Introduction to Fan Energy Index (FEI)

AMCA & O'Dell Associates Education Series | Session 4 | October 28, 2021

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Webinar Moderator

- Joined AMCA in February 2019
- Responsible for development of AMCA's education programs; staff liaison for the Education & Training Committee
- Projects include webinars, AMCA's online learning platform programming, presentations at trade shows, PDH/RCEP account management, and AMCA's Speakers Network

Introductions & Guidelines

- Participation Guidelines:
  - Audience will be muted during the session.
  - Questions can be submitted anytime via the Airmeet platform and will be addressed at the end of the presentation.
  - Reminder: This session is being recorded!
  - To earn PDH credit for today, please stay clicked onto the platform for the entire hour.
  - A post-program survey will be emailed to everyone within one hour of the conclusion. Your feedback is greatly appreciated, and the survey must be completed to qualify for today's PDH credit.

Q & A

To submit questions:

- From the interactive panel on the right side of the screen, select the “Q&A” option at the top.
- Type your question in the box and click “Send”.
- Remember: All attendees can see all questions submitted.
- If you would like to verbally ask your question, please click the “Raised Hand” icon at the bottom of your screen.

- Questions will be answered at the end of the program.

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Mark Bublitz

Executive Vice President - Engineering; The New York Bower Company

- Joined New York Blower in 1994
- BSME from Valparaiso University, an MSME from Purdue University, an MBA from Indiana Wesleyan University, post graduate studies in management of engineering and technology, and various certifications and awards related to technology and participation in industry.
- Responsible for Engineering and industry interests related to energy efficiency regulation

Introduction to Fan Energy Index (FEI)

Purpose and Learning Objectives

The purpose of this presentation is to inform participants about the Fan Energy Index (FEI) Metric that is replacing Fan Efficiency Grade (FEG) in energy codes, standards, and regulations.

At the end of this presentation you will be able to:

1. Describe Fan Energy Index.
2. Understand how FEI will be utilized in regulation.
3. Understand why FEI is best suited as an energy efficiency metric for fans.

If you are going to get a PDH Credit, we need to do at least a little math!

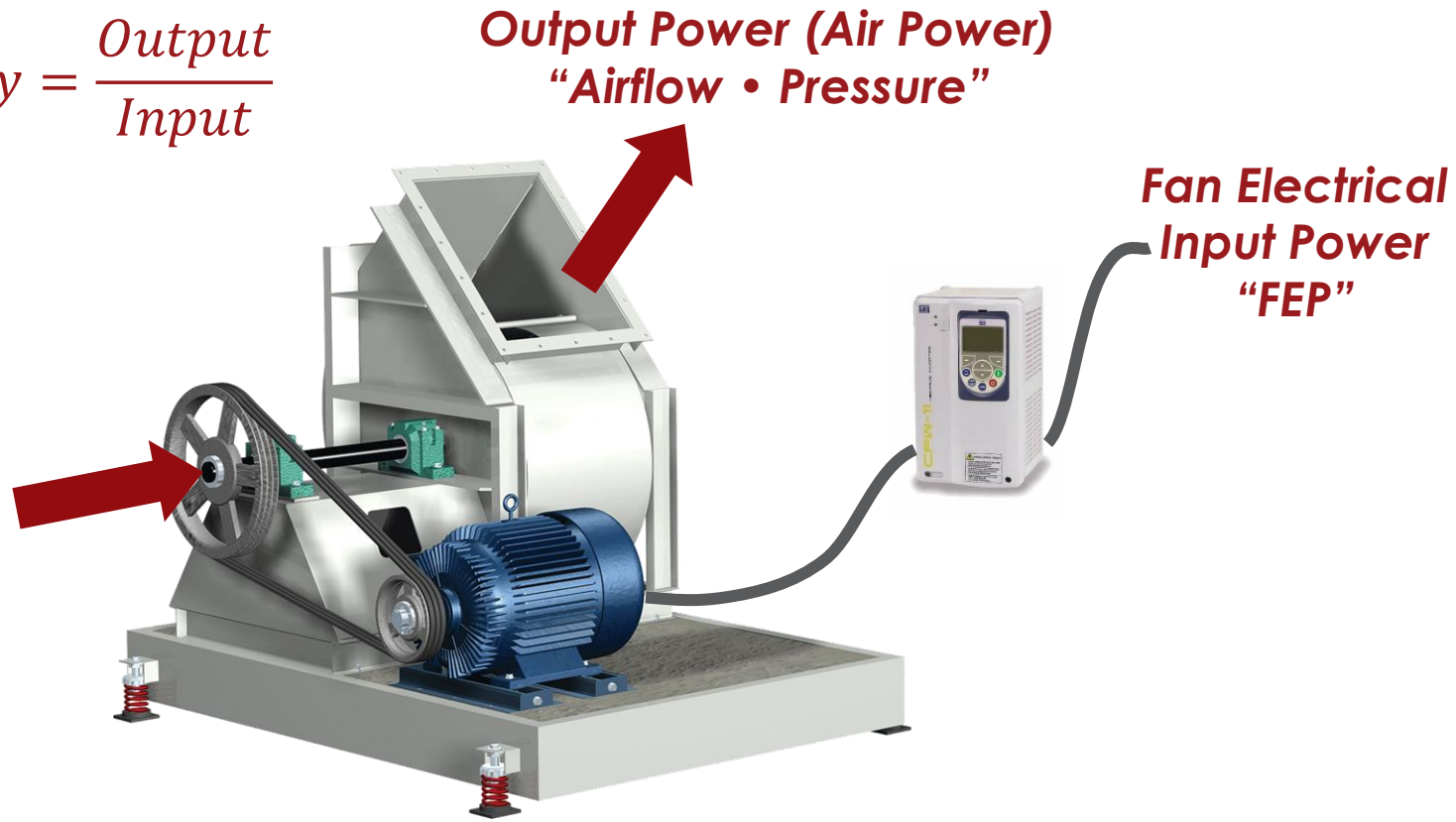
What is FEI?

- A fan system energy efficiency metric
- ≥ 1 ⇨ good
- < 1 ⇨ bad

$$FEI = \frac{Your\ fan\ system\ efficiency}{Fan\ efficiency\ of\ a\ \text{reference}\ fan\ system}$$

What is FEI?

$$Efficiency = \frac{Output}{Input}$$



What is FEI?

- With a little bit of math

$$FEI = \frac{Your\ fan\ system\ efficiency}{Fan\ efficiency\ of\ a\ \text{reference}\ fan\ system}$$

- Can be rewritten as

$$FEI = \frac{Fan\ system\ electrical\ input\ power\ of\ a\ \text{reference}\ fan\ system}{Your\ fan\ system\ electrical\ input\ power}$$

- Remember:
  - ≥ 1 = good
  - < 1 = bad

The FEI is defined as the ratio of the electrical input power of a reference fan to the electrical input power of the actual fan for which the FEI is calculated, both calculated at the same duty point at fan air density.
-AMCA Standard 214

What is FEI?

$$FEI = \frac{Fan\ system\ electrical\ input\ power\ of\ a\ \text{reference}\ fan\ system}{Your\ fan\ system\ electrical\ input\ power}$$

The FEI is defined as the ratio of the electrical input power of a reference fan to the electrical input power of the actual fan for which the FEI is calculated, both calculated at the same duty point at fan air density.

-AMCA Standard 214

What is FEI?

- Is an *operating condition* metric
  - The peculiar nature of fans (light bulbs vs. fans)

- A “fan” does not have an FEI *rating* without an operating condition!
  - Flow
  - Pressure
  - Density*

What is FEI?

Three key things to remember:

1. FEI is the ratio of the power consumed by a “reference fan” to the power consumed by “our fan”.

2. FEI is an operating point efficiency metric.

3. AND NEVER FORGET, for now, above 1 is good, below 1 is BAD!

What is FEI?

- Pause for Questions

- Next Section: *FEI and Regulation*

FEI and Regulation

- FEI and Regulation go hand-in-hand
  - Chicken and the egg
- The US Department of Energy (DOE) regulates products (appliances) that consume electricity for energy efficiency.
- Started with regulation of electric motors. (EPCA 1975)
- Anything that is connected to an electric motor.

FEI and Regulation

- After many years
  - We have arrived at …fans

Consumer Products

- Battery Chargers
- Boilers
- Ceiling Fans
- Central Air Conditioners and Heat Pumps
- Clothes Dryers
- Clothes Washers
- Computer and Battery Backup Systems
- Conventional Cooking Products
- Dehumidifiers
- Direct Heating Equipment
- Dishwashers
- External Power Supplies
- Furnace Fans
- Furnaces
- Hearth Products
- Manufactured Housing
- Microwave Ovens
- Miscellaneous Refrigeration
- Pool Heaters
- Portable Air Conditioners
- Refrigerators and Freezers
- Room Air Conditioners
- Set-Top Boxes
- Televisions
- Water Heaters

Commercial and Industrial Products

- Air-Cooled Unitary Air Conditioners and Heat Pumps
- Automatic Commercial Ice Makers
- Circulator Pumps
- Clothes Washers
- Commercial Packaged Boilers
- Commercial and Industrial Air Compressors
- Computer Room Air Conditioners
- Dedicated Outdoor Air Systems
- Dedicated-Purpose Pool Pumps
- Distribution Transformers
- Electric Motors
- Evaporatively-Cooled Unitary Air Conditioners
- Fans and Blowers
- Packaged Terminal Air Conditioners and Heat Pumps
- Pumps
- Refrigerated Beverage Vending Machines
- Refrigeration Equipment
- Single Package Vertical Air Conditioners and Heat Pumps
- Small Electric Motors
- Unit Heaters
- Variable Refrigerant Flow Air Conditioners and Heat Pumps
- Walk-In Coolers and Walk-In Freezers
- Warm Air Furnaces
- Water-Cooled Unitary Air Conditioners
- Water Heating Equipment
- Water-Source Heat Pumps

Fans and Blowers

Lighting Products

- Ceiling Fan Light Kits
- Certain Lamps
- Compact Fluorescent Lamps
- Fluorescent Lamp Ballasts
- General Service Fluorescent Lamps
- General Service Incandescent Lamps
- General Service Lamps
- High-Intensity Discharge Lamps
- Illuminated Exit Signs
- Incandescent Reflector Lamps
- Light Emitting Diode Lamps
- Luminaires
- Metal Halide Lamp Fixtures
- Torchieres
- Traffic Signal Modules and Pedestrian Modules

Plumbing Products

- Commercial Prerinse Spray Valves
- Faucets
- Showerheads
- Urinals
- Water Closets (Flush Toilets)

FEI and Regulation

- DOE suspended efforts in November of 2016
- The State of California picked up the regulatory effort
- California Energy Commission (CEC) under California Title 20.
- Regardless of the regulatory channel, here is the important thing to remember:

It appears FEI will be THE metric (measure) of fan energy efficiency used in government regulation of fans and blowers. For this reason, it is important for us to understand what FEI is and how it works.

FEI and Regulation

- Fan Efficiency Grade (FEG) – previous metric (fan industry)
  - Single point metric
  - Fan only; not motors/drives
  - Peak total efficiency only
- Baseline energy codes
  - ASHRAE 90.1: 2013, 2016
  - International Energy Conservation Code (IECC): 2015, 2018
- Green building codes
  - ASHRAE 189.1: 2014, 2017
  - International Green Construction Code (IGCC): 2012, 2015, 2018

FEI and Regulation

- FEI Replaced FEG in model energy codes
  - ASHRAE 90.1: 2019
  - ASHRAE 189.1: 2020
  - IECC, IGCC: 2021
- Third-party certified ratings required for FEI ratings in IECC
  - www.AMCA.org/find-FEI
- Florida now has IECC-2018, but IECC-2021 FEI language
- Oregon soon to have ASHRAE 90.1-2019 language
- California Title 24 (2022) will have FEI requirements

FEI and Regulation

- AMCA 210 – how to conduct a test
- AMCA 207 – how to deal with drives
- AMCA 208 – how to calculate FEI
- AMCA 211 – more steps for FEI ratings
- …
- Regulator fatigue

- Enter AMCA Standard 214 - *Test Procedure for Calculating Fan Energy Index for Commercial and Industrial Fans and Blowers*

