New Fan Efficiency Requirements in ANSI/ASHRAE/IES 90.1-2019

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Content Manager, AMCA International

Webinar Moderator

- Joined AMCA in 2017
- Leads development and publication of technical articles, white papers and educational materials.
- Editor-in-chief of the award-winning *AMCA inmotion* magazine.

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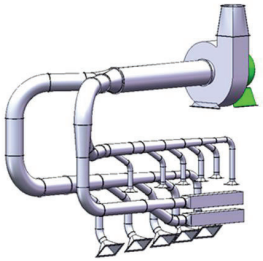

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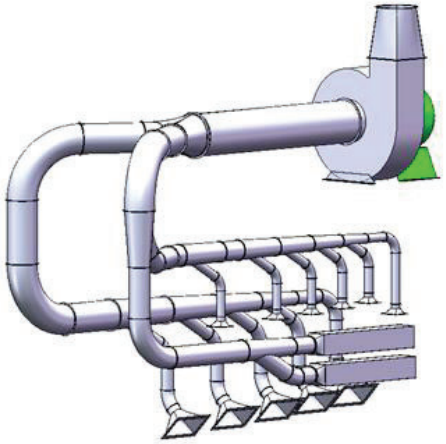

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- Participation Guidelines:
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  - Questions can be submitted anytime via the Go24 webinar platform and will be addressed at the end of the presentation.
  - Reminder: This webinar is being recorded!
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New Fan Efficiency Requirements in ANSI/ASHRAE/IES 90.1-2019

Purpose and Learning Objectives

The purpose of this presentation is to inform participants about AMCA International, the AMCA Certified Ratings Program (CRP), and 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. Explain why FEI is replacing FEG in model energy codes and standards, including ASHRAE 90.1-2019 and ASHRAE 189.1-2020.
2. Apply FEI for sizing and selecting fans for Constant Speed (CS) and Variable Air Volume (VAV) systems.
3. Describe how to find FEI ratings from manufacturers.

TODAY'S PRESENTERS

- Tim Mathson, AMCA Principal Engineer
- Jeff Boldt, Managing Principal and ASHRAE Fellow
- Michael Ivanovich, AMCA Sr. Director, Global Affairs

Michael Ivanovich

Senior Director, Global Affairs AMCA International

- Joined AMCA July 2011
- Voting member of ASHRAE 90.1 Mechanical Subcommittee
- Represents AMCA on codes, standards and regulations
- Coordinates advocacy in N. America, Asia, Europe, and Middle East

Jeff Boldt

PE, FASHRAE, LEED® AP, HBDP, FPE

- Managing Principal – Director of Innovation & Quality at IMEG Corp. with 39 years experience
- Chair ASHRAE SSPC-90.1 Mechanical Subcommittee
- Former Chair ASHRAE 189.1 Acoustics Group
- Member ASHRAE Technical Committees 2.6, 3.6, 5.2, & 8.6

Tim Mathson

Principal Engineer, AMCA International

- Joined AMCA 2019
- 30 years as a fan designer/engineer at Greenheck
- Chaired AMCA 208 Committee, Fan Engineering Committee
- Member of ASHRAE TC 5.1

Fan Energy Index Basics

Tim Mathson

AMCA Is…

- Air Movement and Control Association International
- Not-for-profit
- Established 1917 with six member companies in USA
- Now global with almost 400 companies
- More than half of AMCA members are outside North America

The AMCA Mission:

To advance the knowledge of air systems and uphold industry integrity on behalf of AMCA members worldwide.

Advocate

Certify

Educate

FEI Outline

- FEI Basics (Tim)
- FEI in ASHRAE 90.1 and 189.1 (Jeff)
- Why Specify Certified FEI Ratings (Jeff)
- FEI in CV and VAV Systems (Mike)
- AMCA Resources for FEI (Mike)

Why Change from FEG?

