VAV Systems

Design, Performance and Commissioning Issues

Terminal Unit Basics

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Facility Dynamics Engineering

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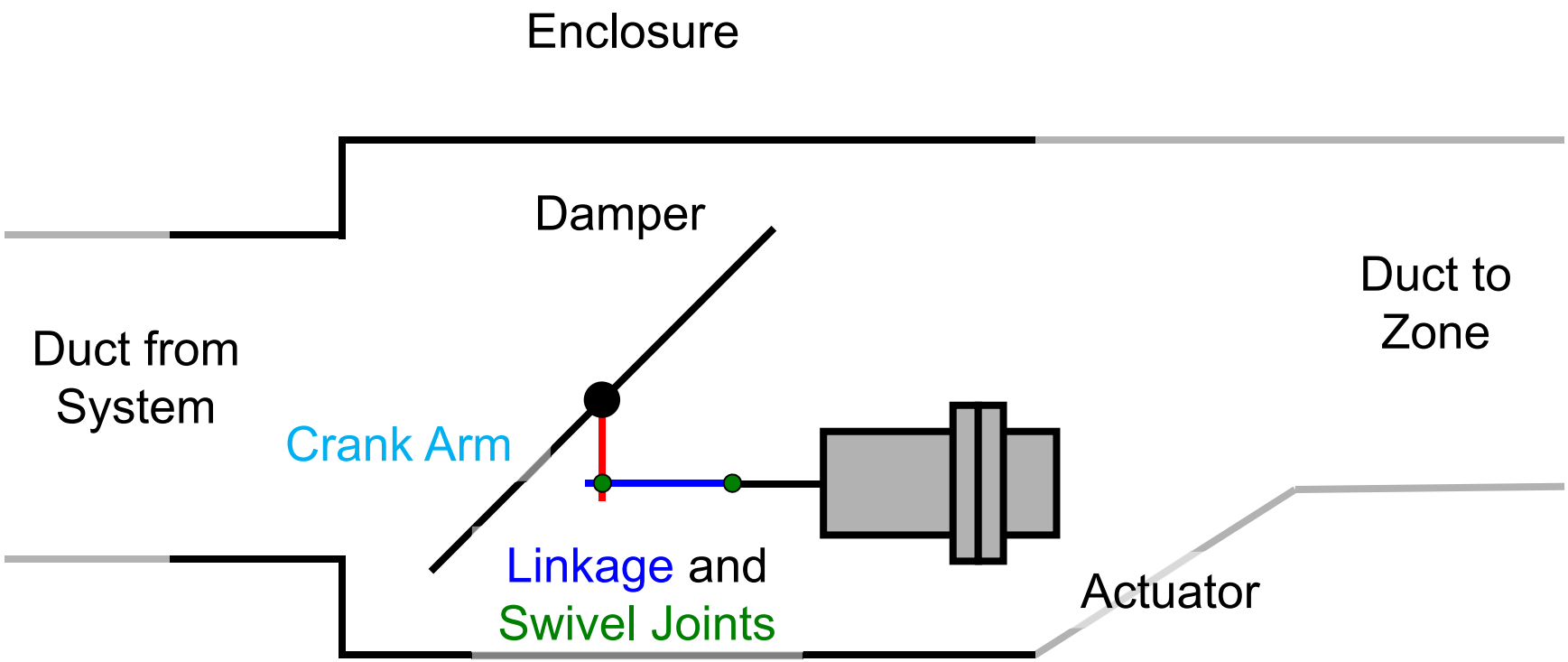
What's In This Module

- Your basic box:
  - Pressure dependent
  - Pressure independent
  - Fan powered boxes
  - Double duct boxes

Your Basic Box



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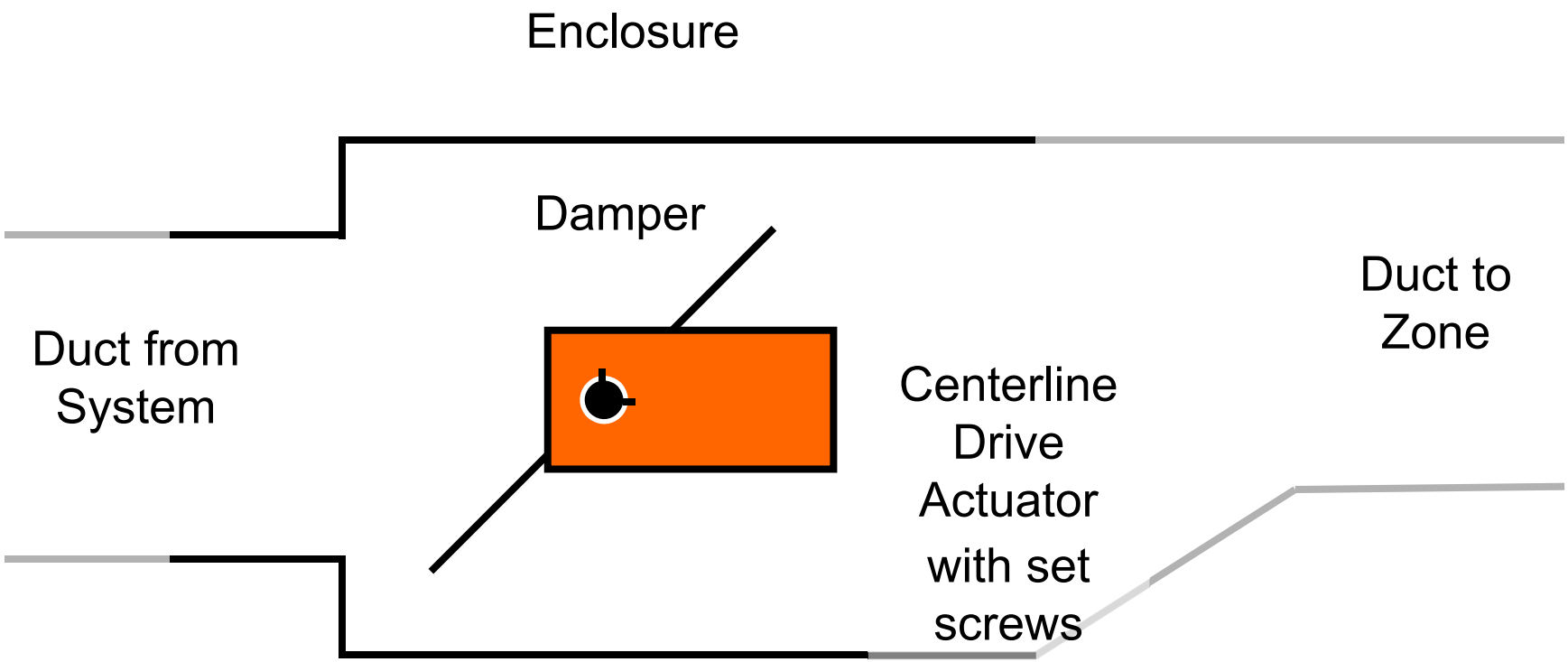

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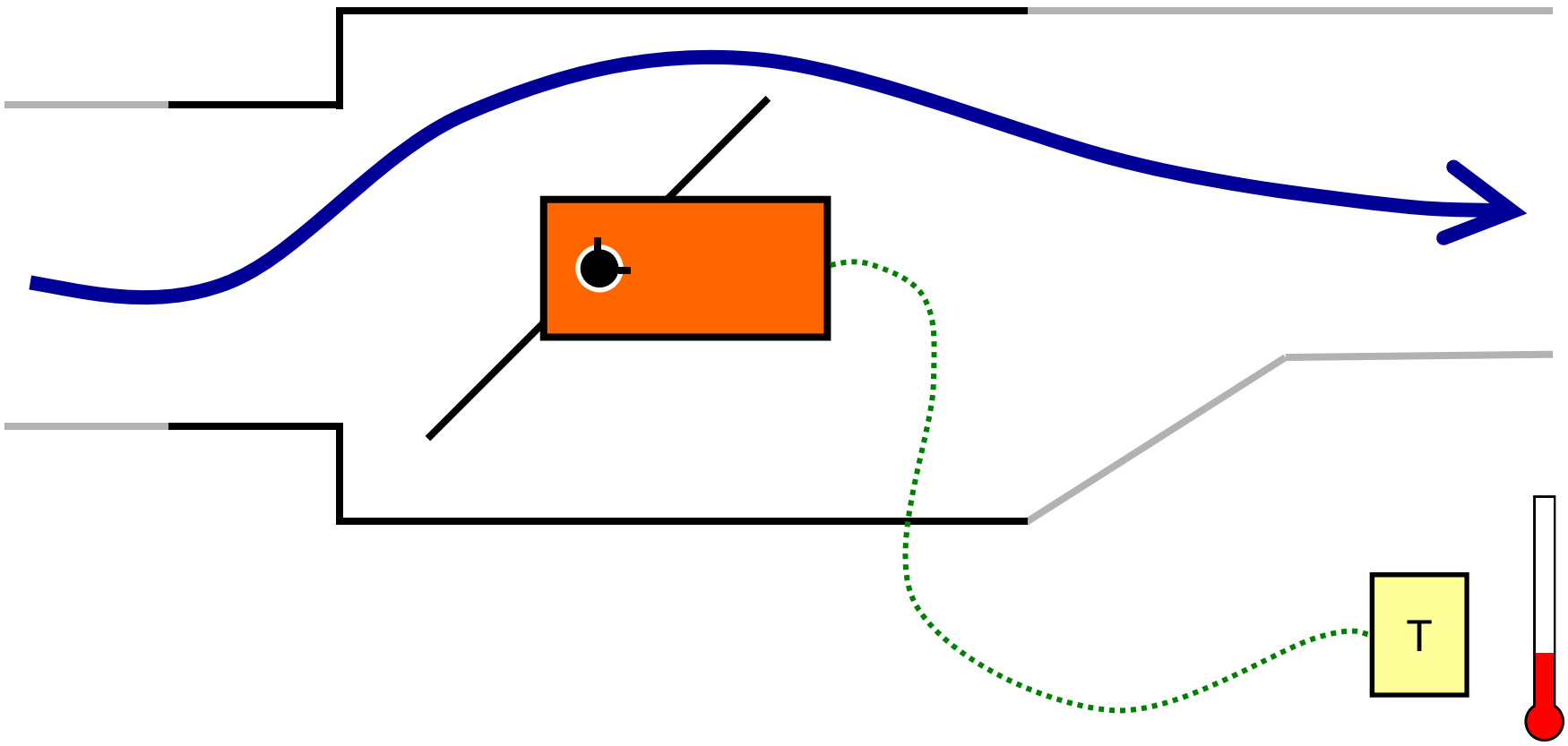

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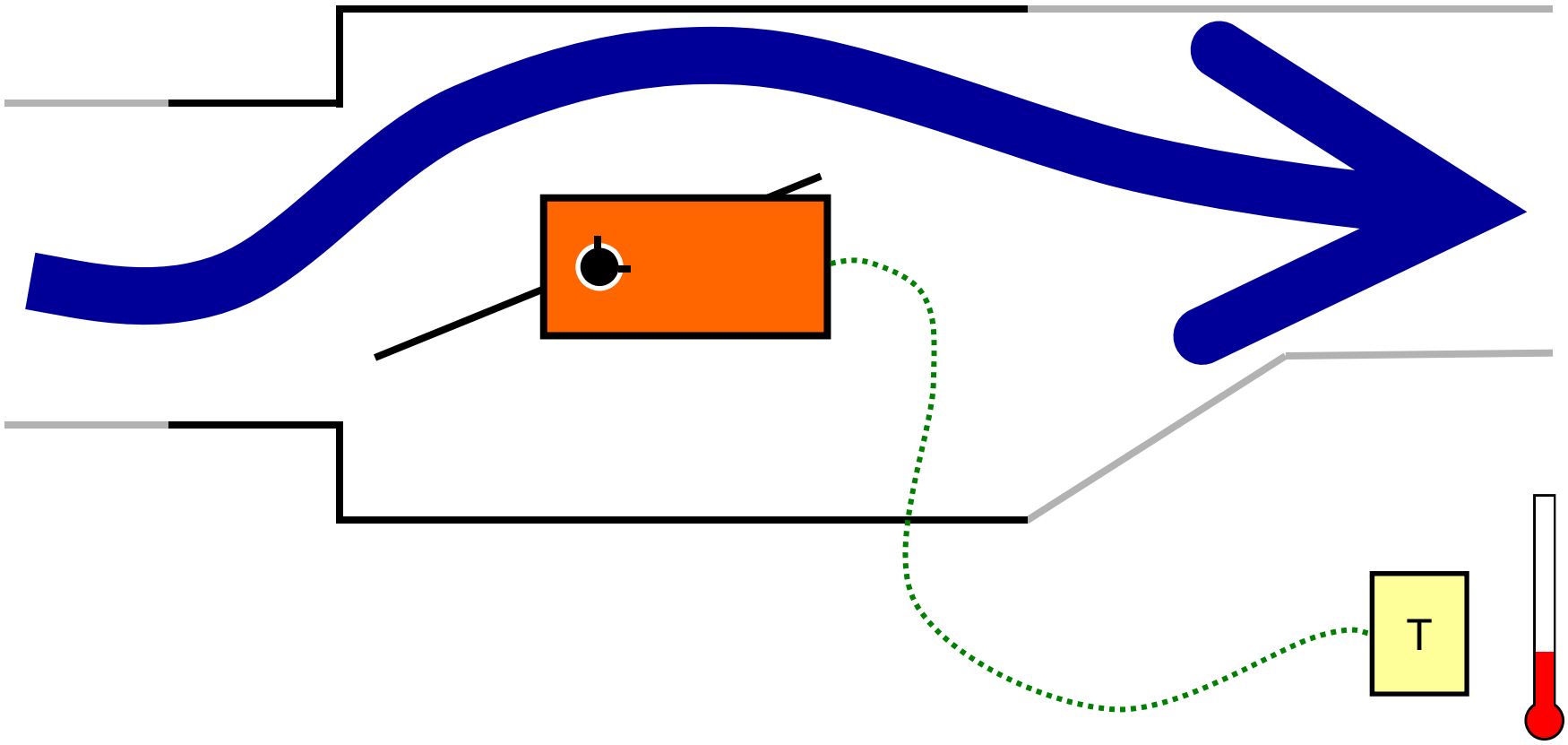