FEI and Regulation

- Pause for Questions

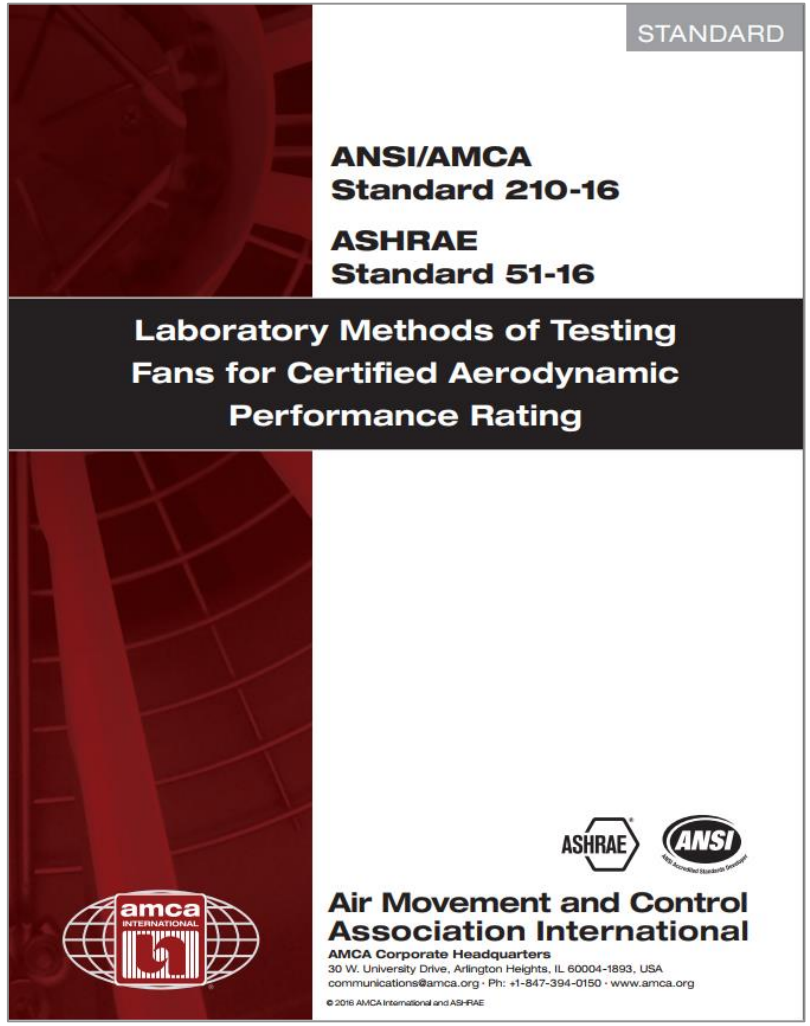
- Next Section: *Mechanics of FEI*

Mechanics of FEI

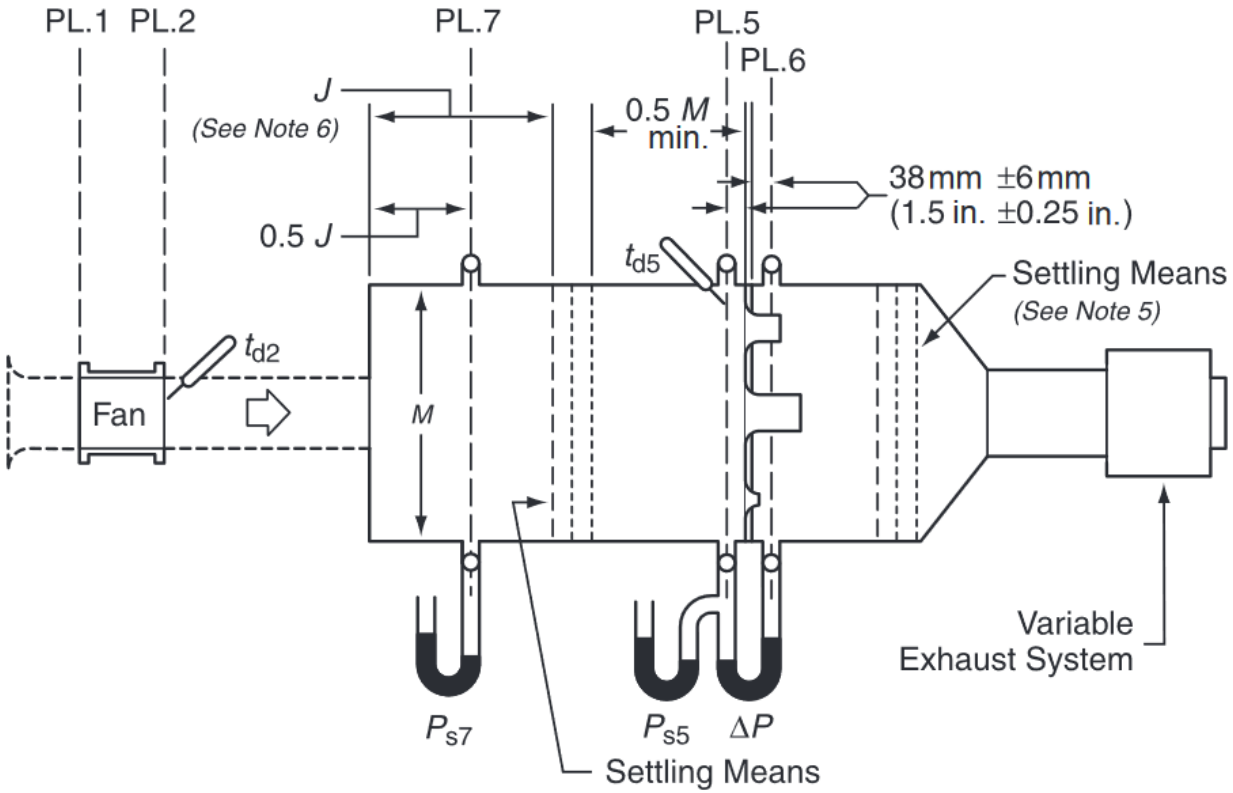
- Efficiency
- The peculiar nature of fans