- Origin of FEI is a now-stalled USA federal regulation
- Problems with Fan Efficiency Grade (FEG)
  - Not wire-to-air
    - Bare-shaft fan only
    - No inclusion of motors, drives
  - Peak total efficiency only
    - Needed a selection window applied by designers

      "Fans must be selected to operate within 10 percentage points of peak total efficiency"
    - Cannot apply such a window for an equipment/appliance regulation

FEI Fixes FEG Problems

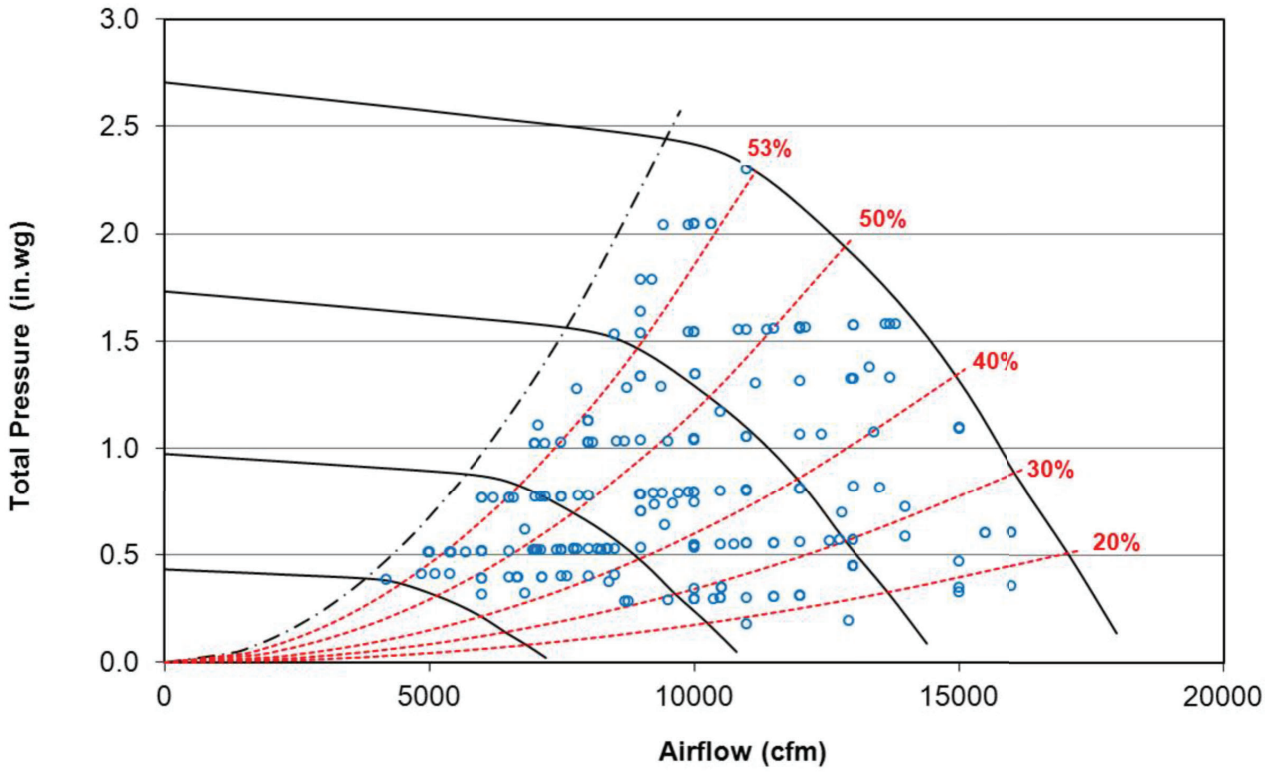
- FEI fixes all these issues:
  - Wire to air – covers fan, transmission, motor, speed control
  - Considers off-peak fan efficiency
  - Static or total pressure, as appropriate
  - Includes fans testable to:
    - Most commercial/industrial fans: AMCA 210 / ISO 5801
    - Jet fans: AMCA 250 / ISO 13350
    - Induced flow fans: AMCA 260

Fan Selection

- Fan efficiency is highly dependent on where the fan is operating on the fan curve.
- Fans are typically selected to provide a designated duty point.
  - Airflow
  - Pressure
  - Air Density (sea level vs. high elevation)
- Turns out, help is needed for selecting fans.

Square Inline Fan – Size 30

295 Actual Fan Selections



Benefits of FEI

Clarity

- FEI includes effect of losses from fans, motors, and drives
- FEI rating allows instant identification of compliance

Flexibility

- Fan selections allow variety of fan types, sizes, motors, and drives
- Facilitates consideration of budget, acoustics, form factor, etc.