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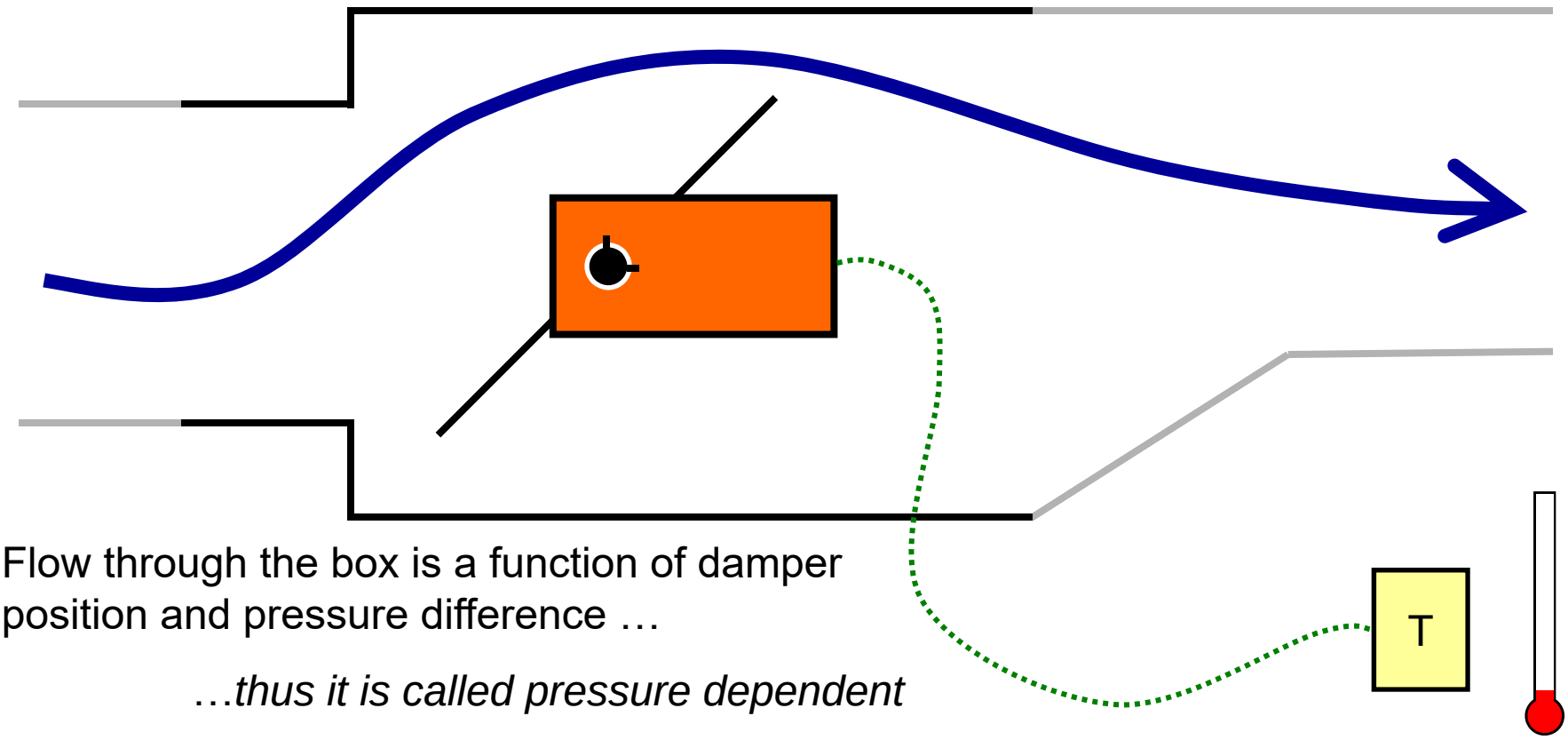
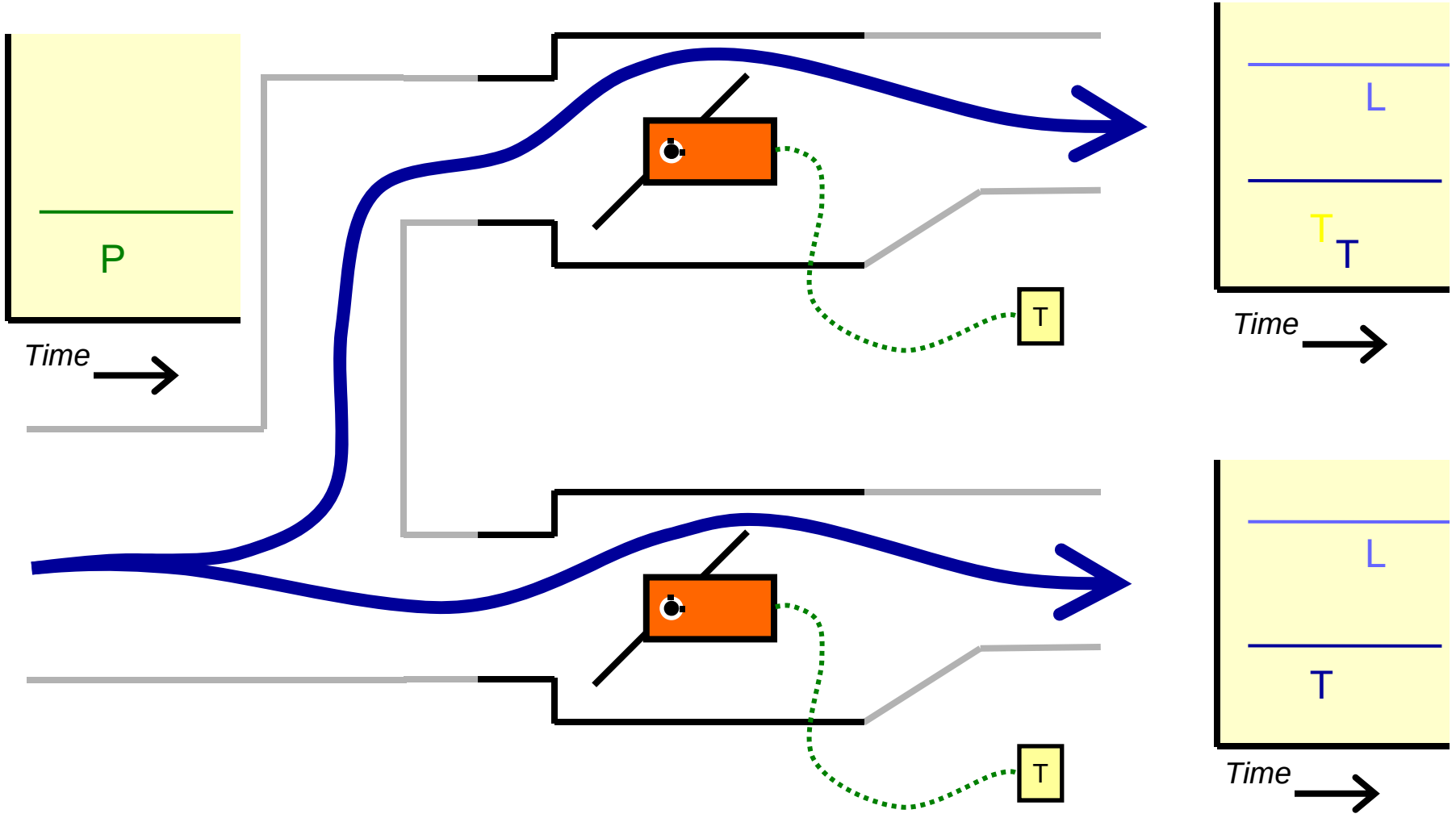


Flow through the box is a function of damper position and pressure difference …

…thus it is called pressure dependent

Your Basic Box



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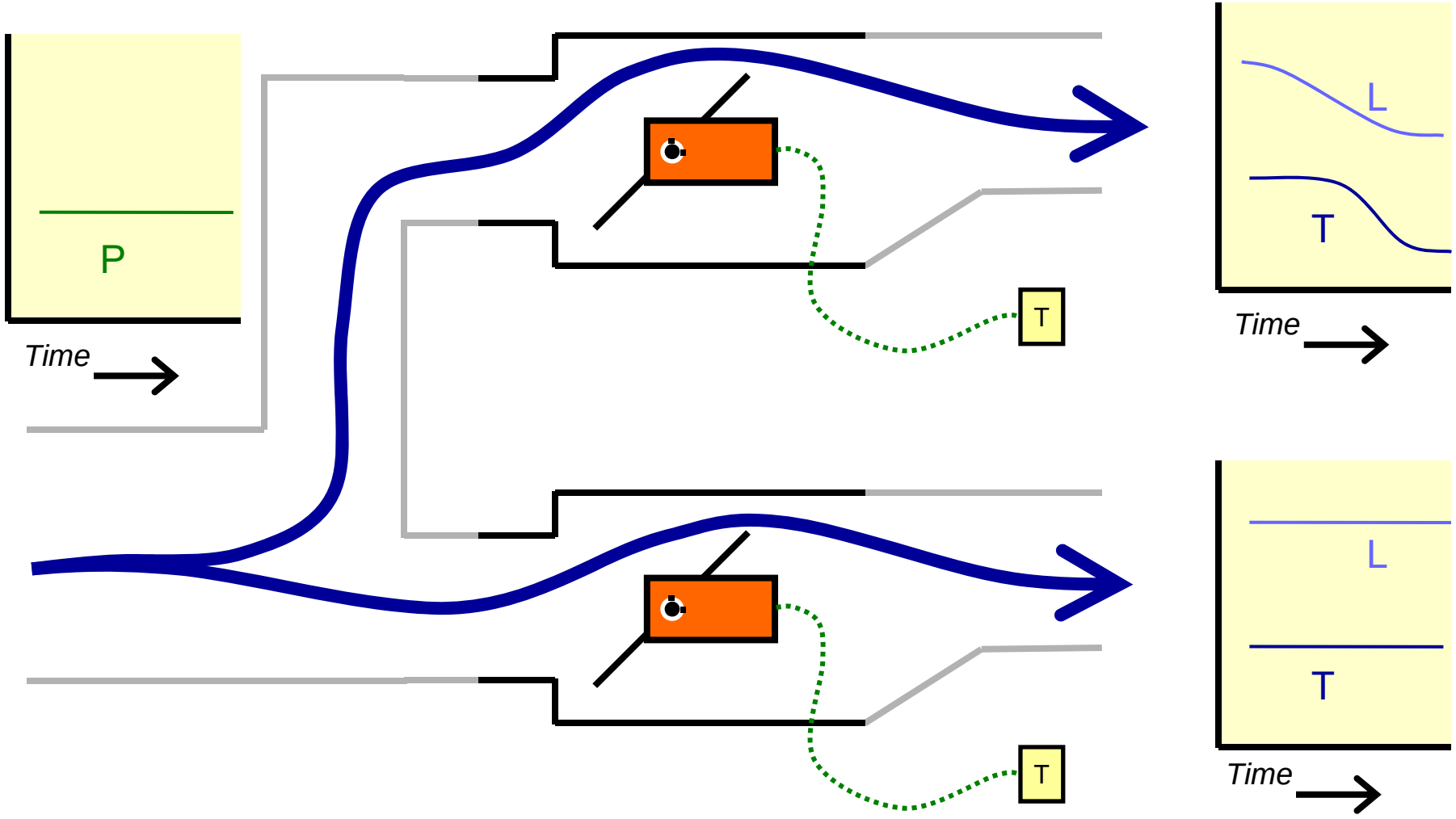