Mechanics of FEI

AMCA Standard 210



Mechanics of FEI

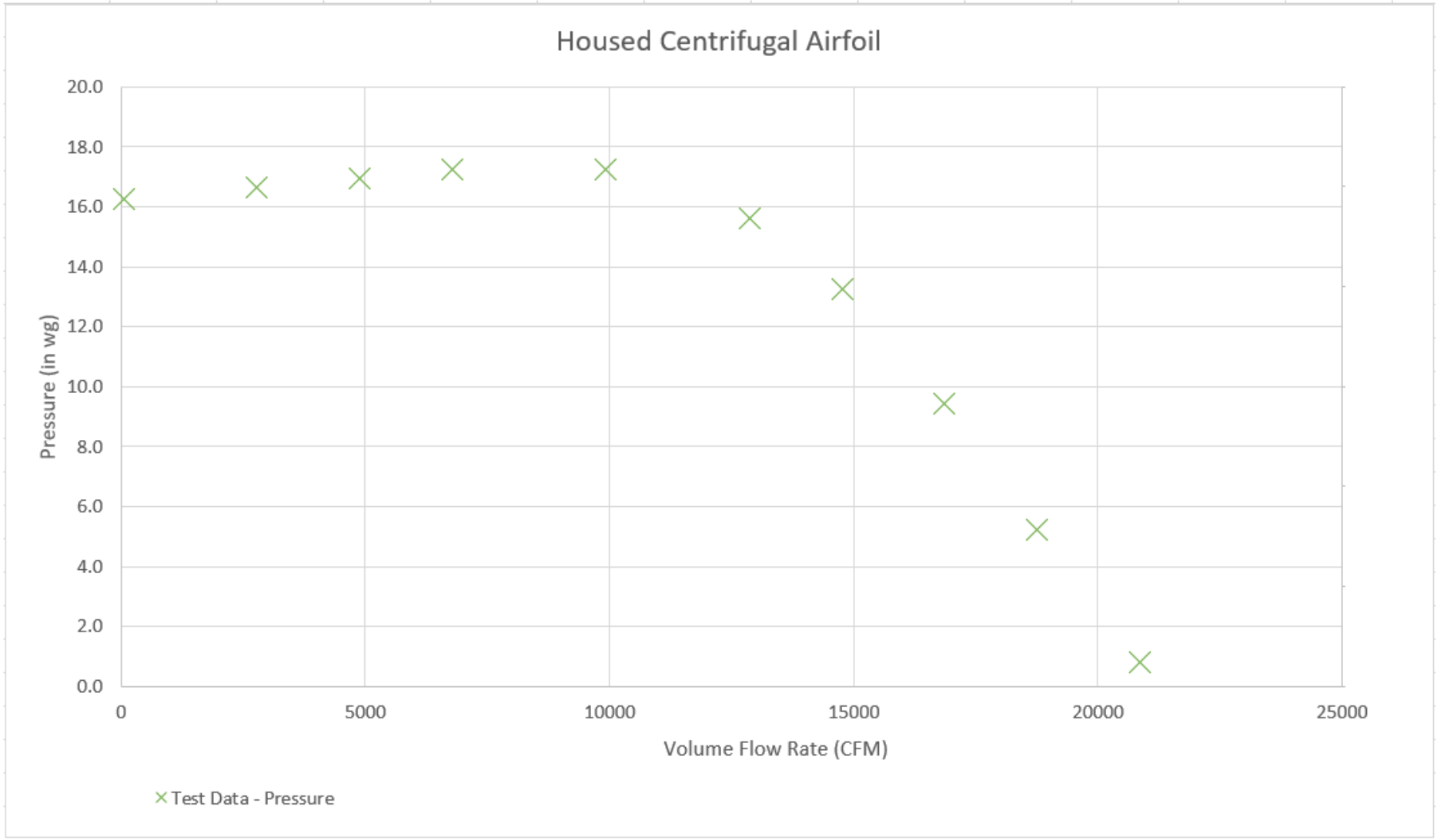


AMCA Standard 210 – Figure 12 Diagram

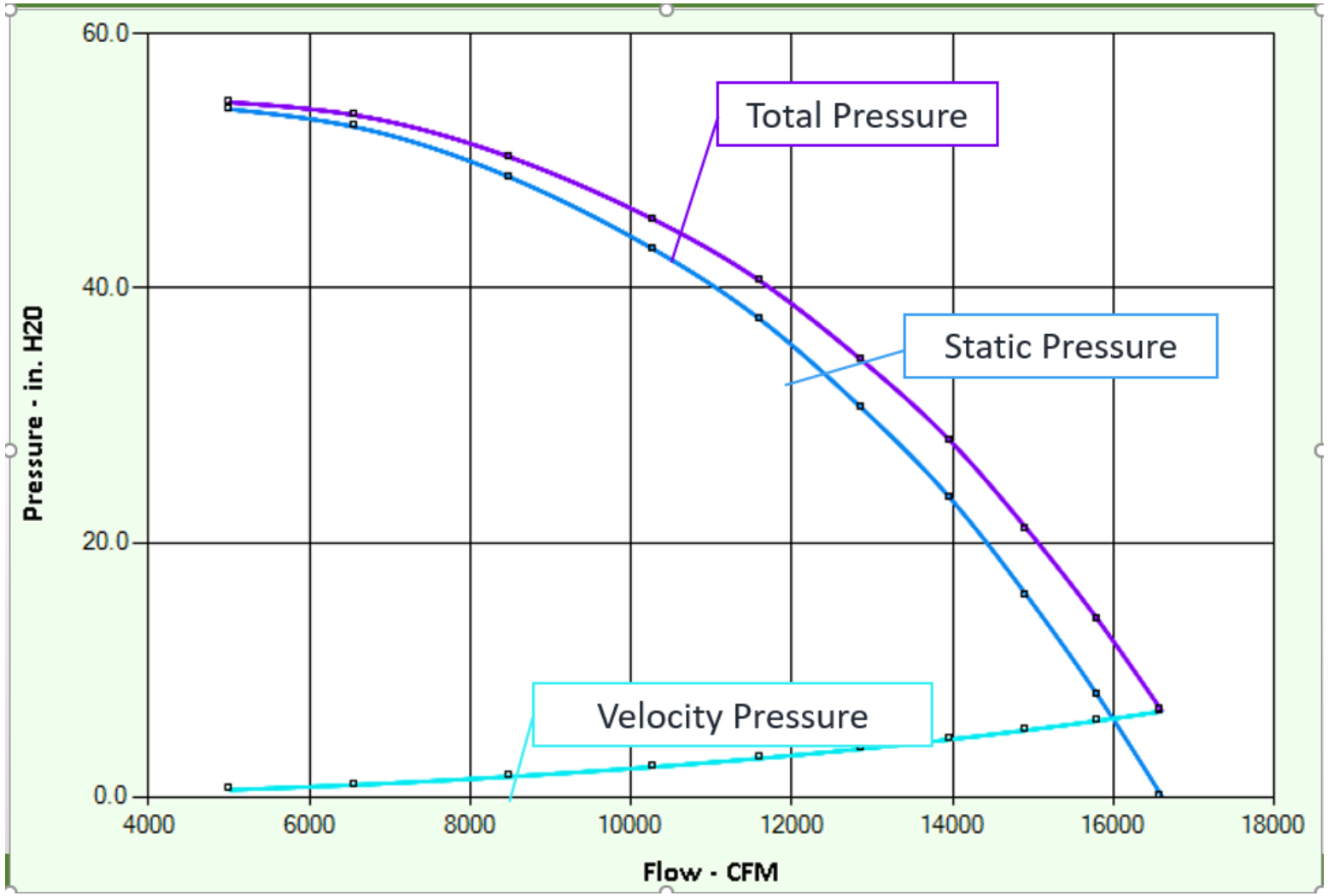
Mechanics of FEI

- Fans on the test chamber

Mechanics of FEI



The Test: Exhaust fan & Damper



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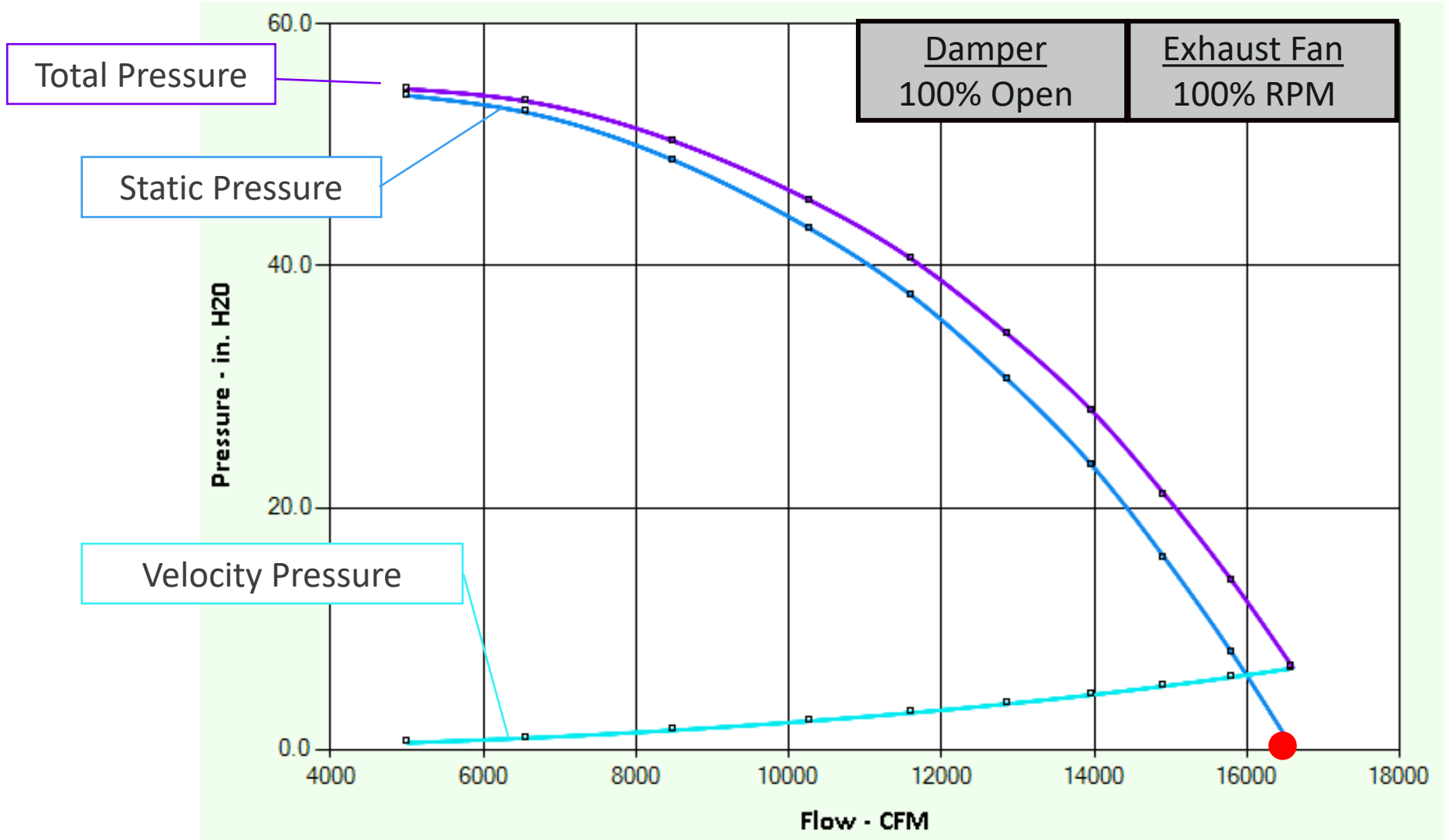

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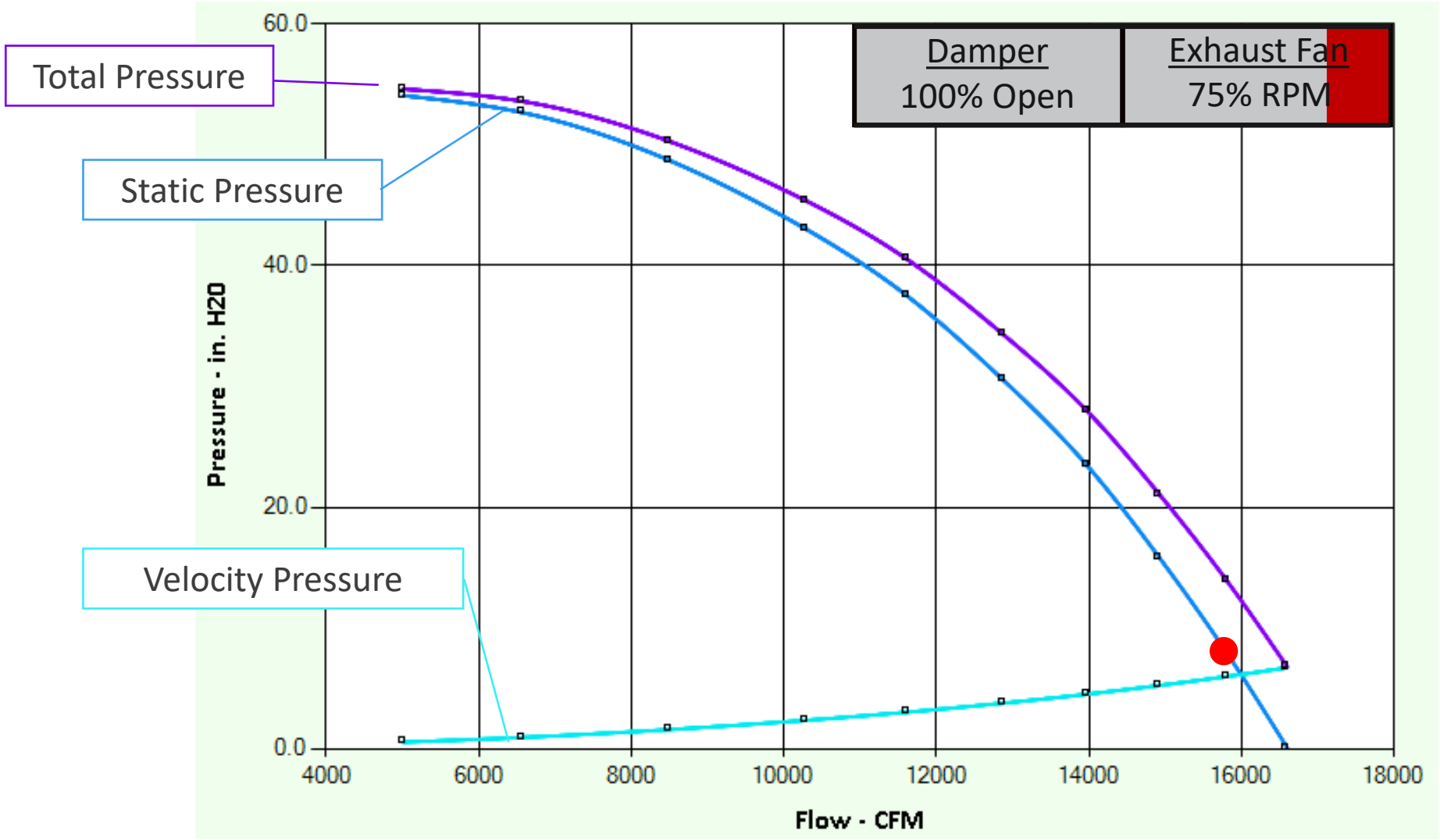

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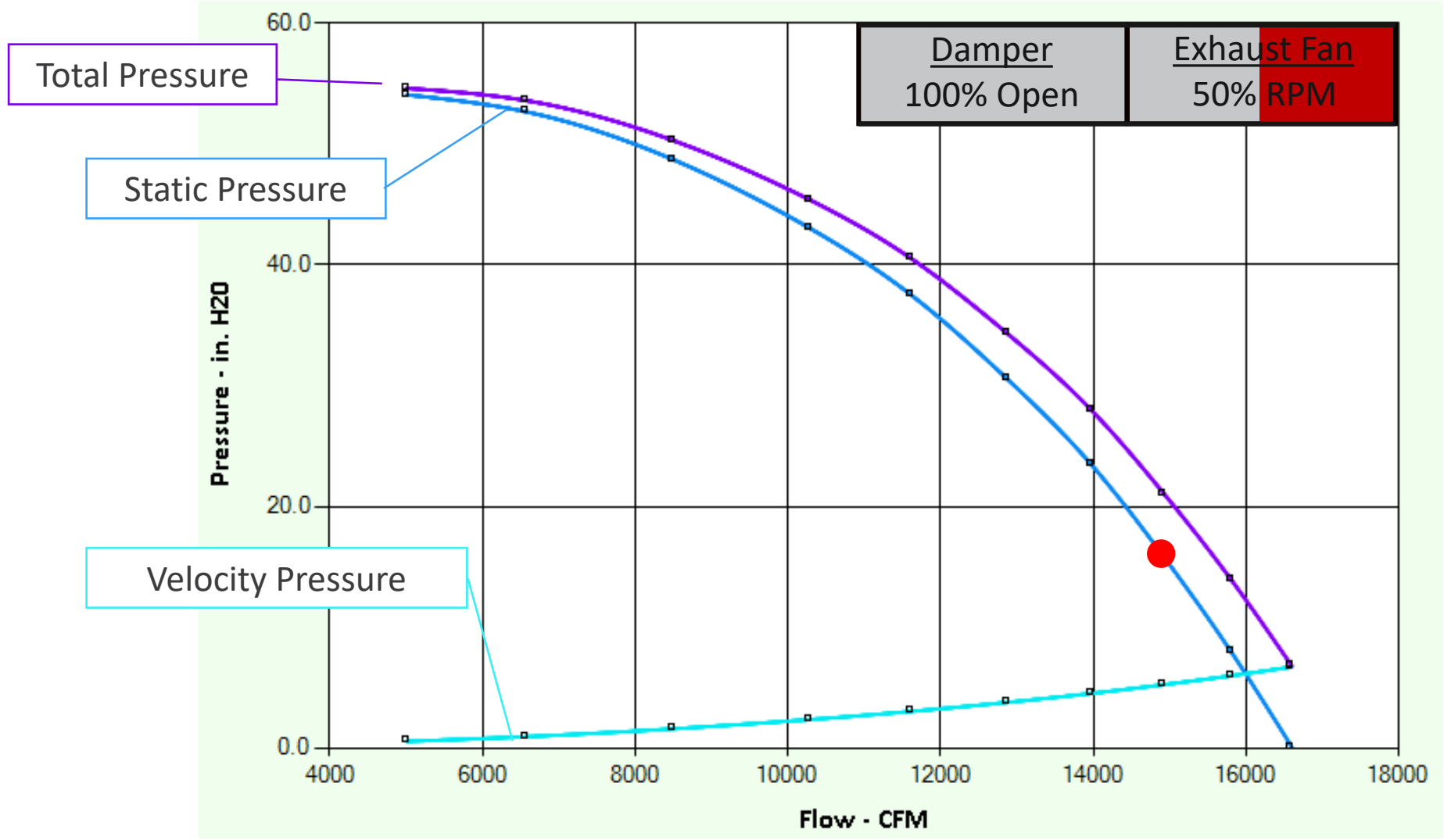

