting your sequence is an *Excellent* idea
- Using the English language to do it may provide a few challenges



"Wait! Wait! Cancel that. … I guess it says 'helf.'"

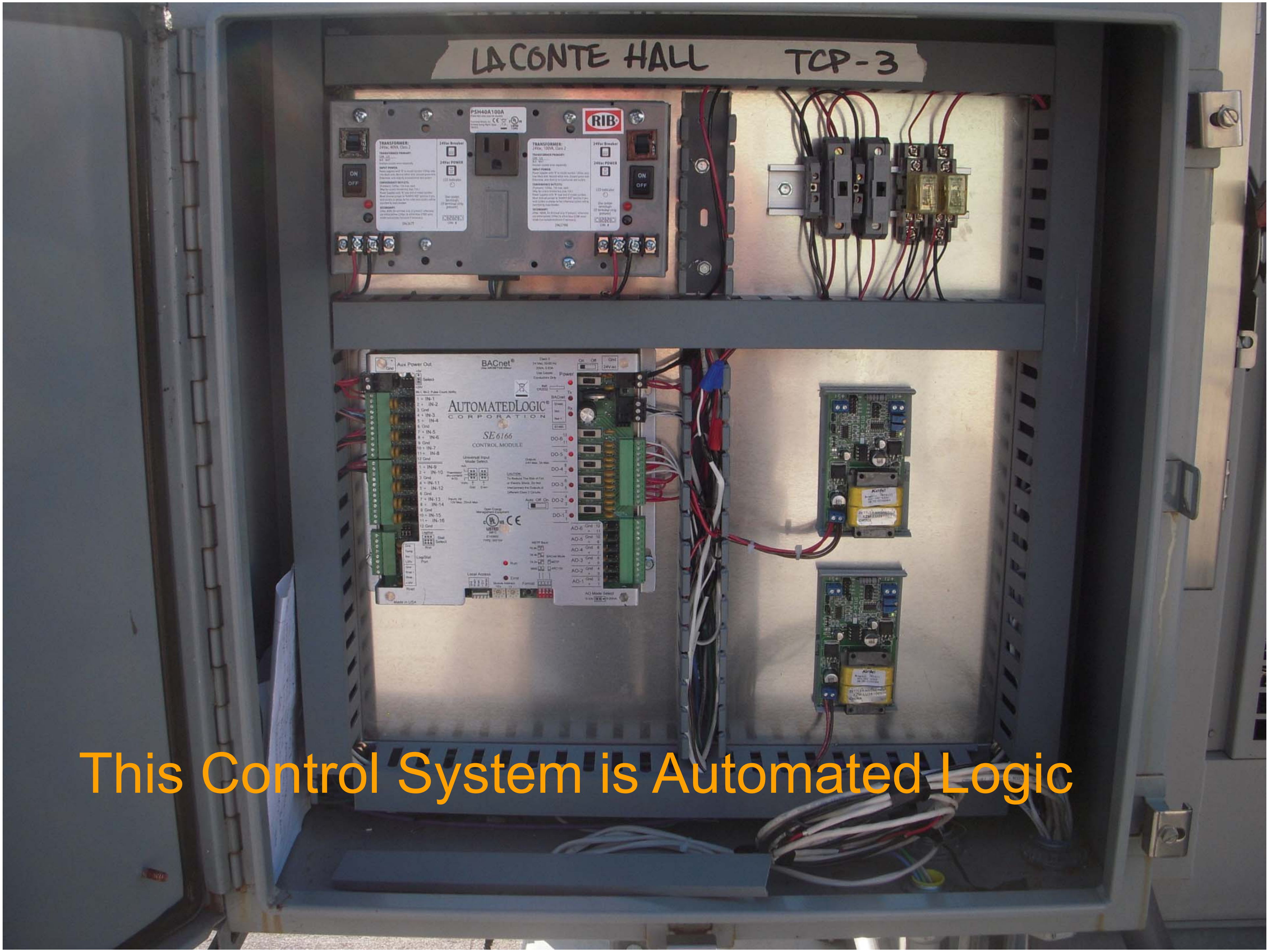
Does the text to the left say

Molly Poom

or

Wood Hollow?


THE MIRAGE
BEATLES
LOVE
THE MIRAGE
Clear Communication is Important



This Control System is Automated Logic

But in the general sense, so is this one

But in the general sense, so is this one, and this one

A Few Resources

Articles on Developing Control System Design and Logic Sequences

https://www.av8rdas.com/magazine-articles.html#Controls

https://www.av8rdas.com/magazine-articles.html#Lessons

Logic Diagram Tool with Examples

https://www.av8rdas.com/logic-diagram-tool.html

Examples of Control and Logic Standards

https://www.av8rdas.com/control-and-logic-diagram-standards.html

Logic Diagram Tools with Simulation Capability

https://www.av8rdas.com/eikon-for-educators-and-windlgc.html

Preparing for Next Geeks Class

Preparing for Next Weeks Class

Preparing for Next Weeks Class

1. Read through the article Jay Santos wrote about how to develop a control sequence. It is the file named CSE (02-2008_-_writing_control_sequences_vweb.pdf) which is located with several other articles at the first link in the previous slide.
2. Using the techniques Jay discusses:
   a. Consider a VAV reheat terminal
   b. Consider an air handling system with an air side economizer
3. Put together a bullet point or outline sequence of how you would go about controlling them
   a. What is the primary input required?
   b. What other inputs are required?
   c. What needs to be sequenced and how?
   d. Are their any interlocks required?

Preparing for Next Weeks Class
(Continued)

4. If you need a refresher on how a VAV reheat terminal works, you can review the *Terminal Unit Basics* slide module that is included with the Variable Air Volume Systems; Design Performance and Commissioning Issues class materials at this location.

   https://www.av8rdas.com/pacific-energy-center-design-performance-and-commissioning-issues-classes.html#VAV

5. If you need a refresher on how an air side economizer works, you will find several modules in the Economizers; Design Performance and Commissioning Issues class materials that will bring you up to speed. The files are located at this location.

   https://www.av8rdas.com/pacific-energy-center-design-performance-and-commissioning-issues-classes.html#Economizers

   You may also find these blog posts to be helpful:

   https://av8rdas.wordpress.com/category/economizers/page/2/