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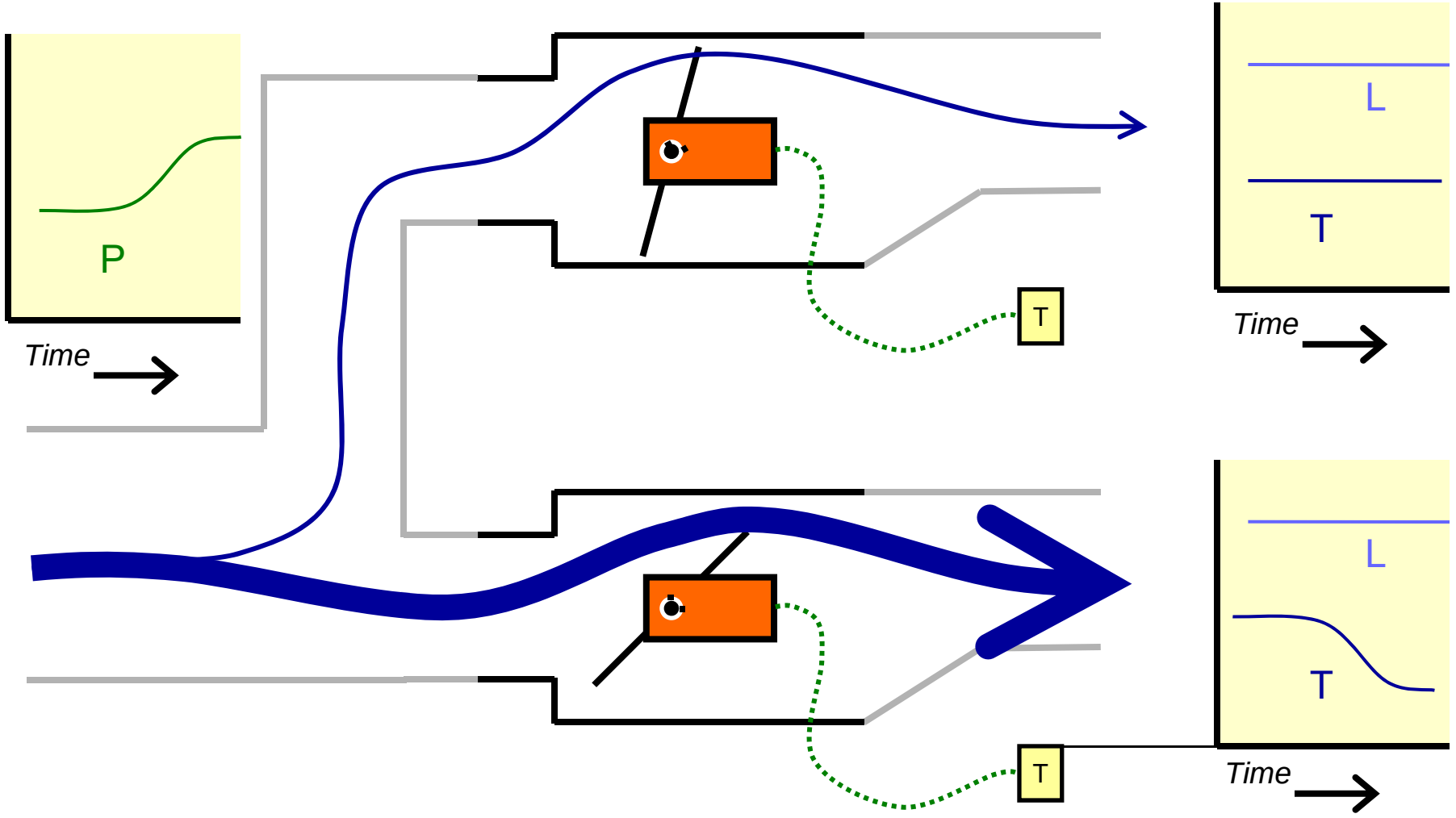

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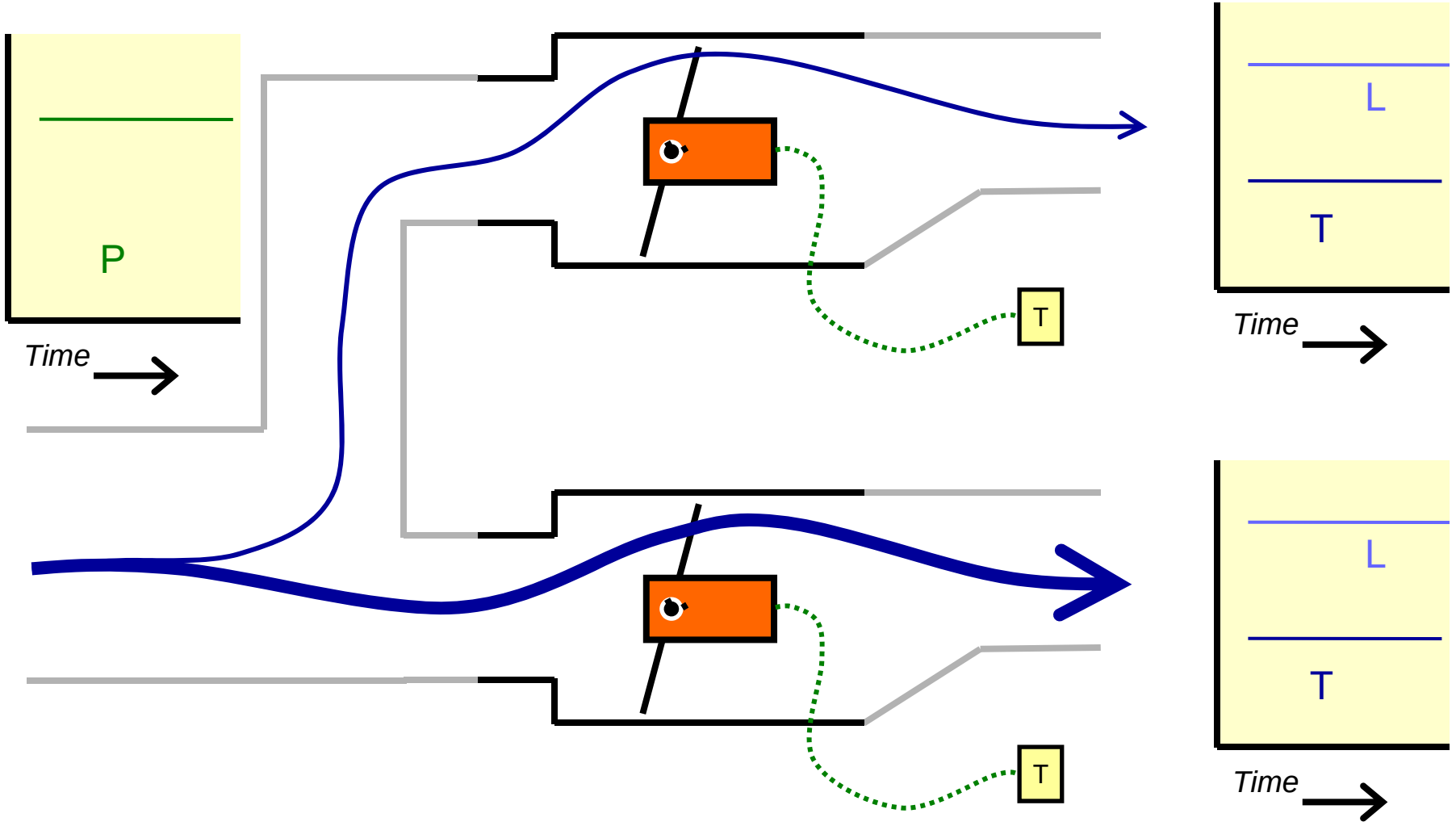
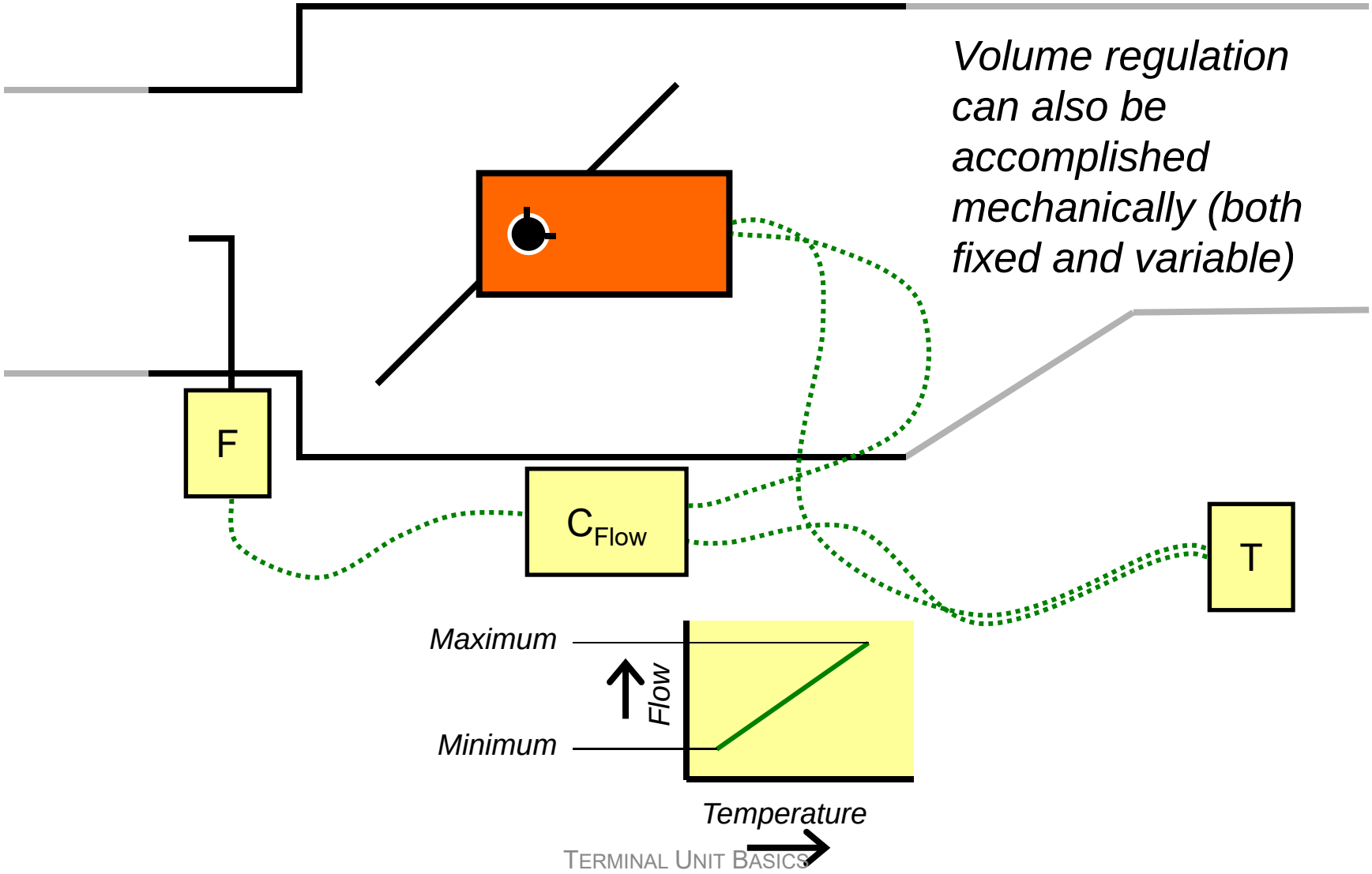


Becoming Pressure Independent



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.

Pneumatic vs. DDC Terminal Unit Controllers

DDC Terminal Units

- Newer technology
- No moving parts
- Maintenance on condition
- Can provide important diagnostics
  - Leaving air temperature
  - Current flow rate
- Can provide data useful for system optimization strategies
- Set points can be adjusted and verified from the OWS
- Performance can be verified from the OWS

Pneumatic Terminal Units

- Been around for a long time
- A lot of moving parts
- Don’t know the condition
- They are low first cost
- They are low first cost
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- They are low first cost

The Relationship Between Velocity and Velocity Pressure

12 inch VAV Box

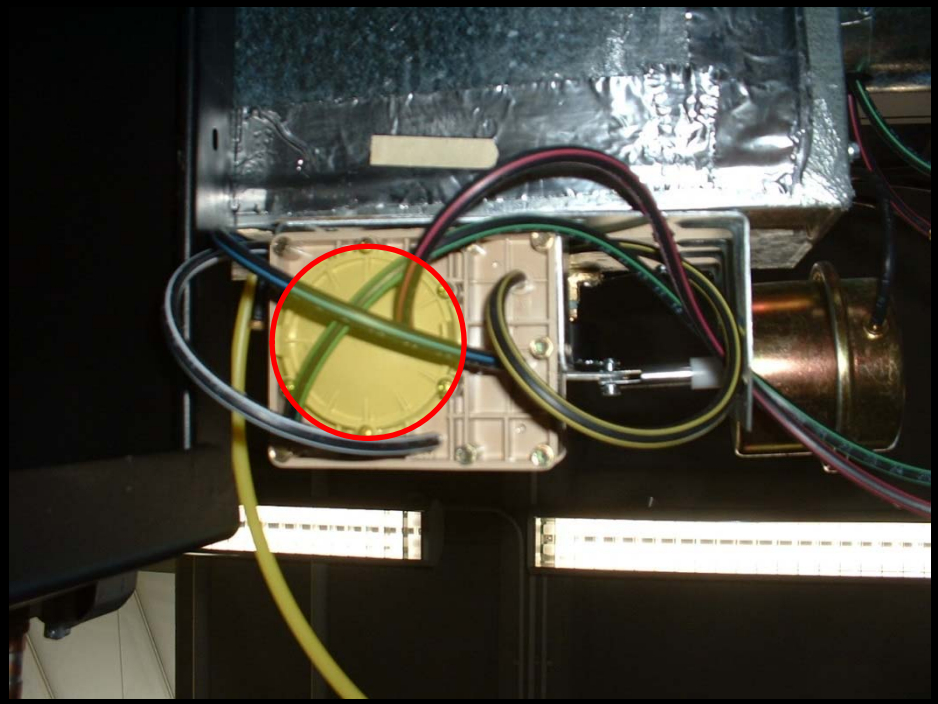
- Maximum flow
  - 2,000 cfm
  - VP = .2494 in.w.c.