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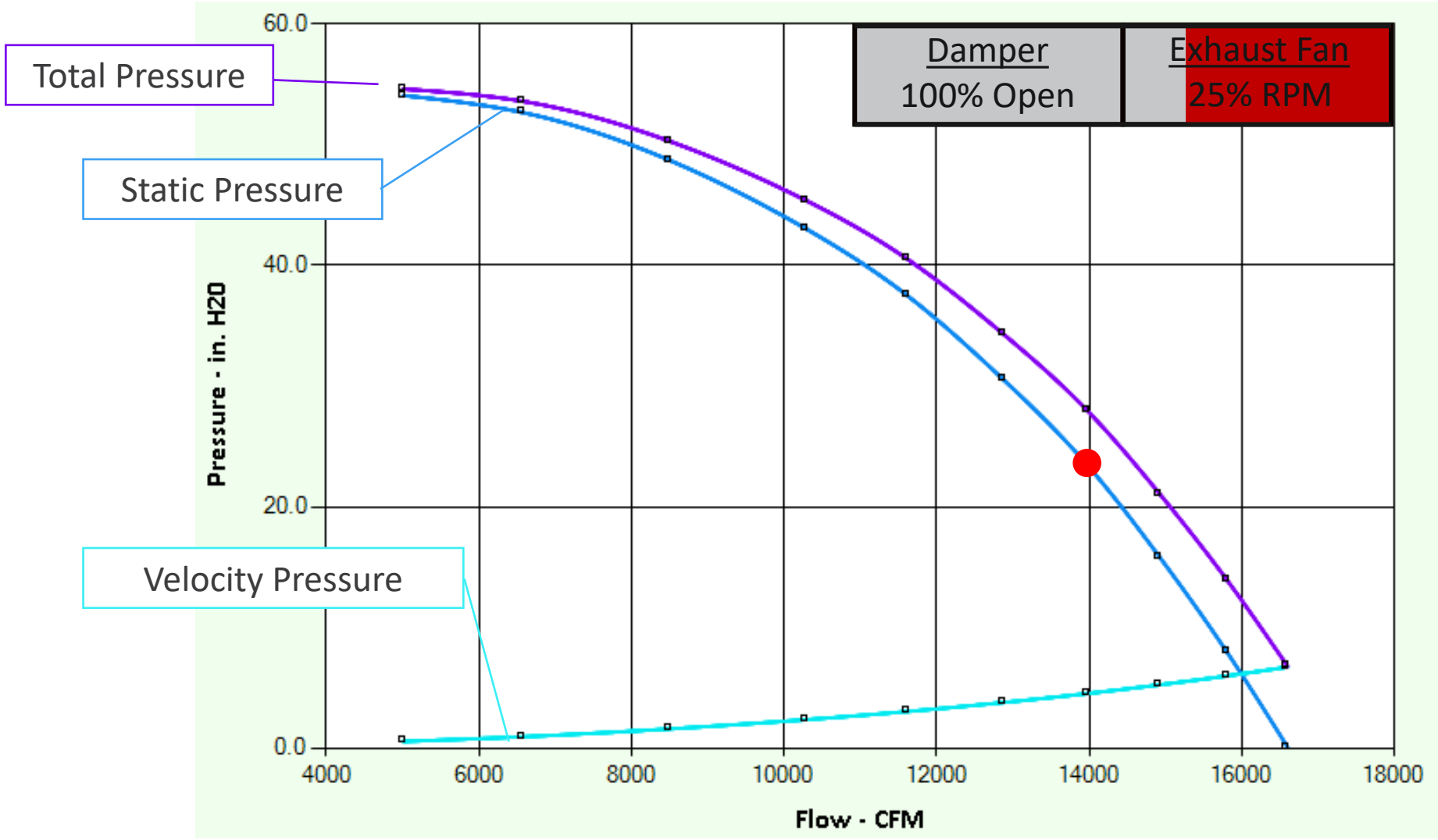

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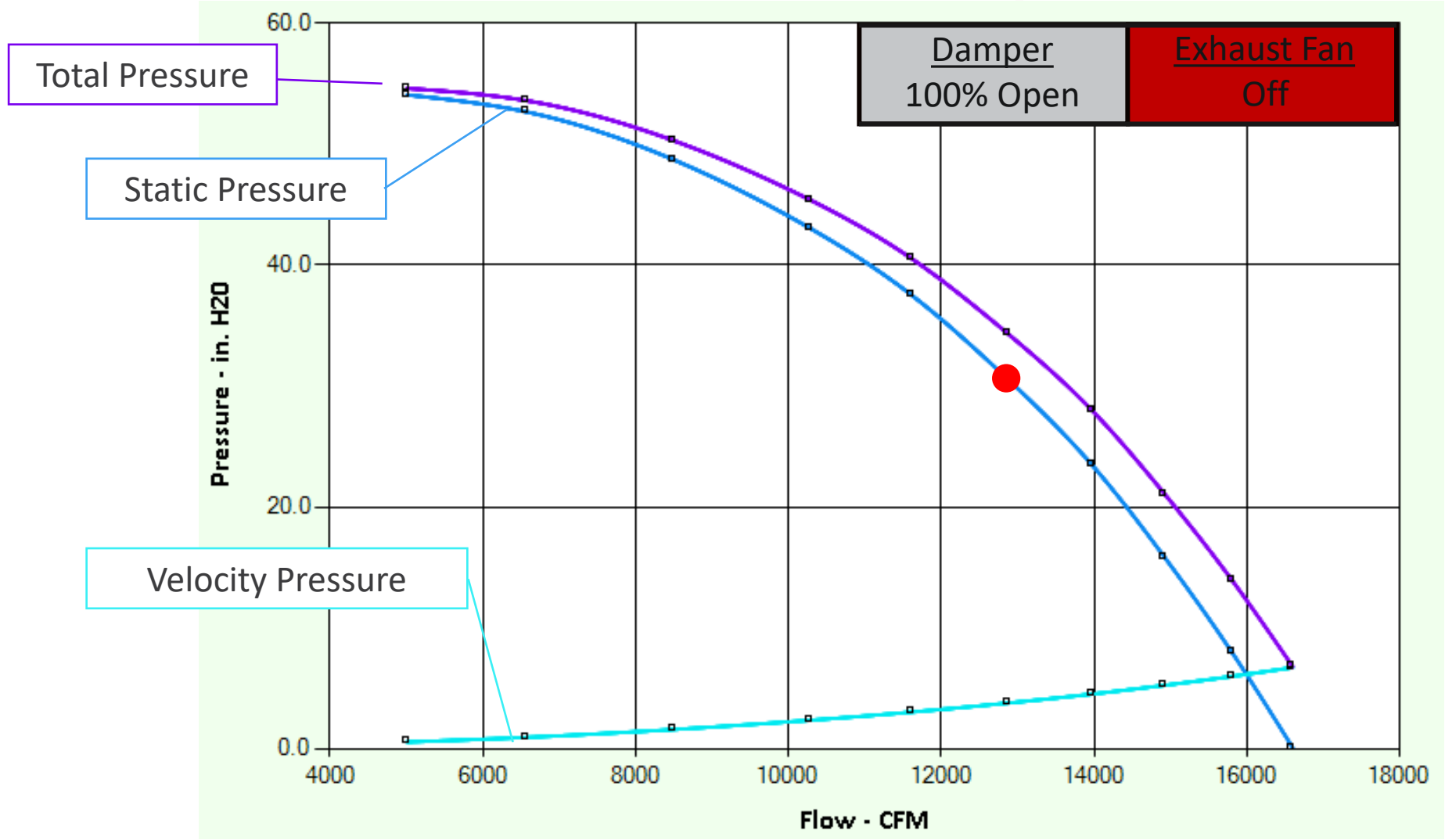

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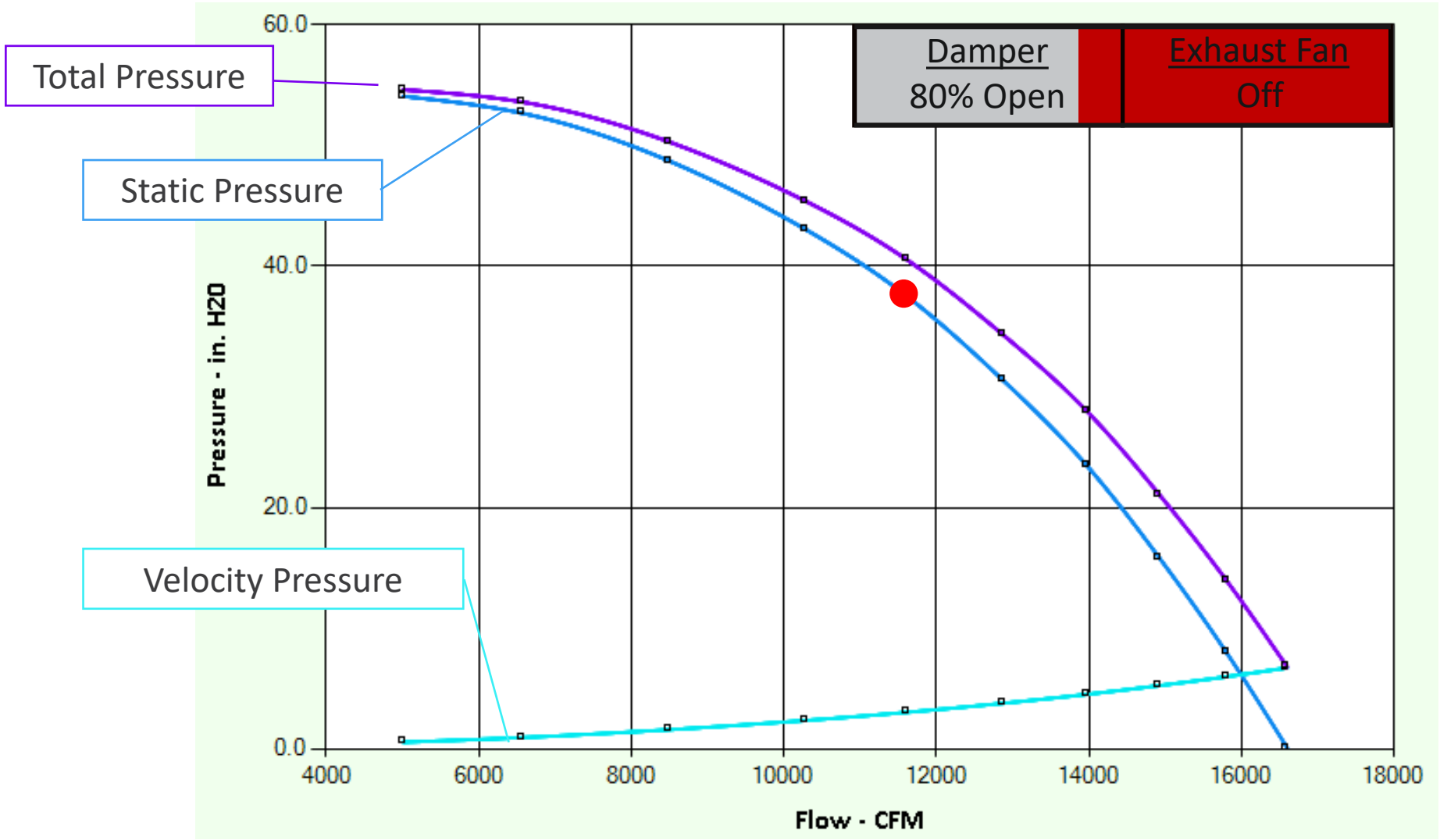

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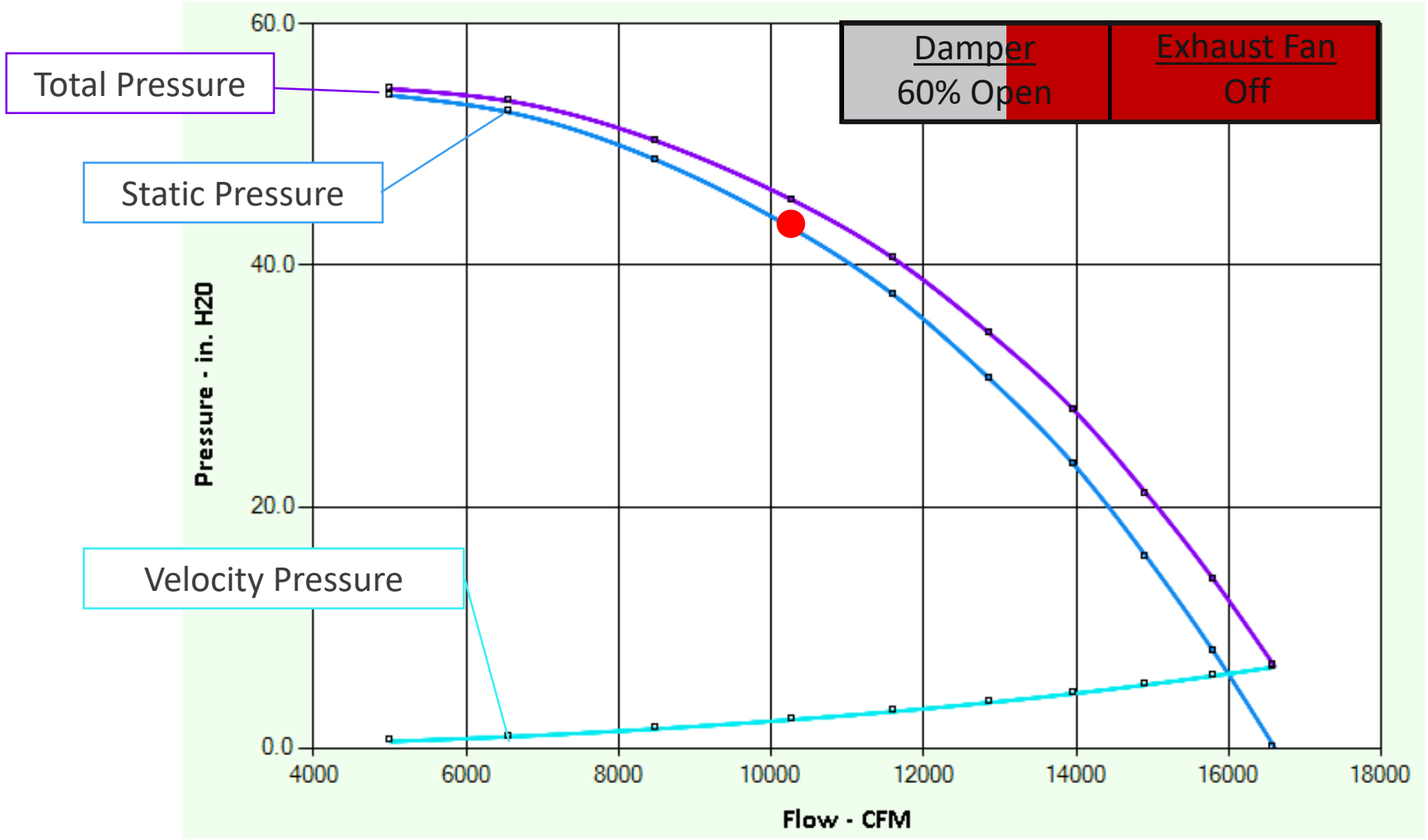