Simplicity

- Intuitive metric that directly reflects power consumed by the fan

Greater energy savings

- Net result is greater energy savings and lower lifecycle cost

Wire-to-Air Metric

Output Power (Air Power)
"Airflow x Pressure"

Duty Point:
A specific combination of airflow and pressure the fan is producing.

Fan Electrical Input Power "FEP"

FEI – Fan Energy Index

Defined in AMCA 208:

$$FEI = \frac{Reference\ Fan\ Electrical\ Input\ Power}{Actual\ Fan\ Electrical\ Input\ Power}$$

$$FEI = \frac{FEP_{ref}}{FEP}$$

- FEP_{ref} and FEP calculated at the same airflow and pressure.
- FEI is a relative measure of power required for a given duty point – relative to the *Reference Fan.*

The Reference Fan

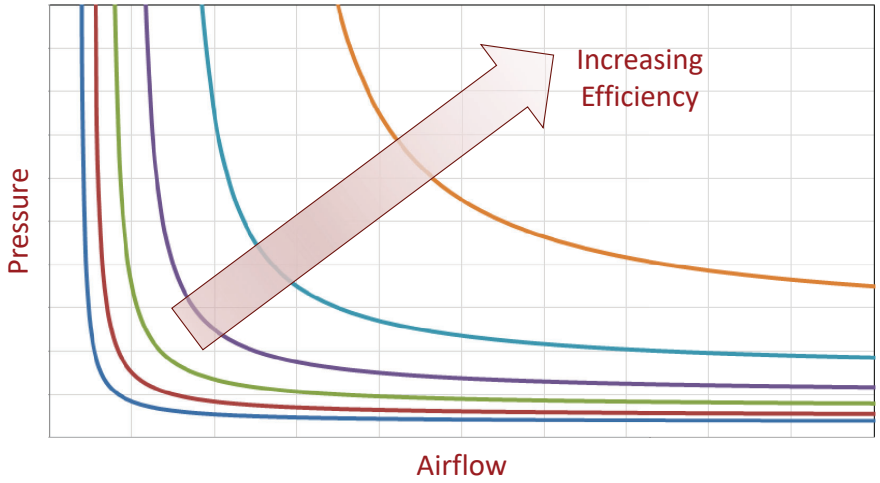
Think of the Reference fan as a "*Reasonably Efficient Fan*"…

- Established by DOE and the fan industry
- Later documented in AMCA 208

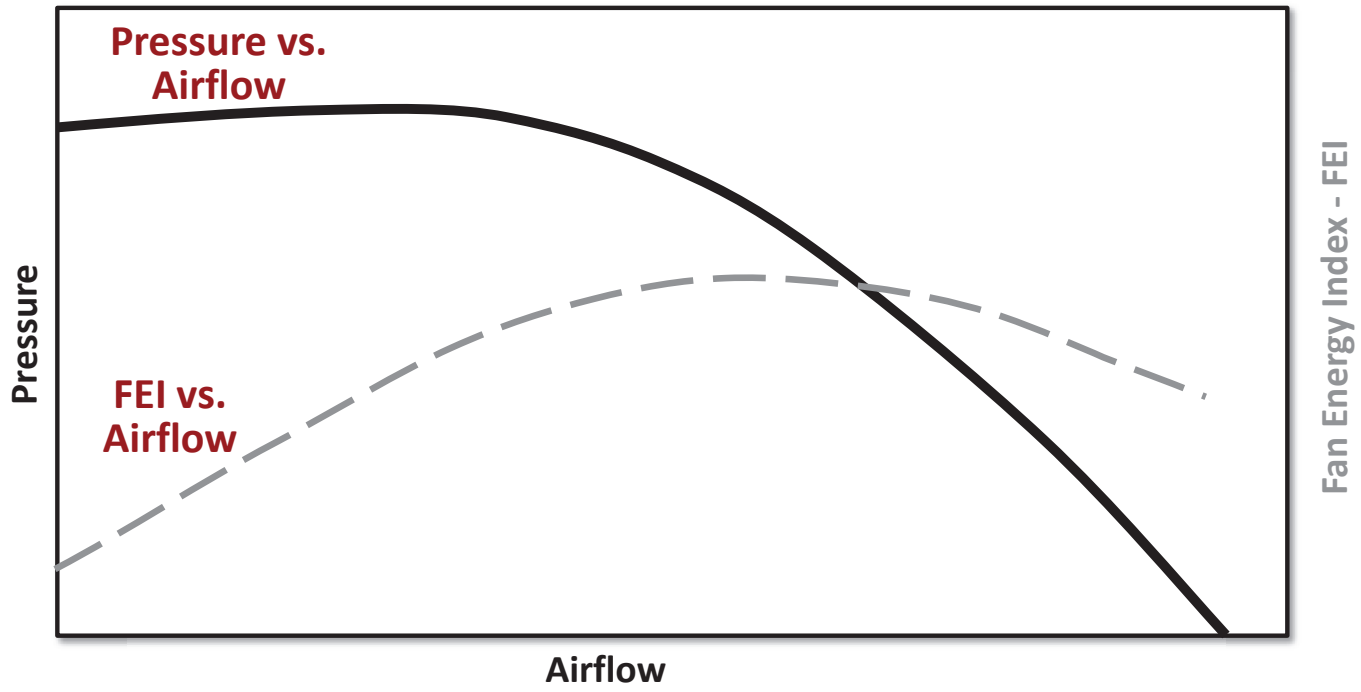
Empirical function of fan efficiency vs. airflow and pressure:

1. Independent of:
   - Fan type
   - Fan size
   - Motor type
   - Belt or direct drive

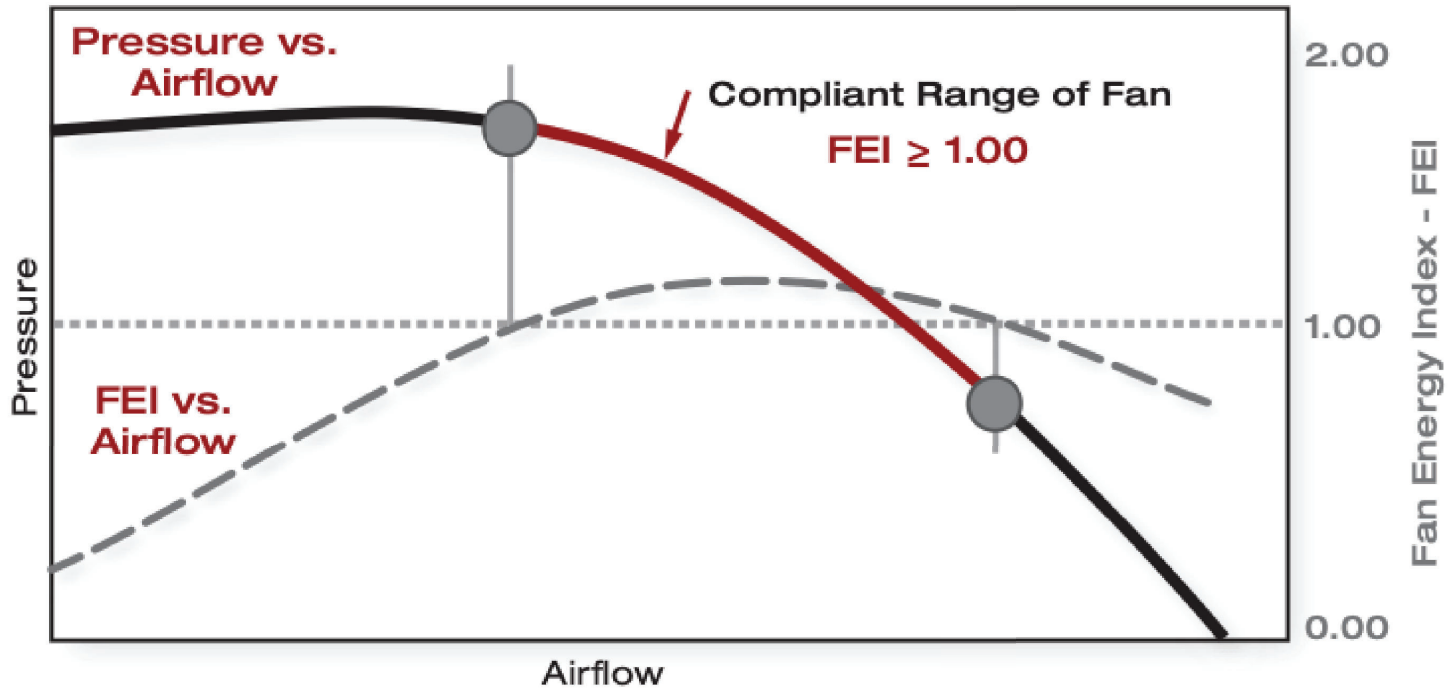
2. Fixed in time