- Minimum flow
  - 325 cfm
  - VP = .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 = 0.0465 lb
  - Force = 0.74 oz
- Minimum flow
  - 325 cfm
  - VP = 0.0066 in.w.c.
  - Force = 0.0017 lb
  - Force = 0.03 oz



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

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 Zones = Opportunity

Troubleshooting a Pneumatic Terminal

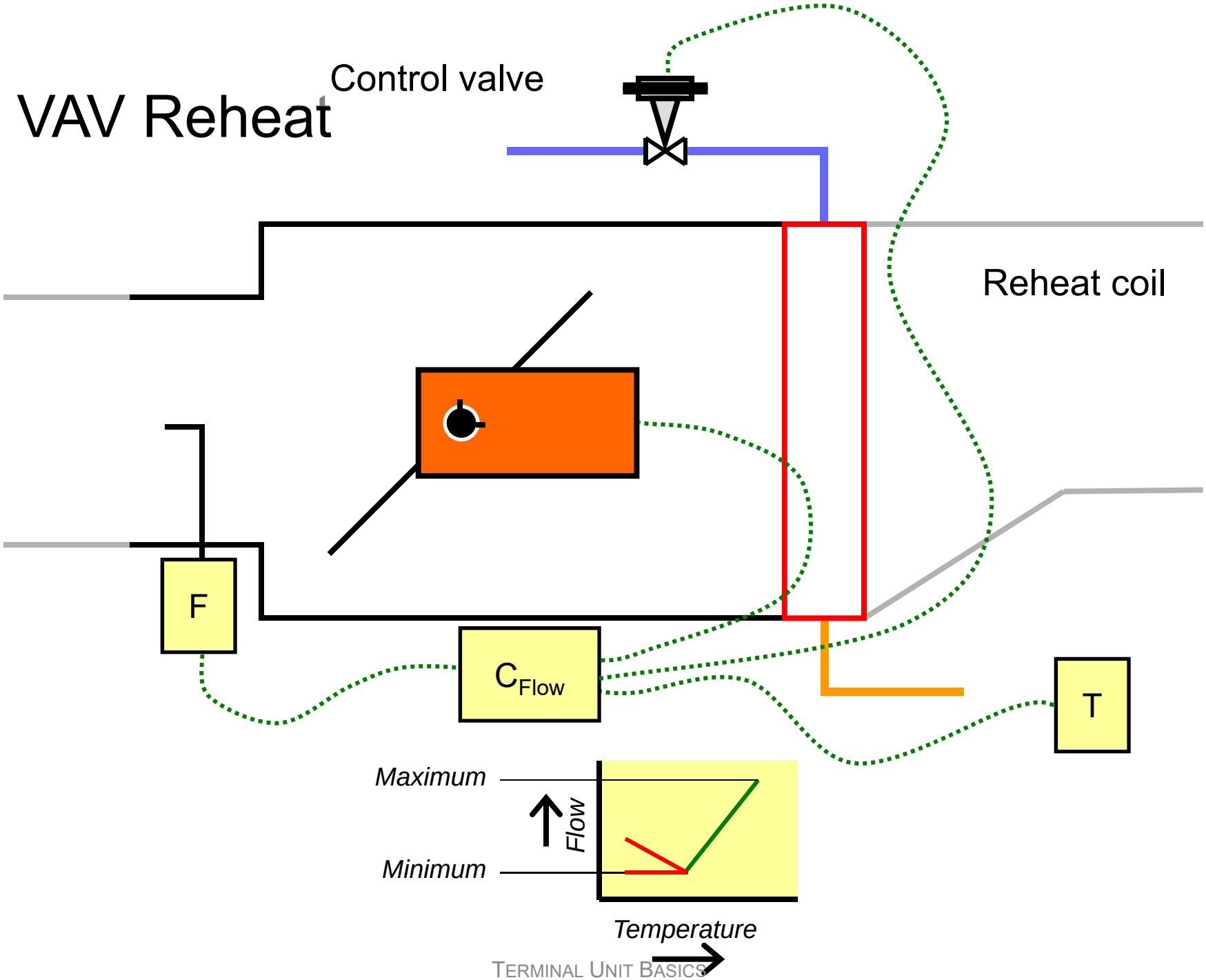
Troubleshooting a DDC Terminal

The Regulator

(PG13)