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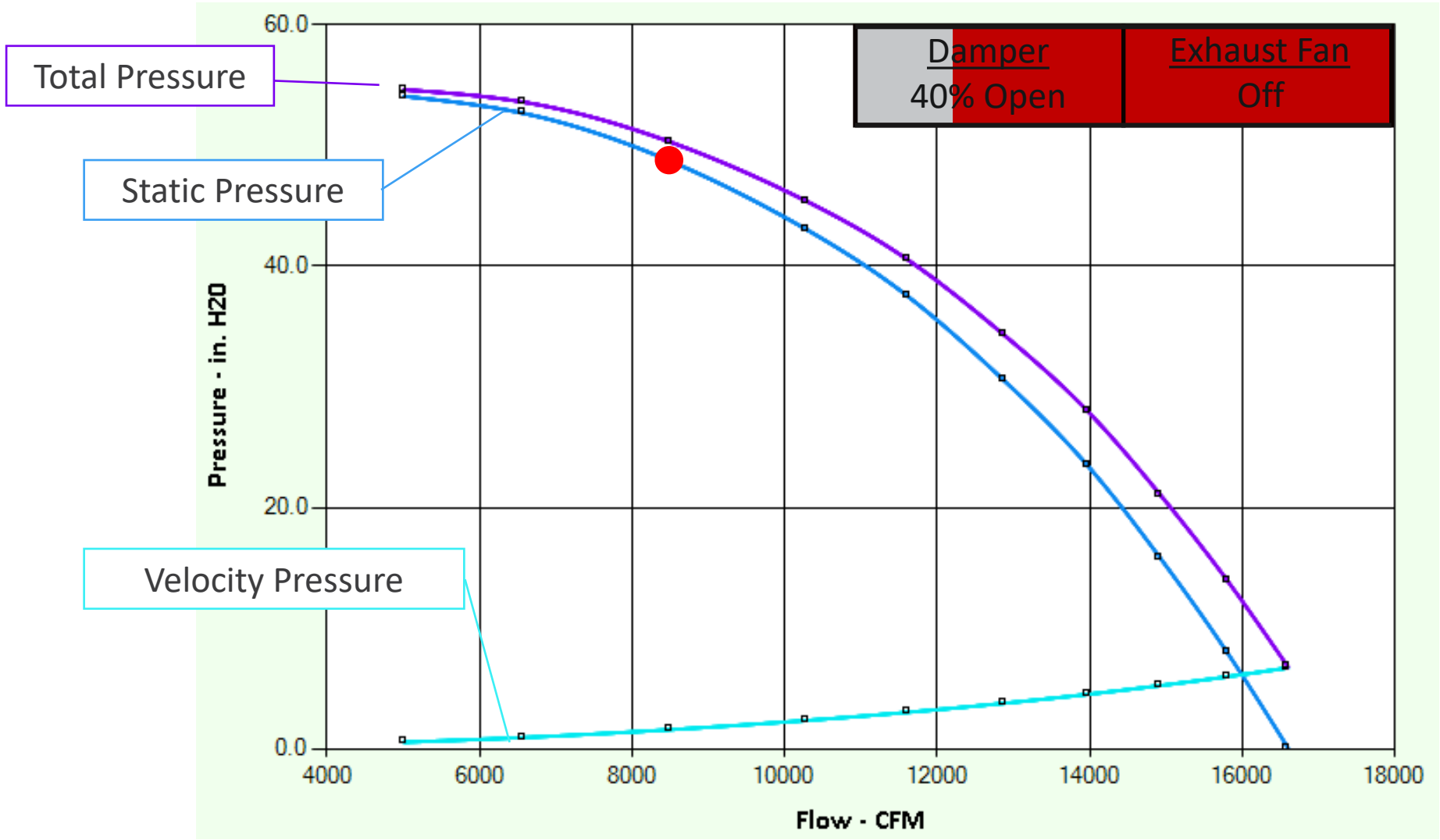

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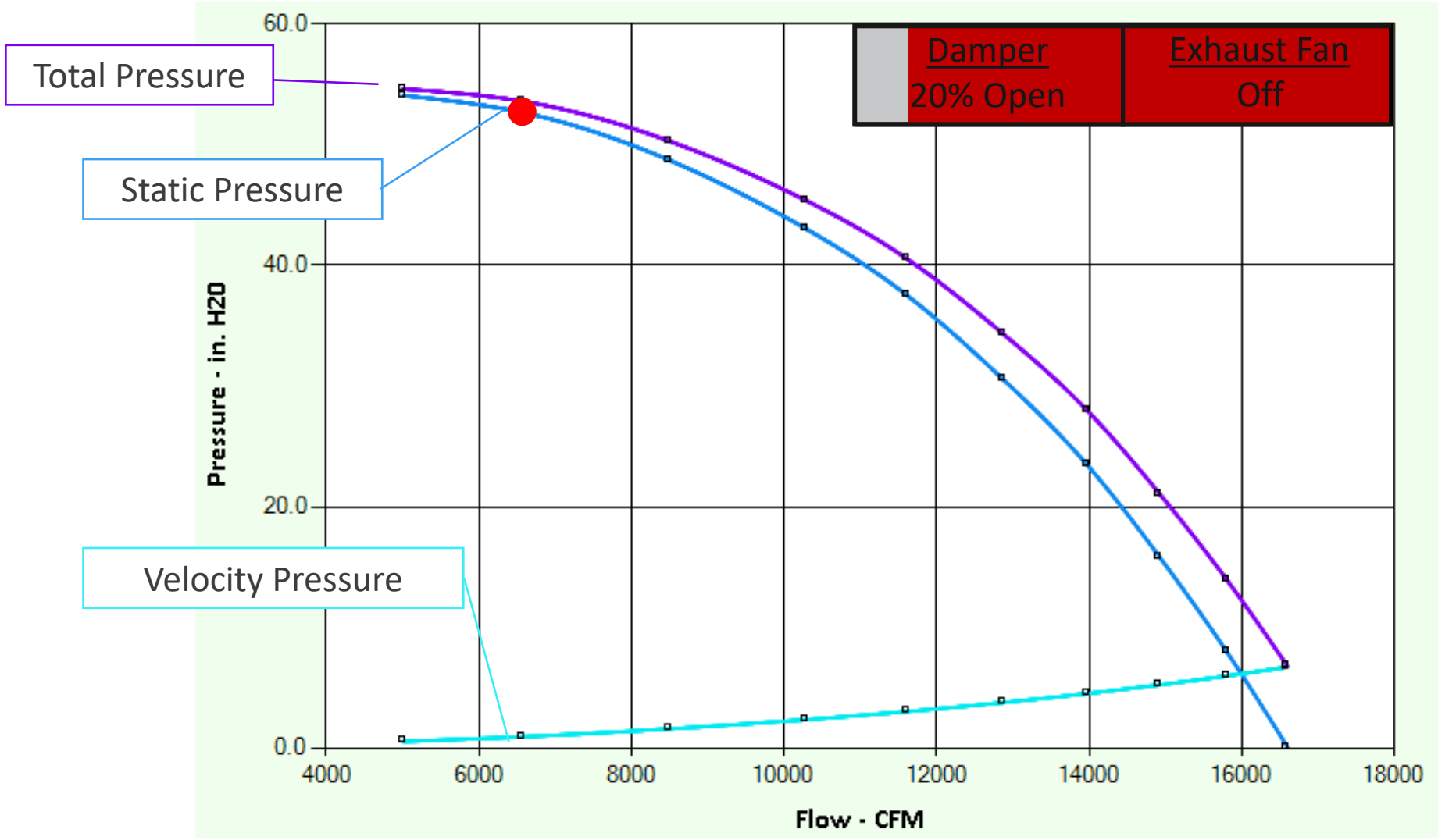

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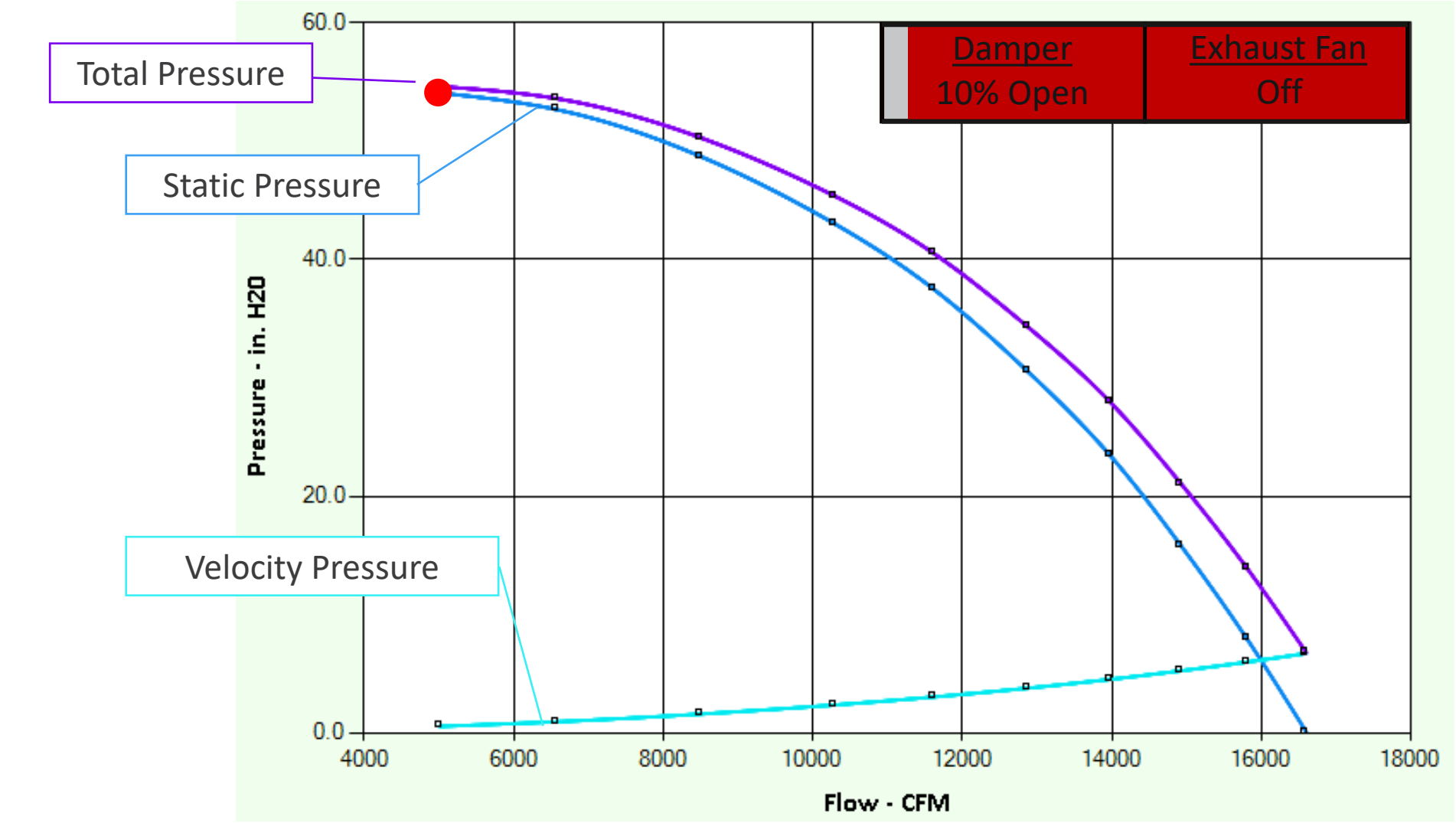
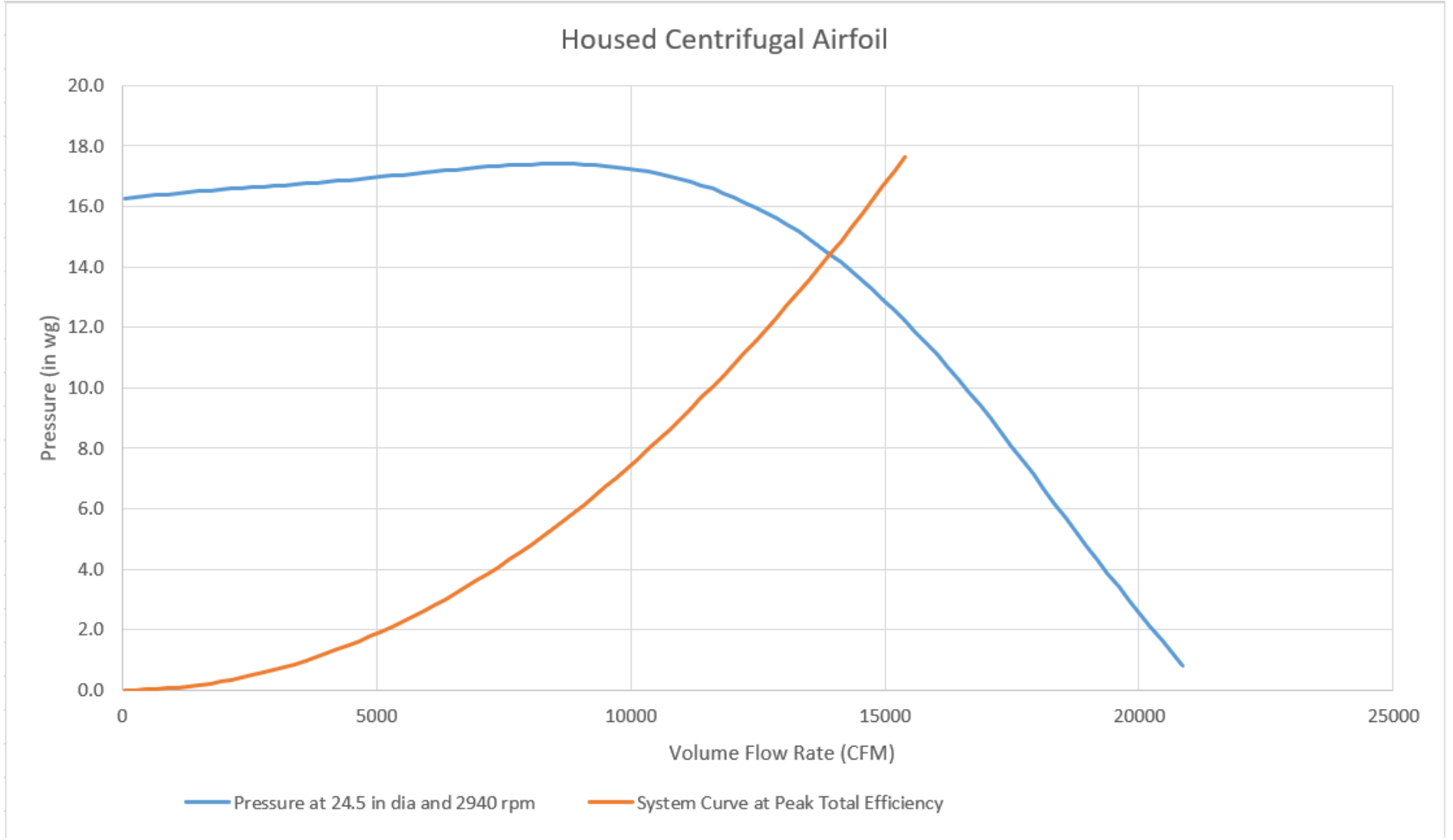