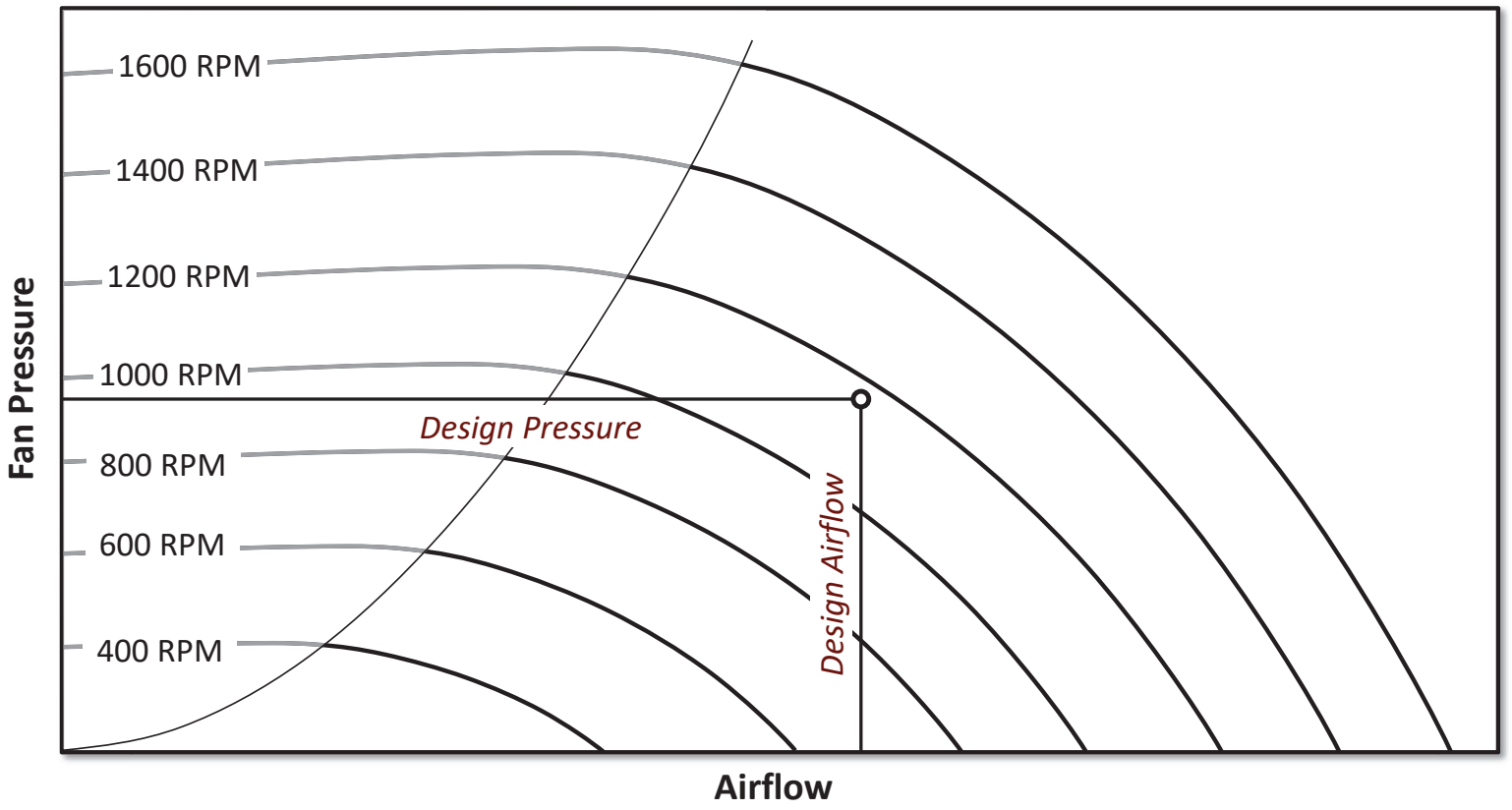
FEI is Defined at Every Duty Point



FEI ≥ 1.00 Defines Compliant Range for Selection