http://tinyurl.com/3kebw3s

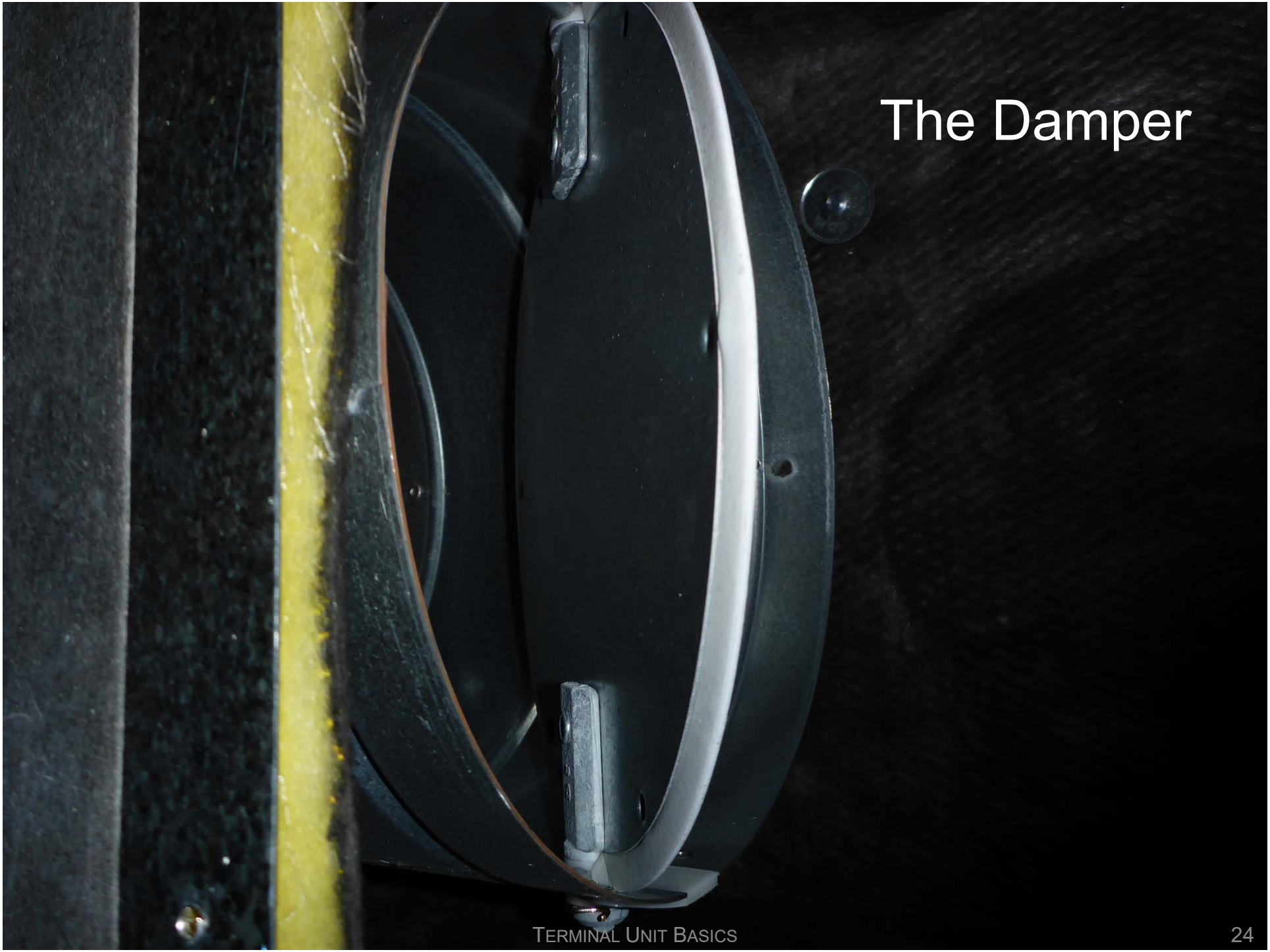
VAV Reheat


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

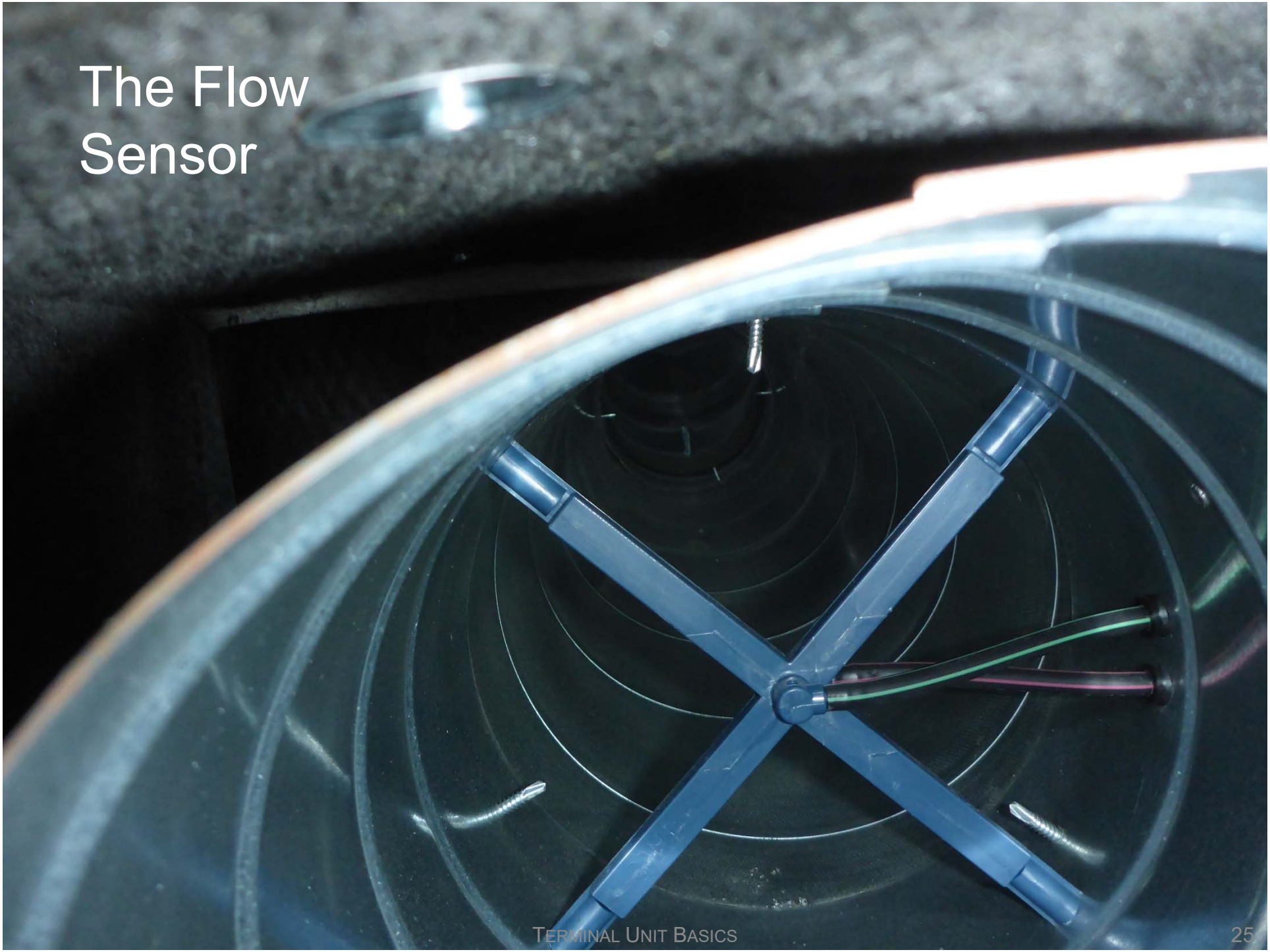
A Typical VAV Reheat Box

Overview

The Damper

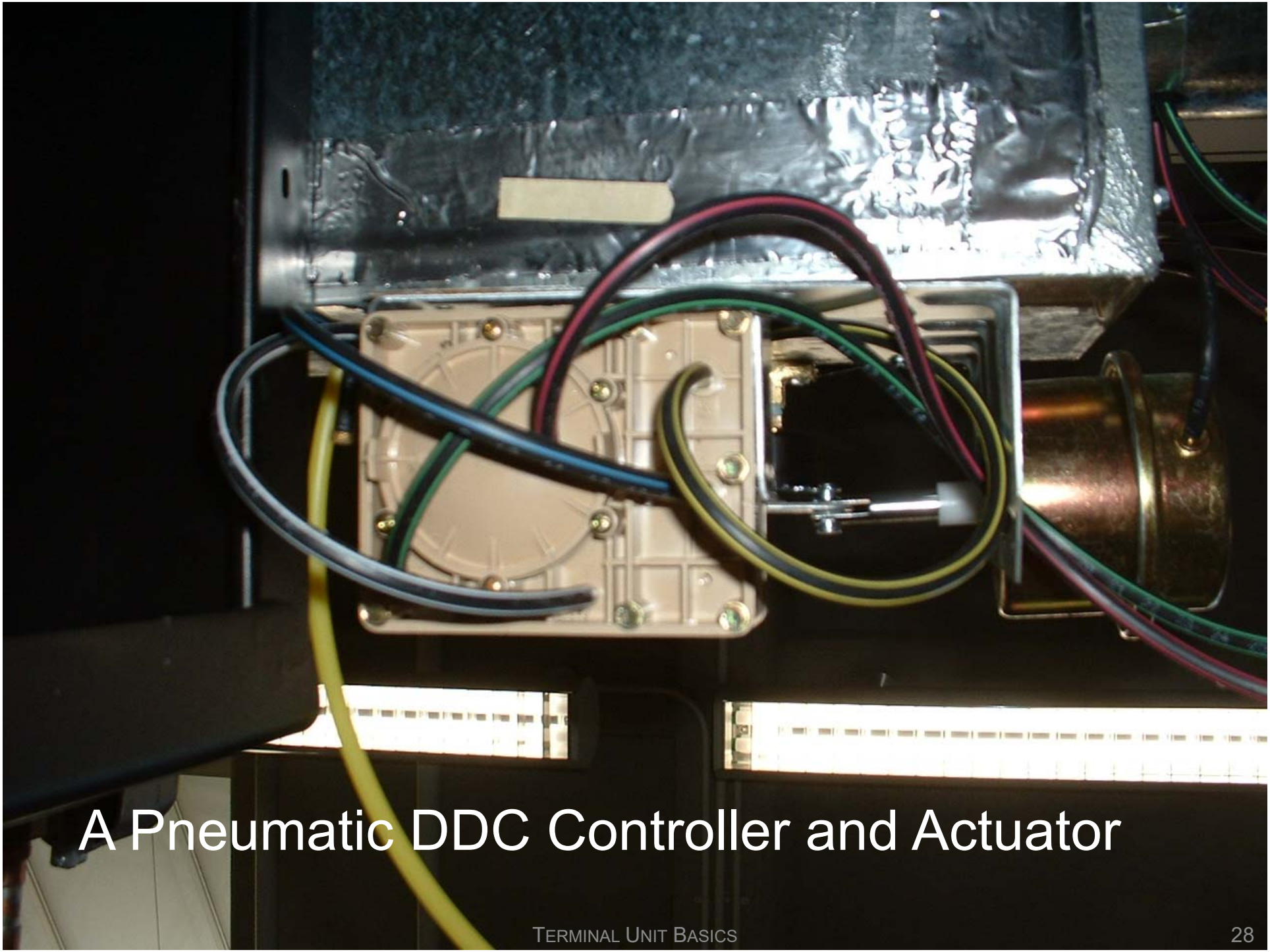


The Flow Sensor



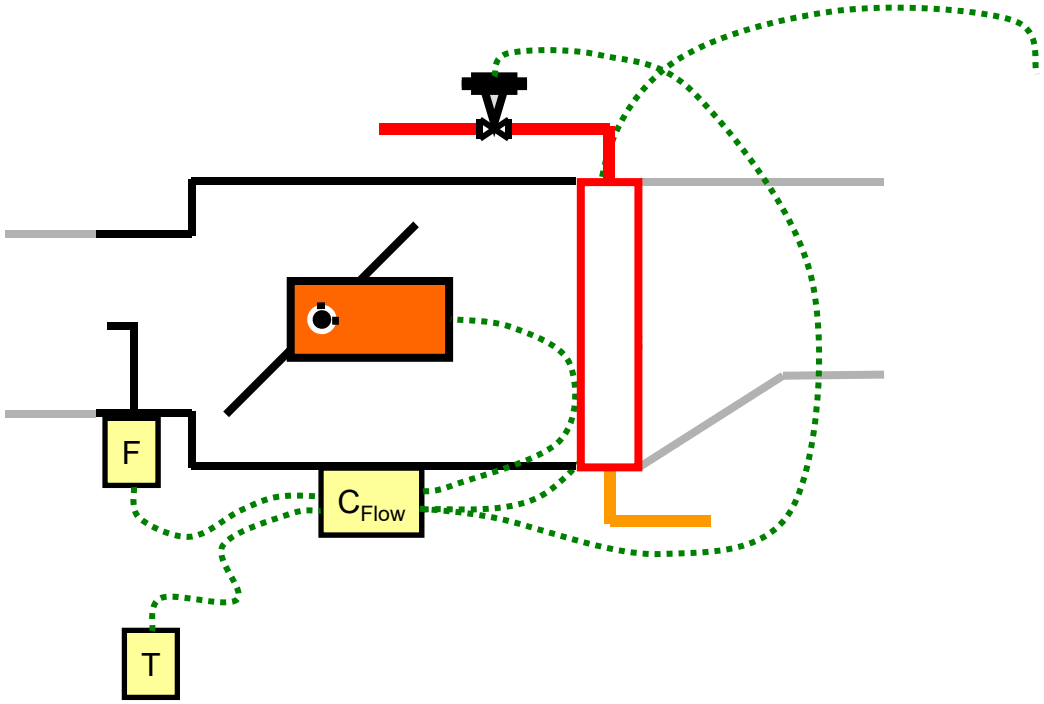
The Reheat Coil

The DDC Controller with Built In Actuator

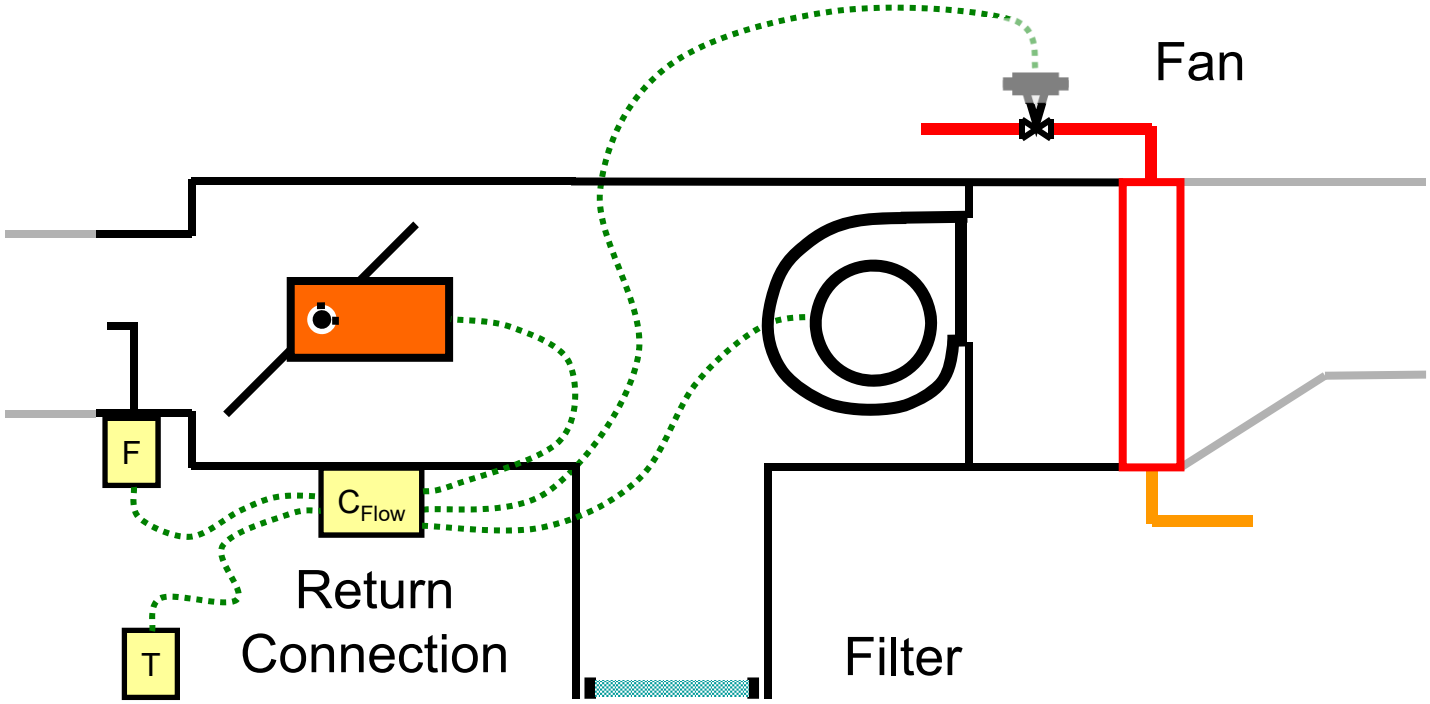


A Pneumatic DDC Controller and Actuator

Recovering Heat to Reheat Series Fan Powered Box



Recovering Heat to Reheat Series Fan Powered Box



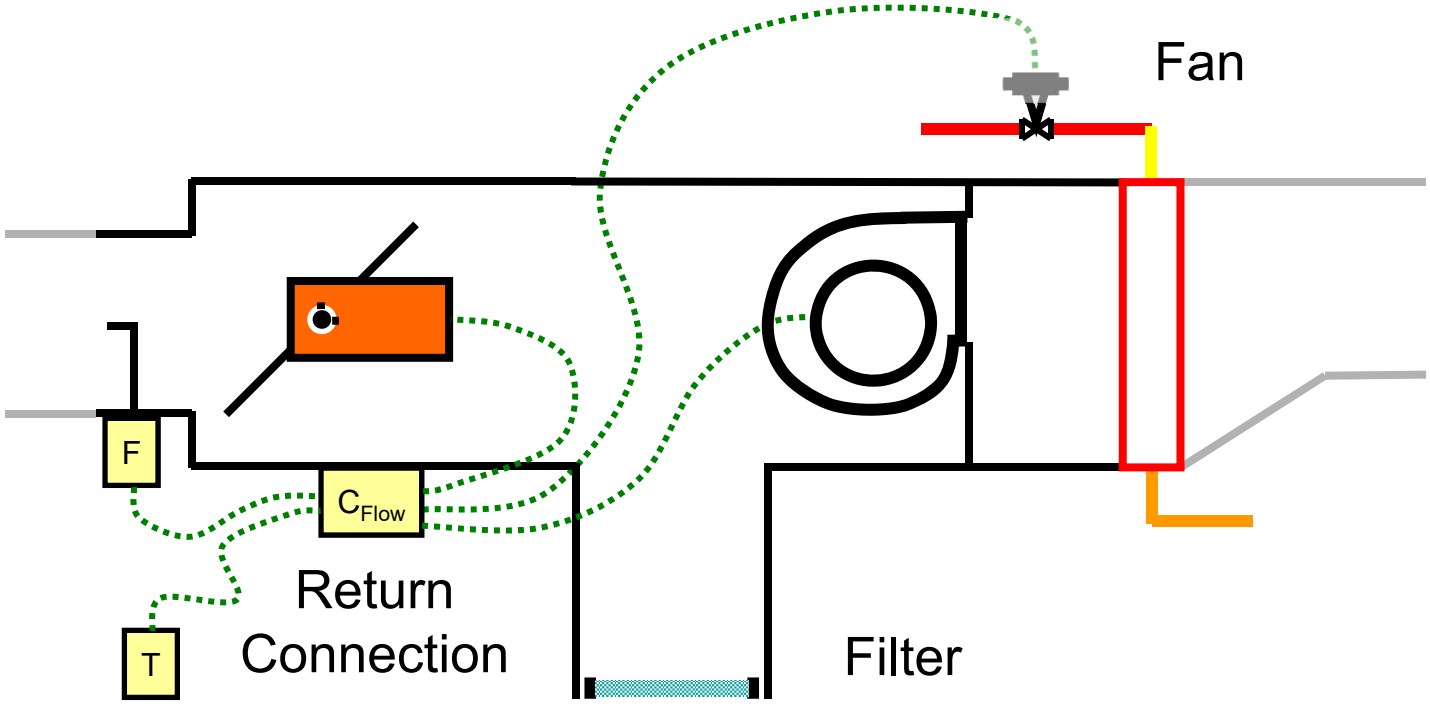
Fan runs continuously when the zone is occupied