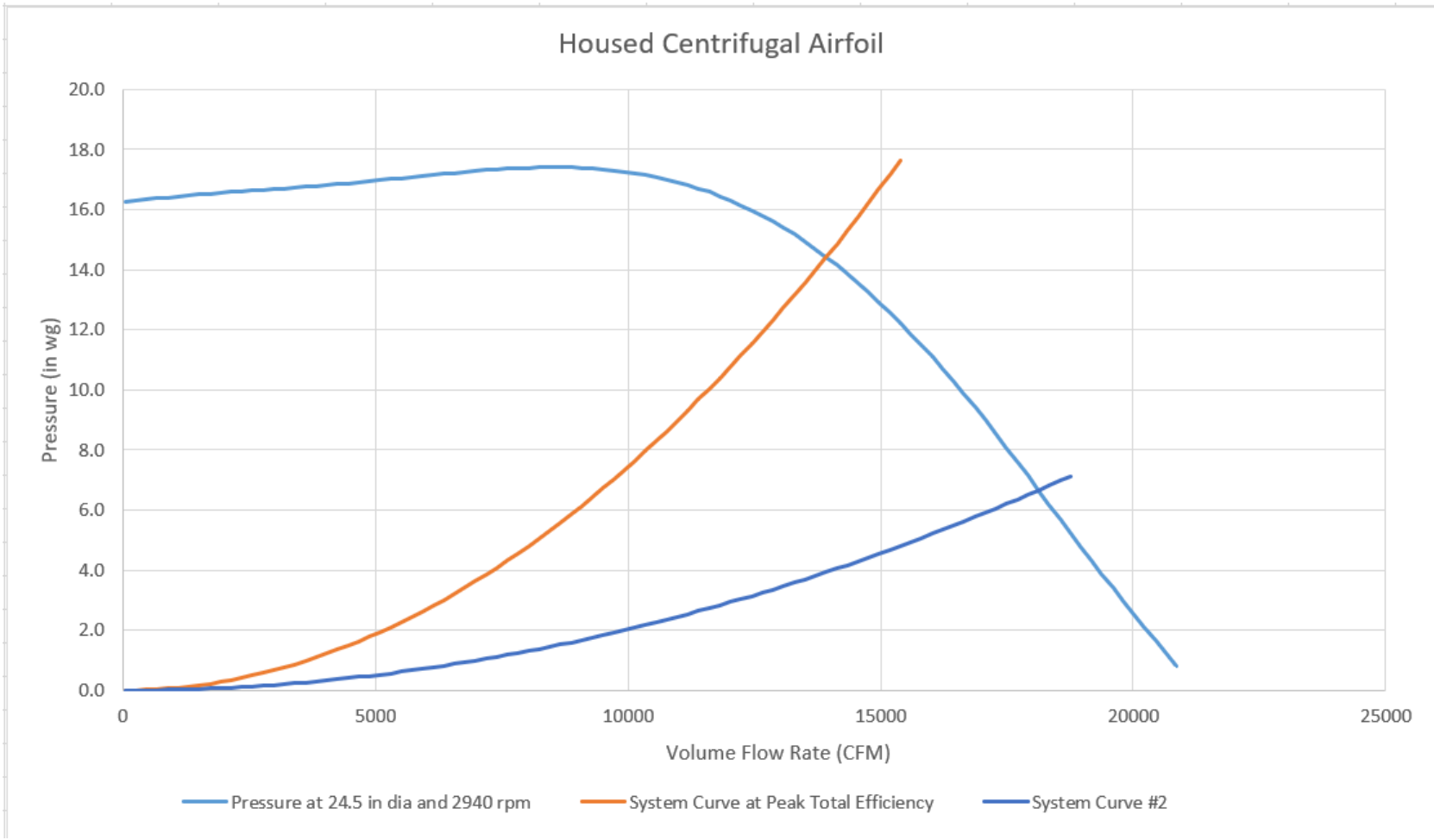
Mechanics of FEI



Mechanics of FEI

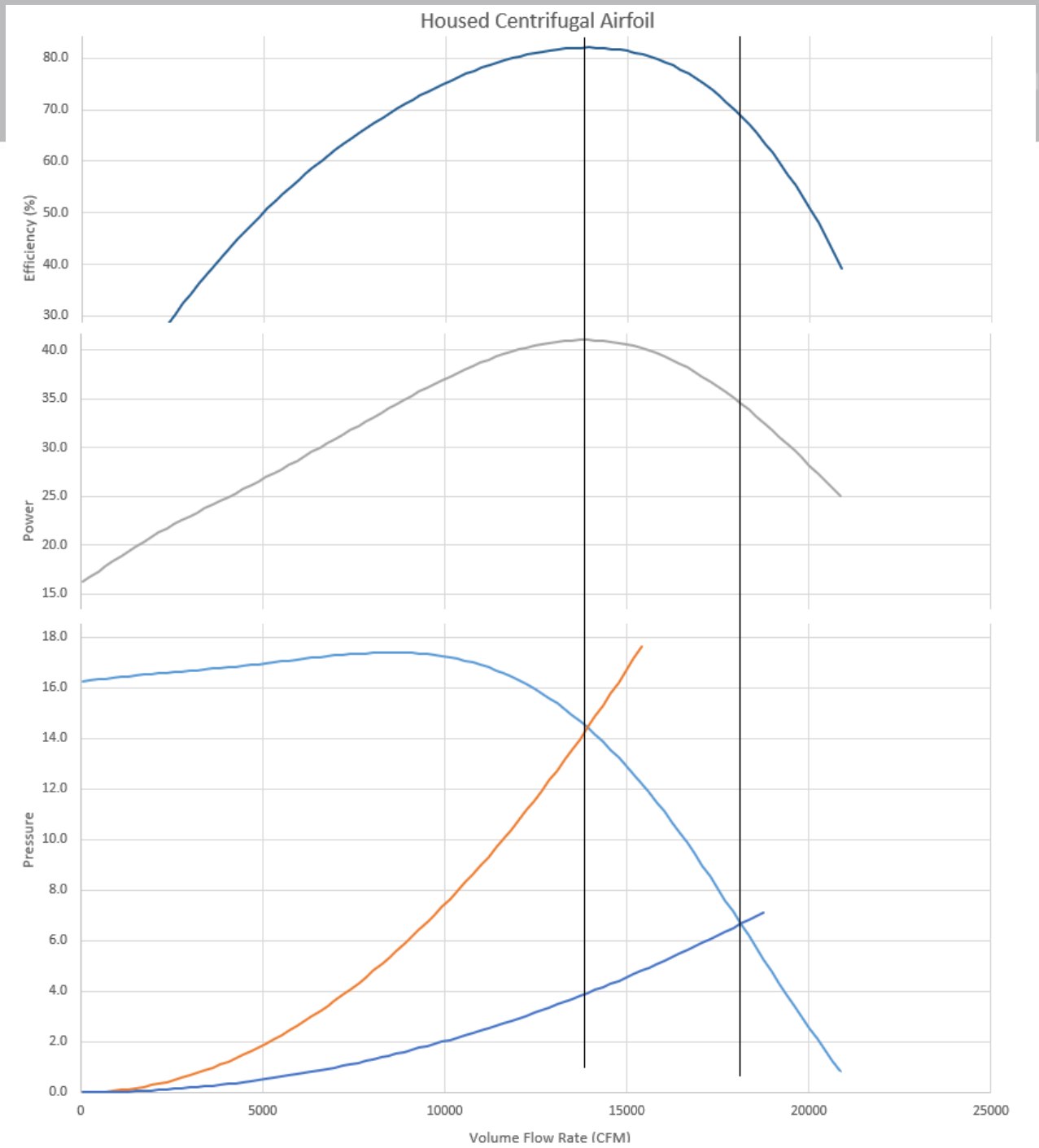
- The peculiar nature of fans

Mechanics of FEI

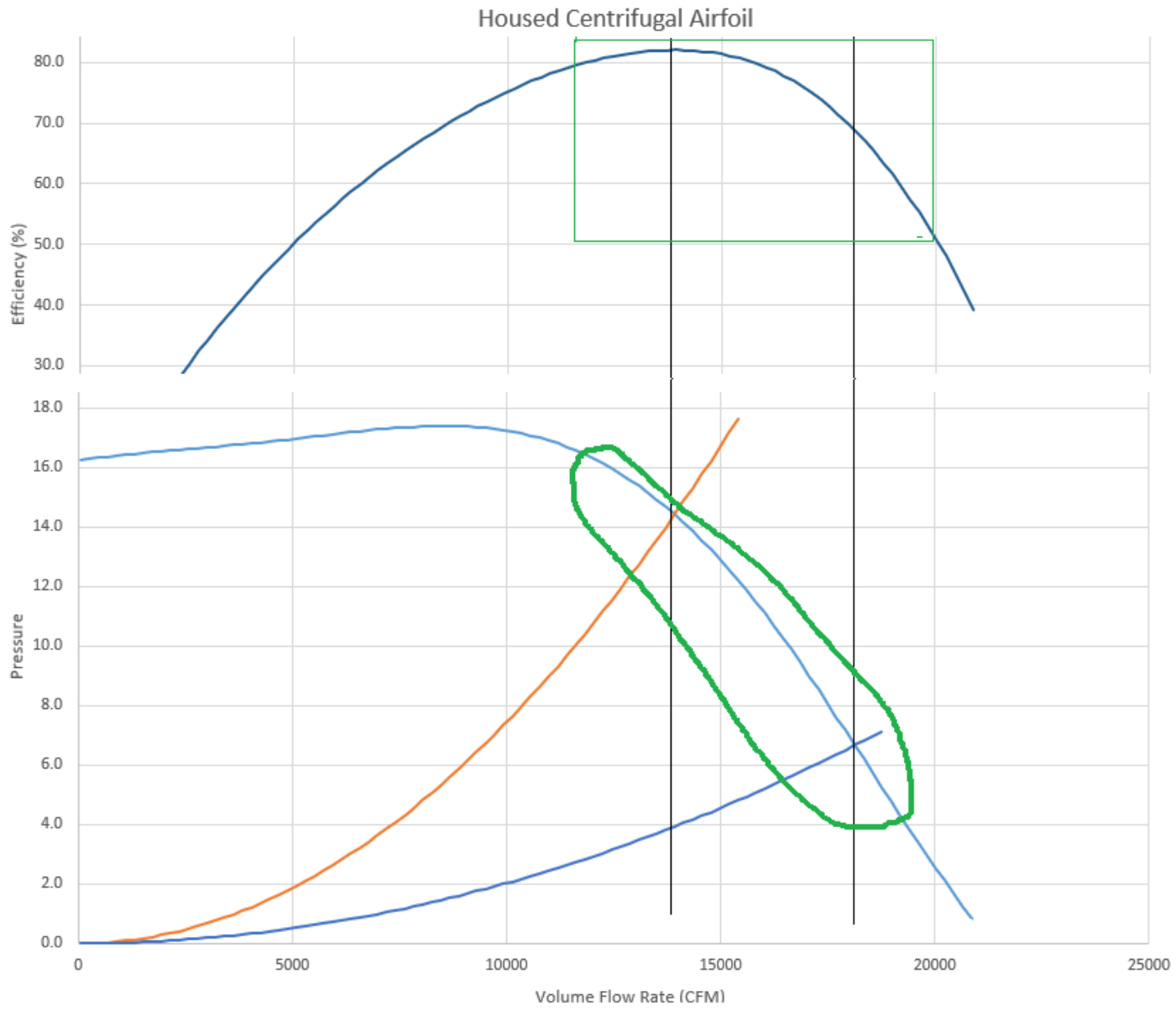


Mechanics of FEI

- All curves are at the *same speed!*



Mechanics of FEI



Mechanics of FEI

- The fan efficiency dilemma
  - Fans do not (typically) display the characteristic of a broad, flat efficiency curve like some other products (motors)