Fan Selection Using Multiple Speed Fan Curves



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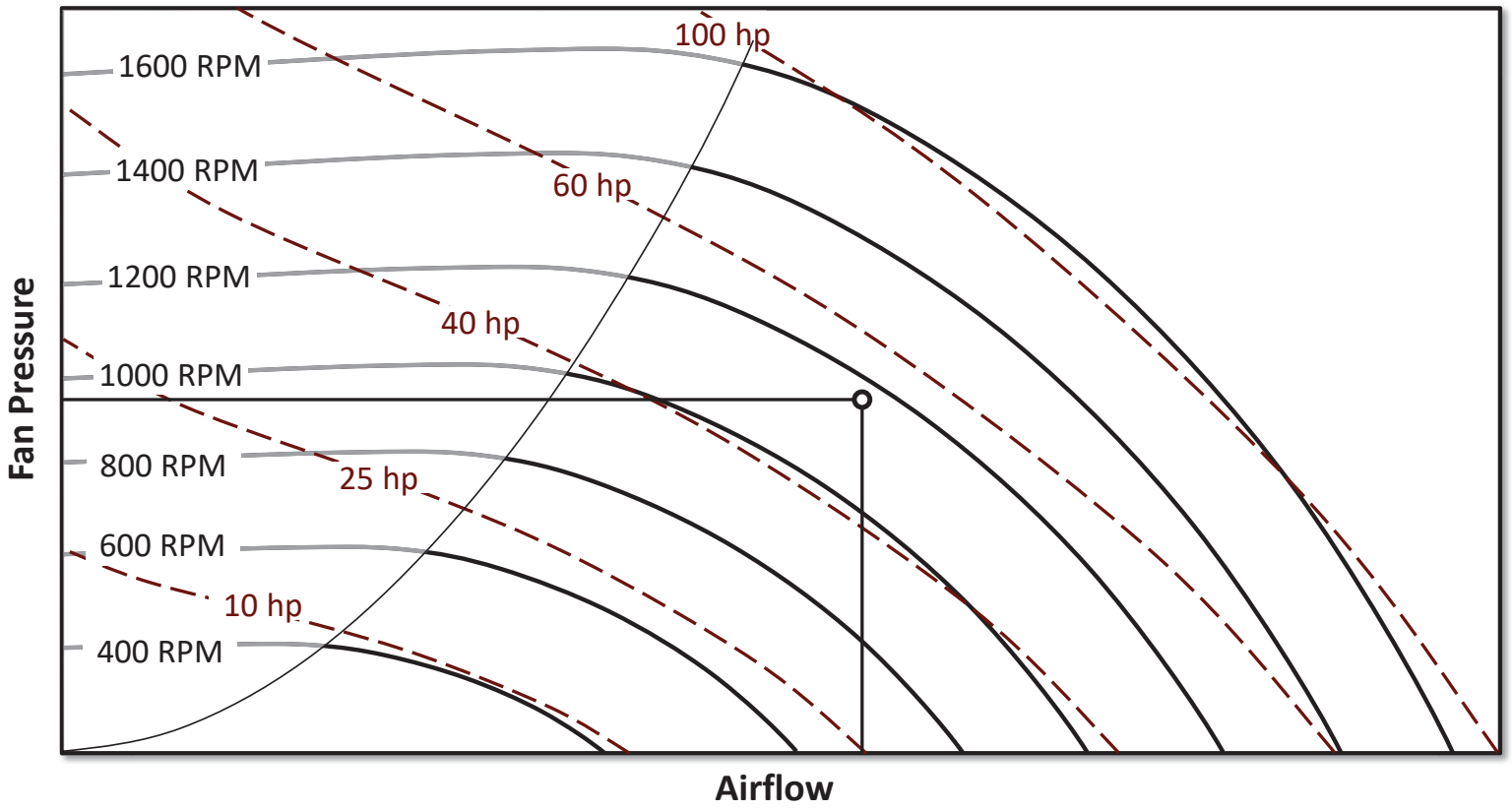