- Tends to be constant volume

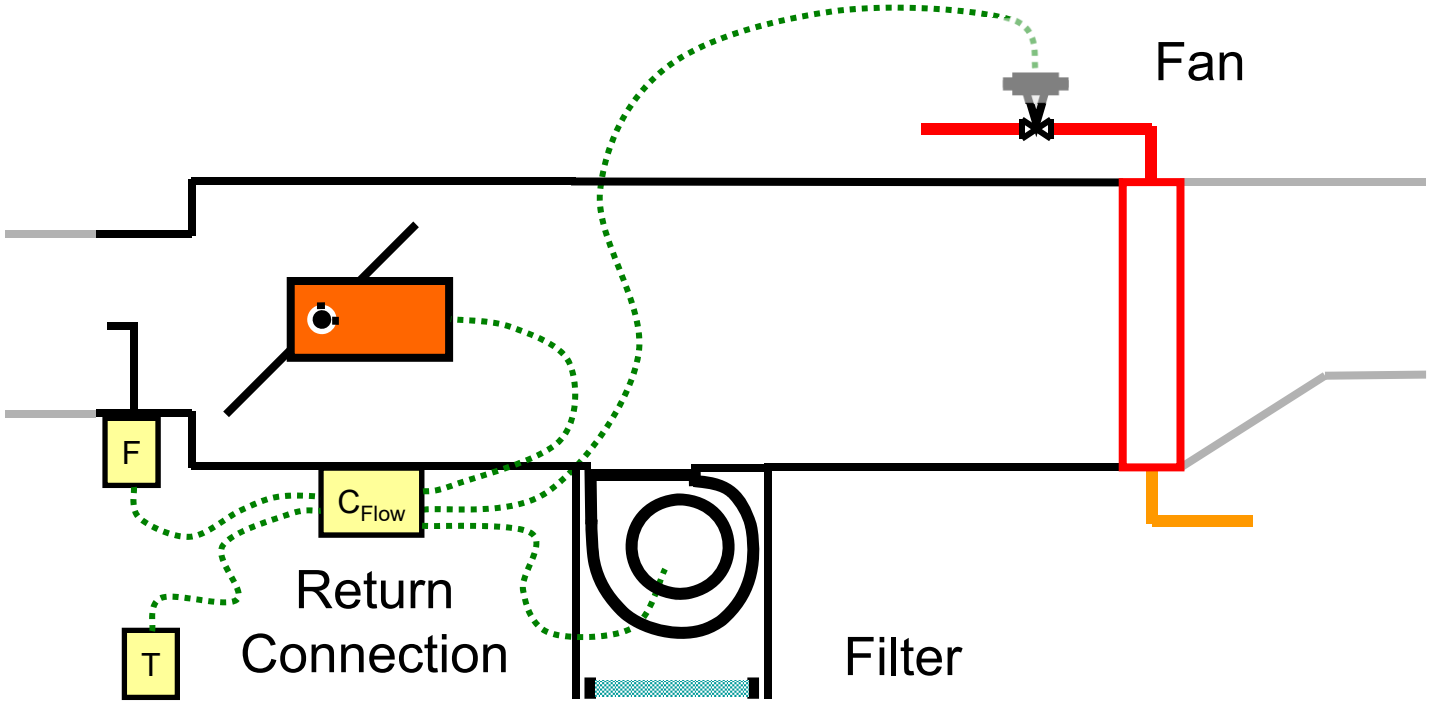
Reduction in primary flow (cooling air) is compensated for by increased return flow

- First stage of reheat
- Coil provides second stage

Recovering Heat to Reheat Series Fan Powered Box



Recovering Heat to Reheat
Parallel Fan Powered Box

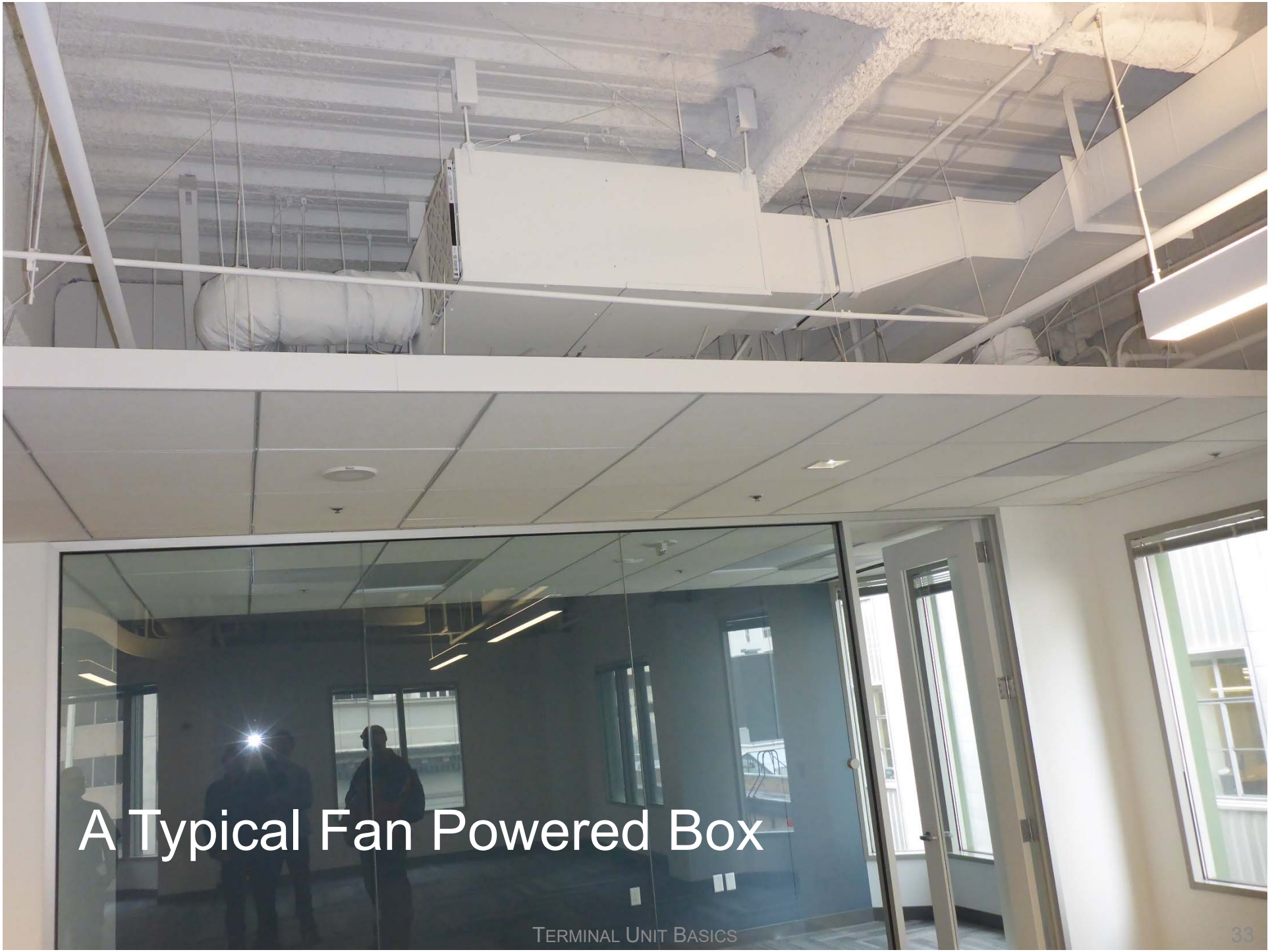


Fan runs intermittently when the zone is occupied

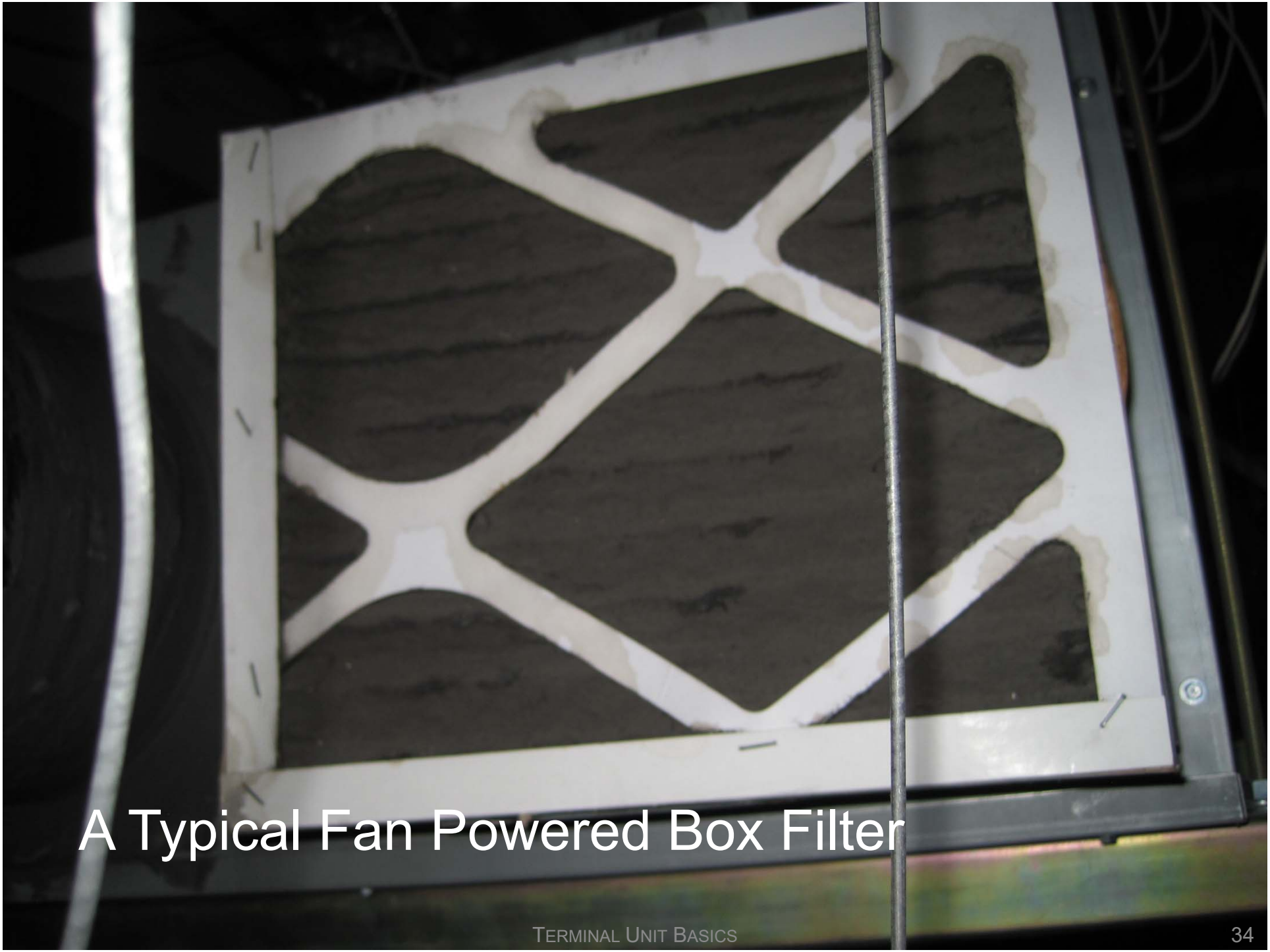
- Tends to be constant volume *when the fan runs*