Mechanics of FEI

- FEI is an *operating condition* (duty point) metric
- Combines the duty point of the fan with an *efficiency expectation* (reference fan)
- Given:
  - Flow
  - Pressure
  - Density
- The metric specifies:
  - Efficiency
  - Maximum Electrical Input Power

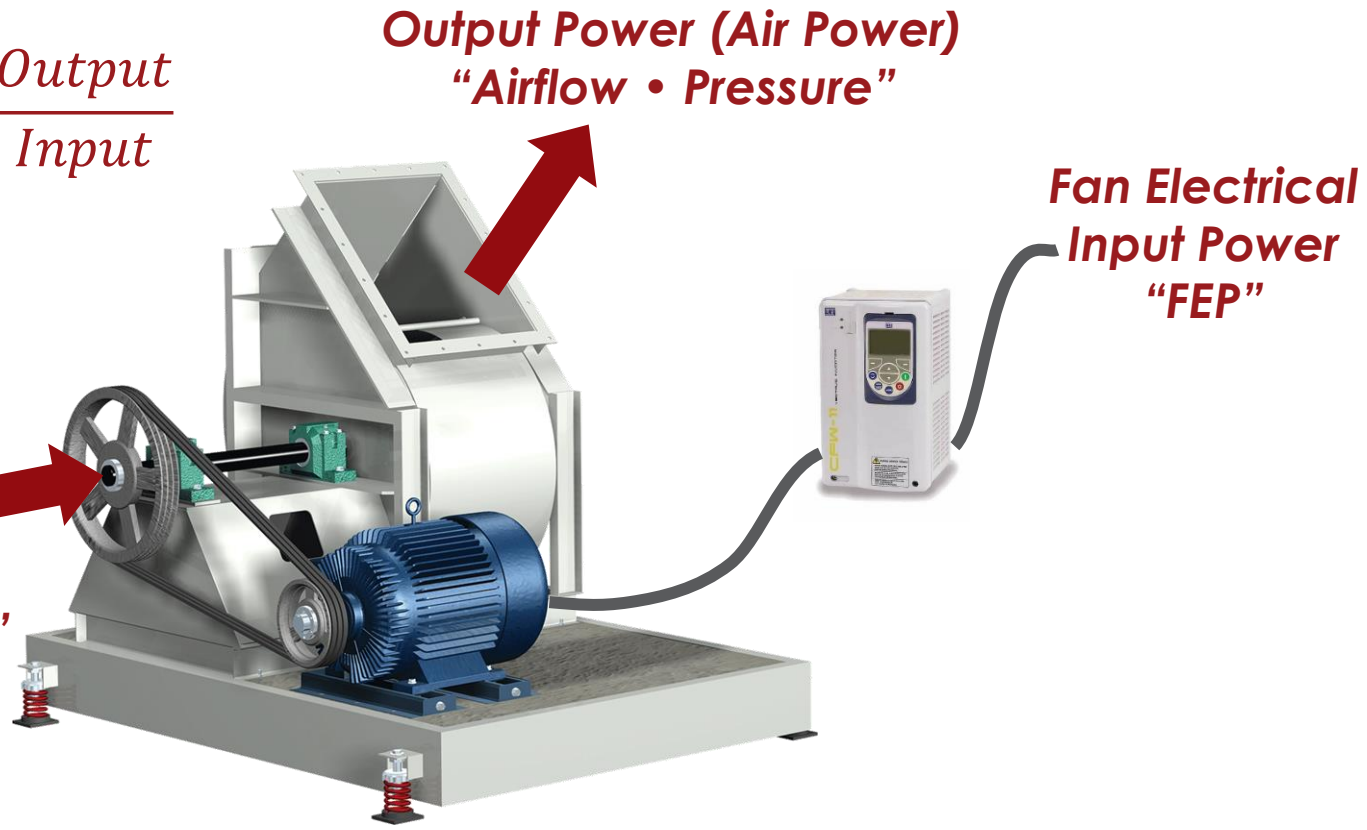
Mechanics of FEI

- Result: An FEI rating can be compared across fan types *at the duty point*
- Notes:
  - Other considerations may influence fan selection
  - From an efficiency perspective (energy consumption), at the duty point, FEI accurately captures an efficiency *incentive*
  - Given a flow and pressure requirement, FEI incents providers to consume the least amount of power by specifying the maximum allowed power consumption.

Mechanics of FEI

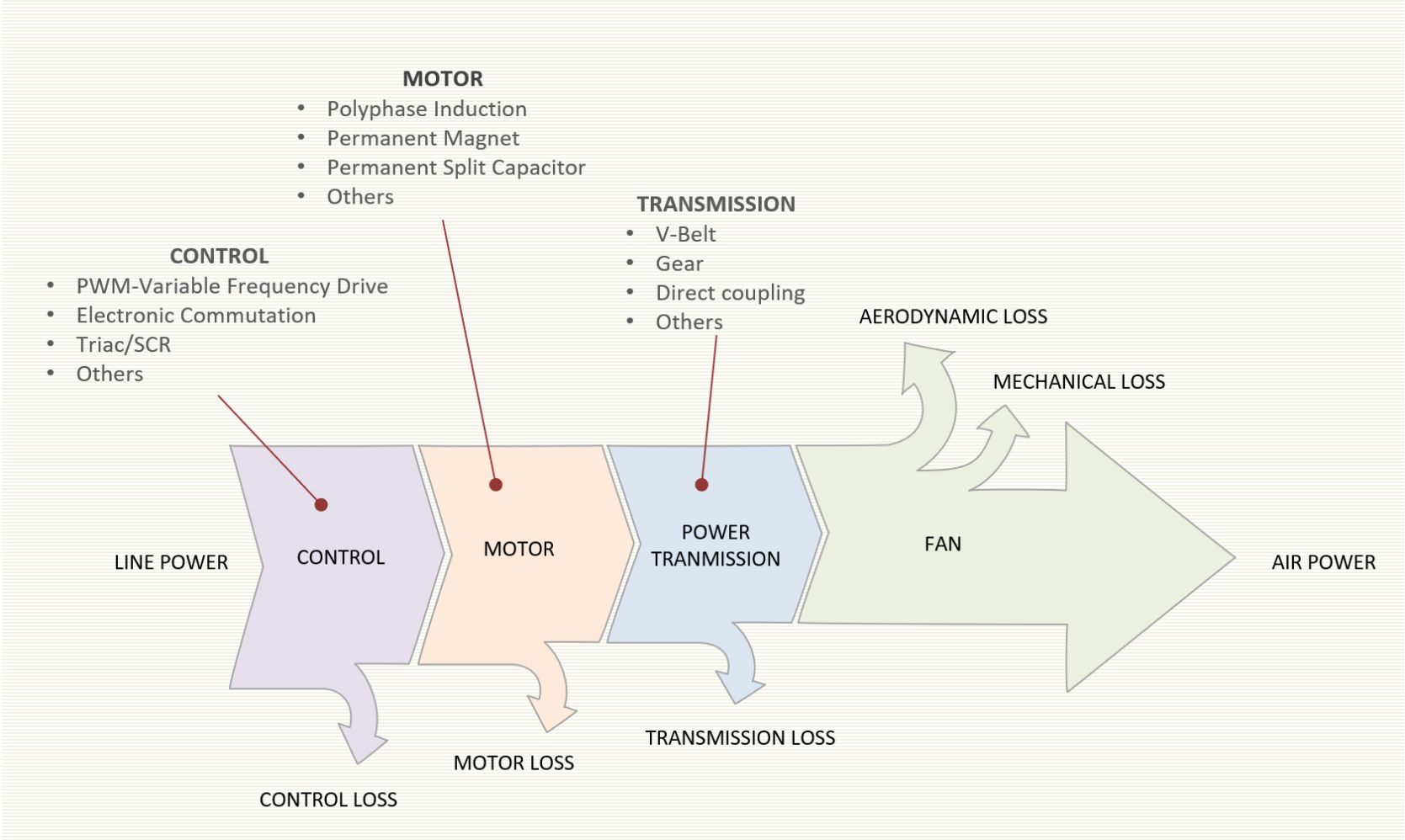
- FEI is a wire-to-air metric

$$Efficiency = \frac{Output}{Input}$$



Mechanics of FEI

- System Components – AMCA 207



Mechanics of FEI

- Consolidated Reference – AMCA 214

$$FEI_t \text{ or } FEI_s = \frac{\text{Reference Fan Electical Power}}{\text{Actual Fan Electrical Power}} = \frac{FEP_{ref}}{FEP_{act}}$$

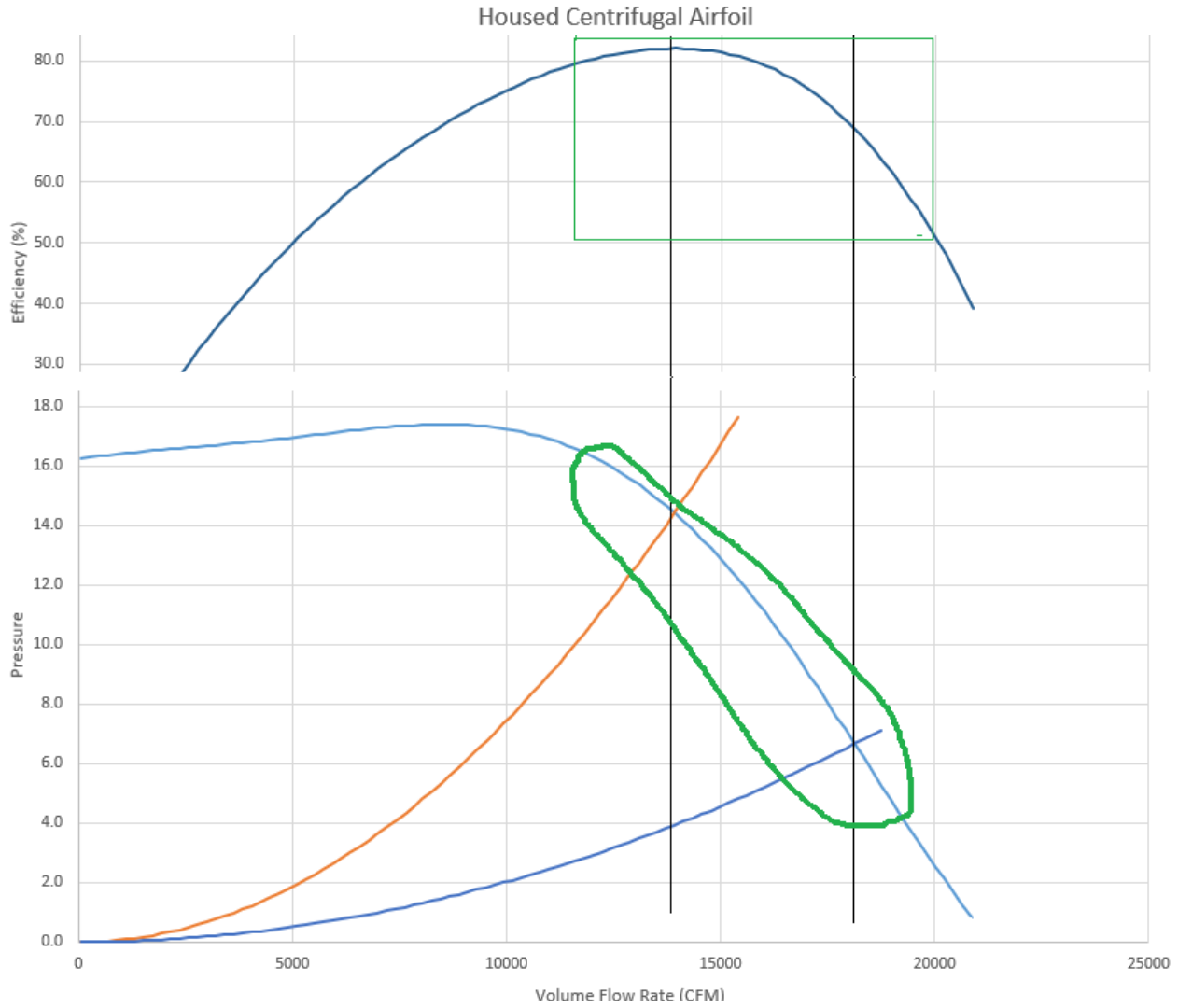
$$FEP_{ref} = \mathrm{H_{i,ref}}\left(\frac{1}{\eta_{\mathrm{trans,ref}}}\right)\left(\frac{1}{\eta_{\mathrm{mtr,ref}}}\right) \quad \text{[SI]}$$

$$FEP_{ref} = \mathrm{H_{i,ref}}\left(\frac{1}{\eta_{\mathrm{trans,ref}}}\right)\left(\frac{1}{\eta_{\mathrm{mtr,ref}}}\right) \times 0.7457 \quad \text{[I-P]}$$

$$FEP_{act} = H_{i,act}\left(\frac{1}{\eta_{trans,def}}\right)\left(\frac{1}{\eta_{mtr,def}}\right) \quad \text{[SI]}$$