Zone sees some reduction in flow until the fan starts

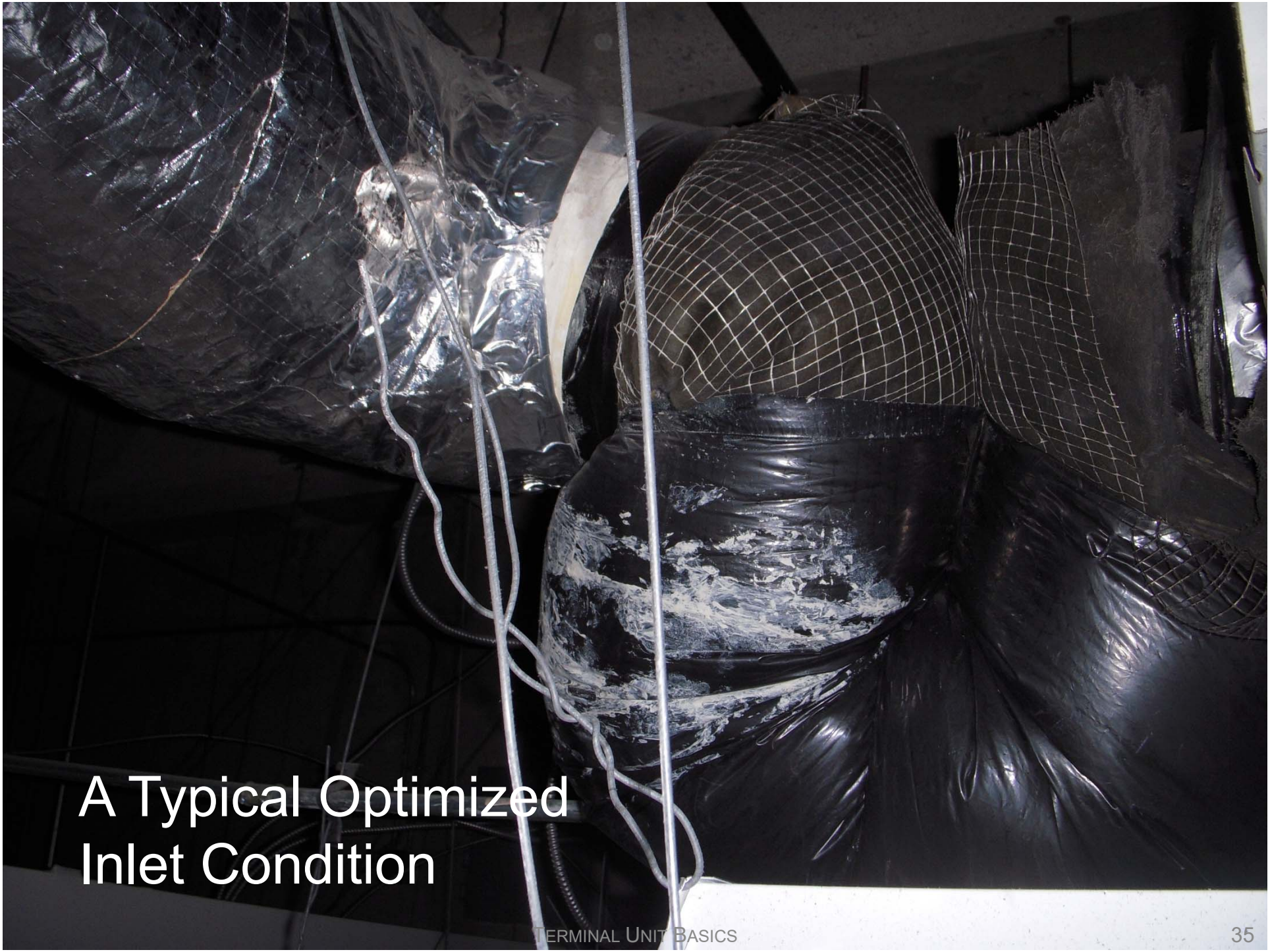
- First stage of reheat
- Coil provides second stage



A Typical Fan Powered Box

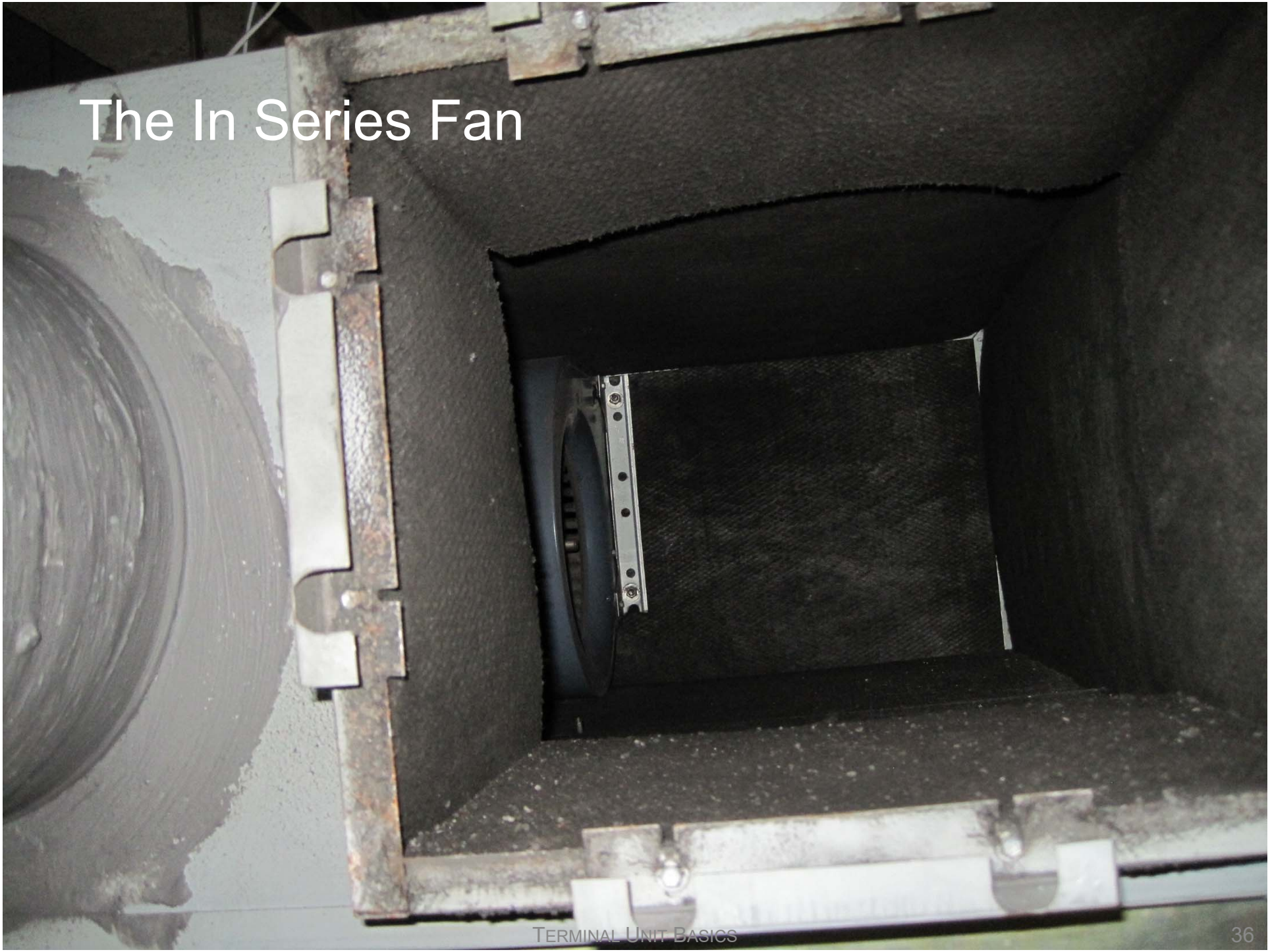


A Typical Fan Powered Box Filter



A Typical Optimized Inlet Condition

The In Series Fan



The In Series Fan

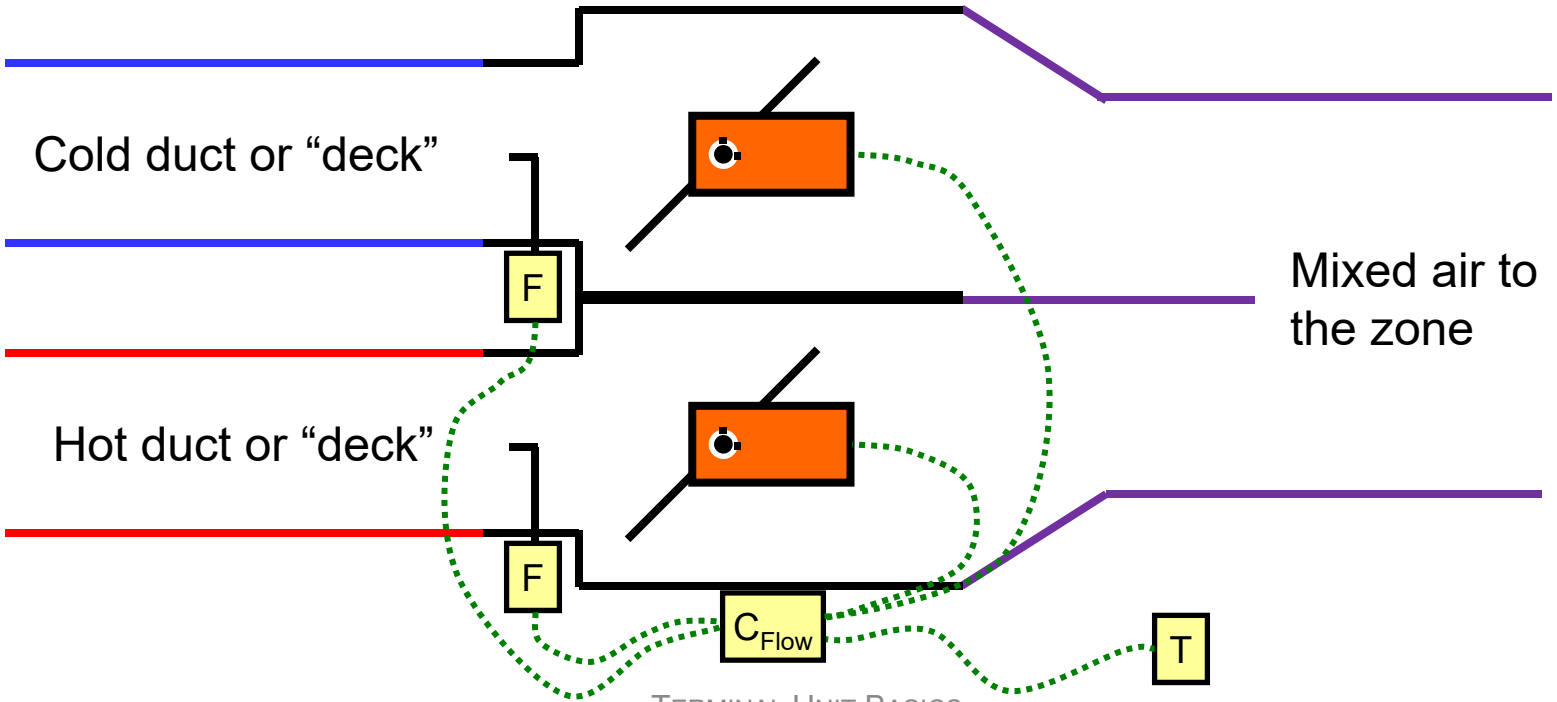
Double Duct Boxes = Reheat with Hot Air

Twice the components = twice the “fun”

Often separate fan systems for each deck

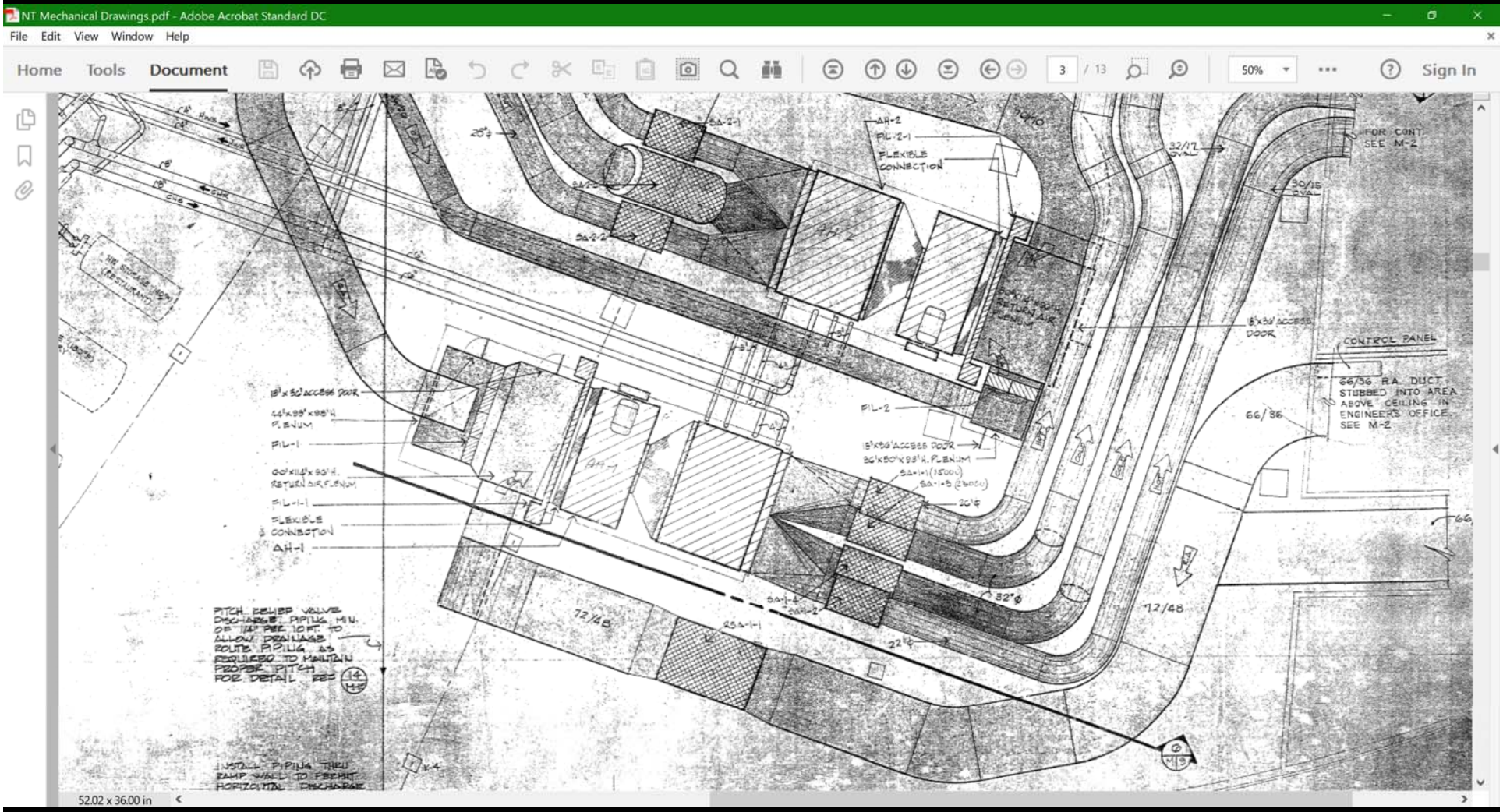
Ventilation air typically provided by the cold deck