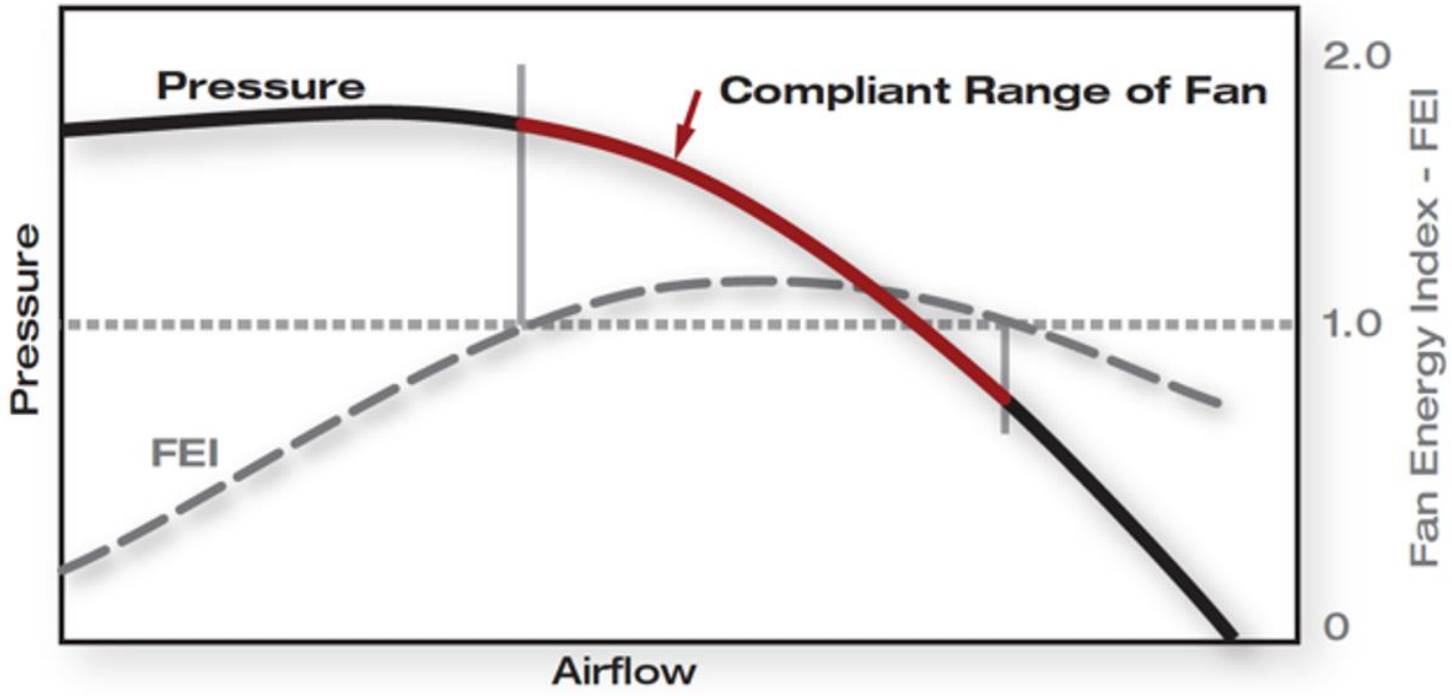
$$FEP_{act} = H_{i,act}\left(\frac{1}{\eta_{trans,def}}\right)\left(\frac{1}{\eta_{mtr,def}}\right) \times 0.7457 \quad \text{[I-P]}$$

Mechanics of FEI



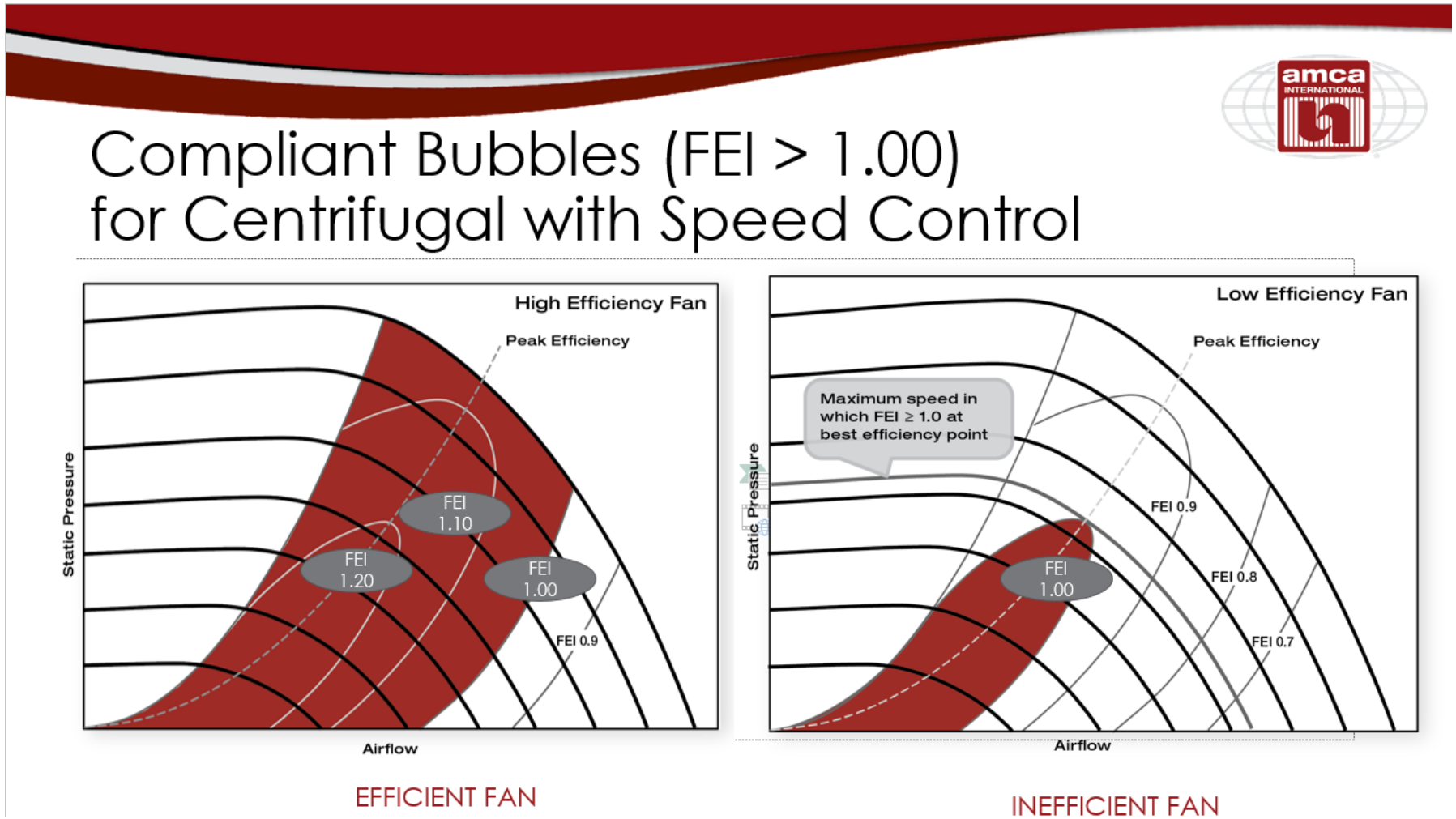
Mechanics of FEI

Compliant Range (FEI ≥ 1.00) for Constant Speed Fan



Mechanics of FEI

- The FEI Bubble



Mechanics of FEI

- Where do the numbers come from?
- FEP_{act}
  - Measured
  - Calculated

Mechanics of FEI

- Total vs. Static Pressure
- Total: Ducting can convert velocity pressure back to static pressure
- Determined by the fan type

Mechanics of FEI

- Sample

FEI Calculations

Instructions:

Please fill the blue colored cells.

Only ODP and TEFC motors are considered.

Please copy down from row 17.

Assumption: VFD capacity is same as motor capacity when VFD capacity is not given.

			AMCA 208 Annex A			Duty Point						FEP_{ref} Calculation Section 5.2				$H_{i,measured}$		Fan paired with regulated motor (US Regulation only) Section 5.3.3 (uses AMCA 207)								
Qty Sold	Model	Size	Fan Category	Test Config	FEI Pressure Basis	Impeller Dia (in.)	Outlet Area (ft^2)	Air Density (lb/ft^3)	Airflow (cfm)	Fan Static Pressure (in. wg)	Fan Total Pressure (in. wg)	$H_{i,ref}$ (bhp)	$\eta_{trans,ref}$	$\eta_{mtr,ref}$	FEP_{ref} (kW)	$H_{i,act}$ (bhp)	Drive Type	Motor Size (hp)	Motor Encl.	No. Poles	Include VFD?	VFD Capacity (hp)	$\eta_{trans,act}$	$\eta_{mtr,act}$	FEP_{act} (kW)	FEI
1	AF	300	Centrifugal Housed	B or D	Total	30.5	5.17	0.075	12000	4	4.34	13.9	95.3%	92.7%	11.7	9.46	V-Belt	10	TEFC	4	No	10	95.0%	91.7%	8.10	1.44
1	AF	300	Centrifugal Housed	B or D	Total	30.5	5.17	0.075	12000	4	4.34	13.9	95.3%	92.7%	11.7	9.46	Direct	10	TEFC	4	No	10	100%	91.9%	7.68	1.52

Mechanics of FEI

- Sample

													H_i Measured									
AMCA 208 Annex A			Duty Point						FEP_{ref} Calculation Section 5.2						Fan paired with regulated motor (US Regulation only) Section 5.3.3 (uses AMCA 207)								
Fan Category	Test Config	FEI Pressure Basis	Impeller Dia (in.)	Outlet Area (ft^2)	Air Density (lb/ft^3)	Airflow (cfm)	Fan Static Pressure (in. wg)	Fan Total Pressure (in. wg)	$H_{i,ref}$ (bhp)	$\eta_{trans,ref}$	$\eta_{mtr,ref}$	FEP_{ref} (kW)	$H_{i,act}$ (bhp)	Drive Type	Motor Size (hp)	Motor Encl.	No. Poles	Include VFD?	VFD Capacity (hp)	$\eta_{trans,act}$	$\eta_{mtr,act}$	FEP_{act} (kW)	FEI
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- Don’t Panic!
  - For the most part, you will not have to calculate these values…although…
  - Fan manufacturers will ☹
  - Expect to be incorporated into fan selection software

Review

- What is FEI?
  - Fan system energy efficiency metric

$$FEI = \frac{Your\ fan\ system\ efficiency}{Fan\ efficiency\ of\ a\ \text{reference}\ fan\ system}$$

  - ≥ 1 ⇨ good
  - < 1 ⇨ bad

$$FEI = \frac{Fan\ system\ electrical\ input\ power\ of\ a\ \text{reference}\ fan\ system}{Your\ fan\ system\ electrical\ input\ power}$$

- FEI and regulation
- Mechanics of FEI
  - Operating Condition Metric

Resources

- **AMCA International- FEI site**: *www.amca.org/fei*
- **AMCA Fan Energy Index video**: *https://amca.wistia.com/medias/3vmsplvbym*
- **ANSI/AMCA Standards**: *www.amca.org/store*

  > 207-17: Fan System Efficiency and Fan System Input Power (available for purchase)

  > 208-18: Calculation of the Fan Energy Index (free PDF download)

  > 214-21: Test Procedure for Calculating Fan Energy Index (FEI) for Commercial and Industrial Fans and Blowers (free PDF download currently available)

Thank you for your time!

*To receive PDH credit for today's program, you **must** complete the online evaluation, which will be sent via email 1 hour after the conclusion of this session.*

PDH credits and participation certificates will be issued electronically within 30 days, once all attendance records are checked and online evaluations are received.

Attendees will receive an email at the address provided on your registration, listing the credit hours awarded and a link to a printable certificate of completion.

Questions?