- Always minimum cold deck flow
- Hot deck goes to 0 cfm

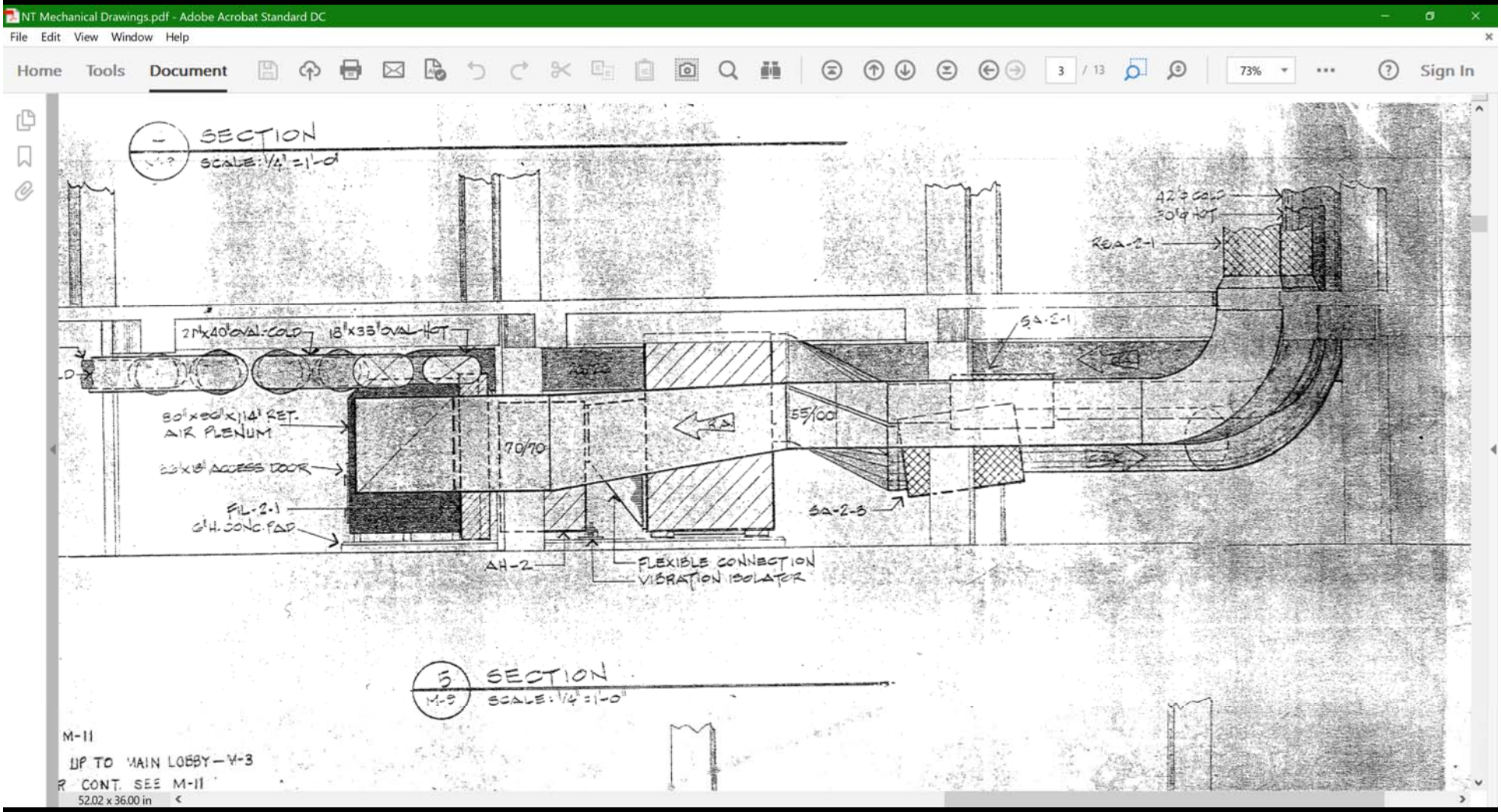


A Single Path Double Duct Unit

A Single Path
Double Duct Unit



A Single Path
Double Duct Unit



NT Mechanical Drawings.pdf - Adobe Acrobat Standard DC
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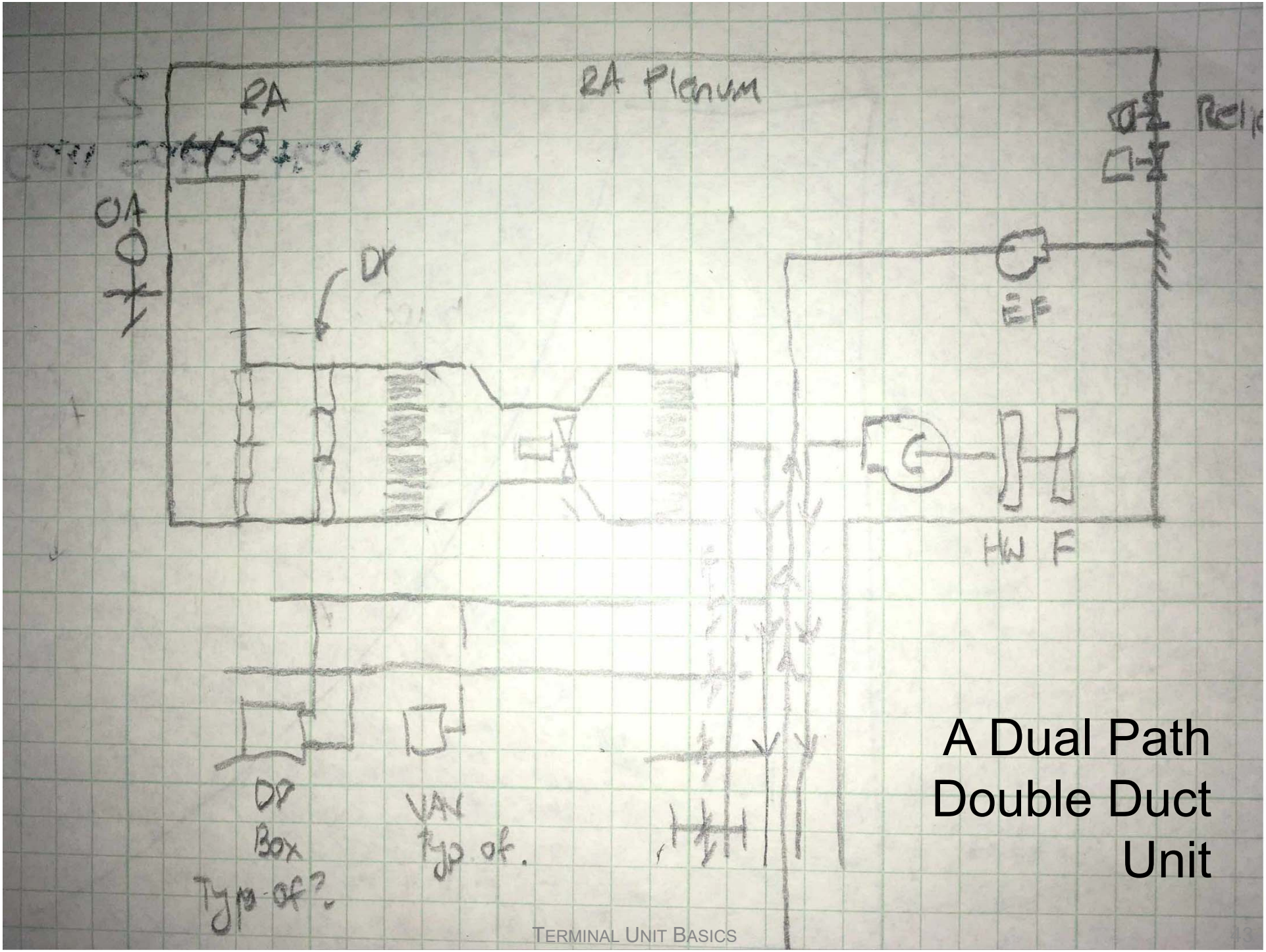
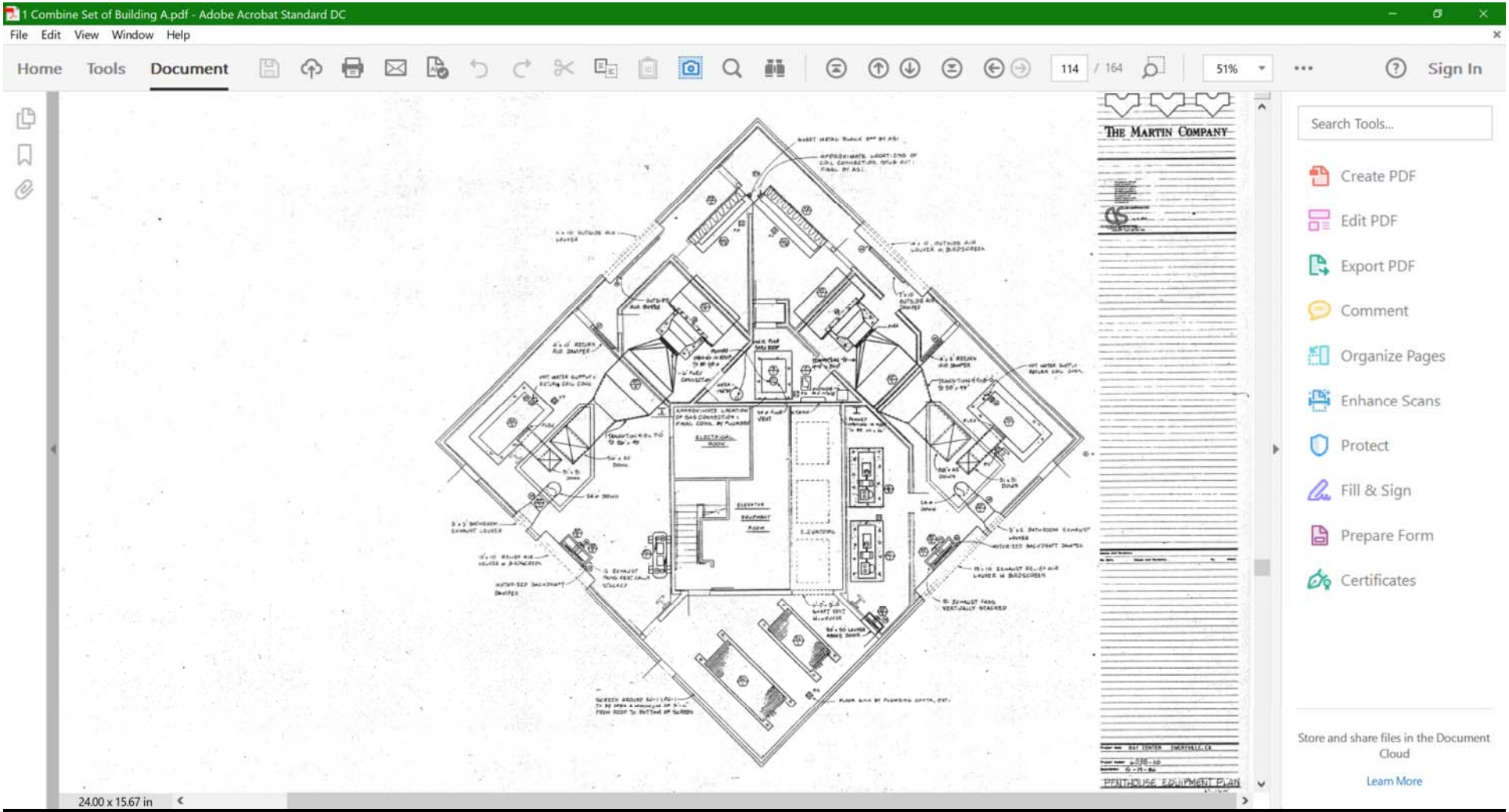
FOR CONT. SEE M-2
FLEXIBLE CONNECTION
CONTROL PANEL
66/36 R.A. DUCT STUBBED INTO AREA ABOVE CEILING IN ENGINEER'S OFFICE. SEE M-2
72/48
PITCH RELIEF VALVE DISCHARGE PIPING MIN. OF 1/4" PER 10 FT. TO ALLOW DRAINAGE ROUTE PIPING AS REQUIRED TO MAINTAIN PROPER PITCH FOR DETAIL REF
52.02 x 36.00 in



A Dual Path Double Duct Unit



A Dual Path Double Duct Unit

A Constant Volume to VAV Conversion

A Double Duct Box

Bottom Lines

1. The basic box is pretty simple
2. Making it bullet proof makes it a bit more complex
3. Making it energy efficient makes it more complex
4. Making it cost effective makes persistent complexity challenging