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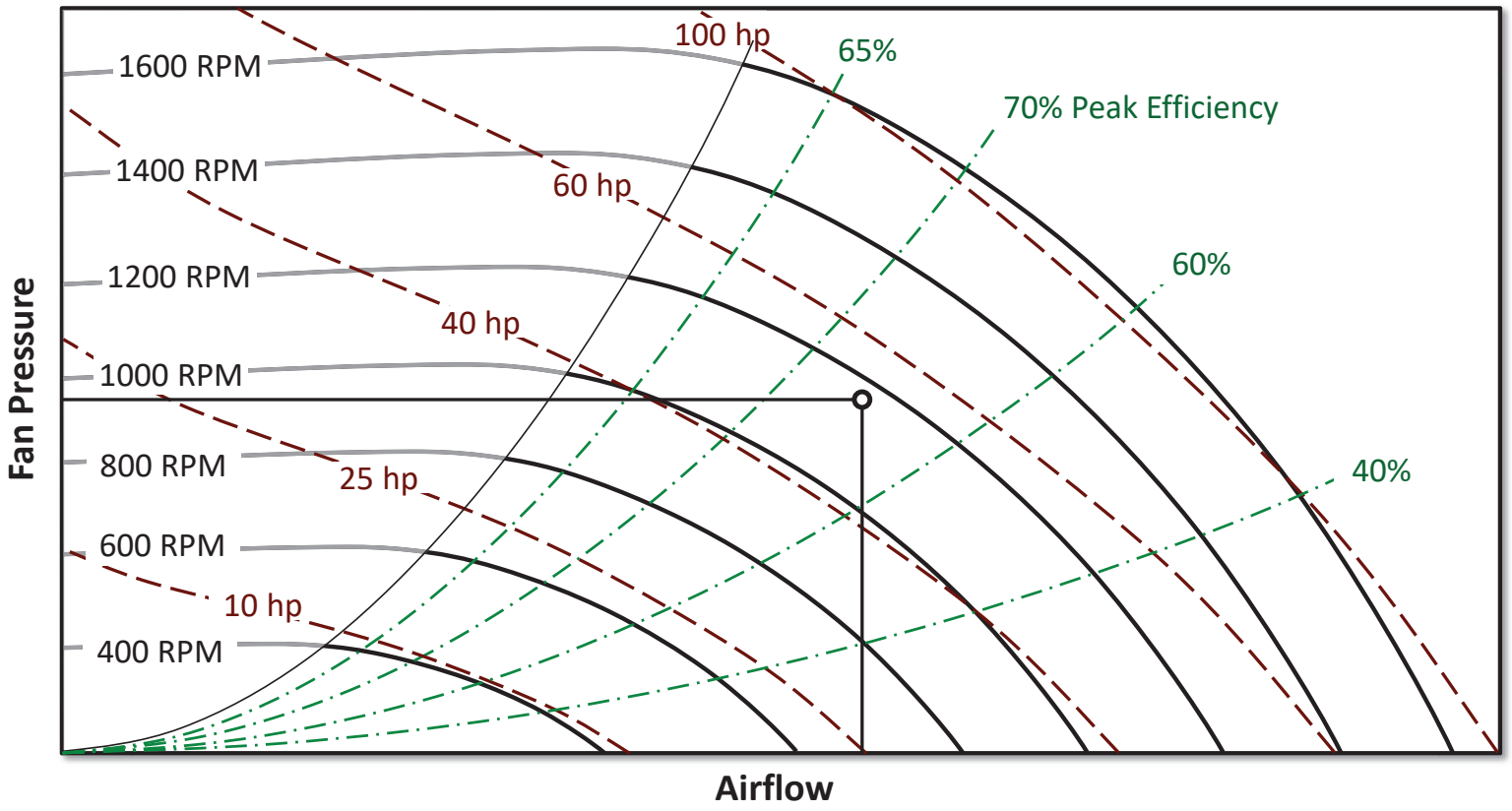

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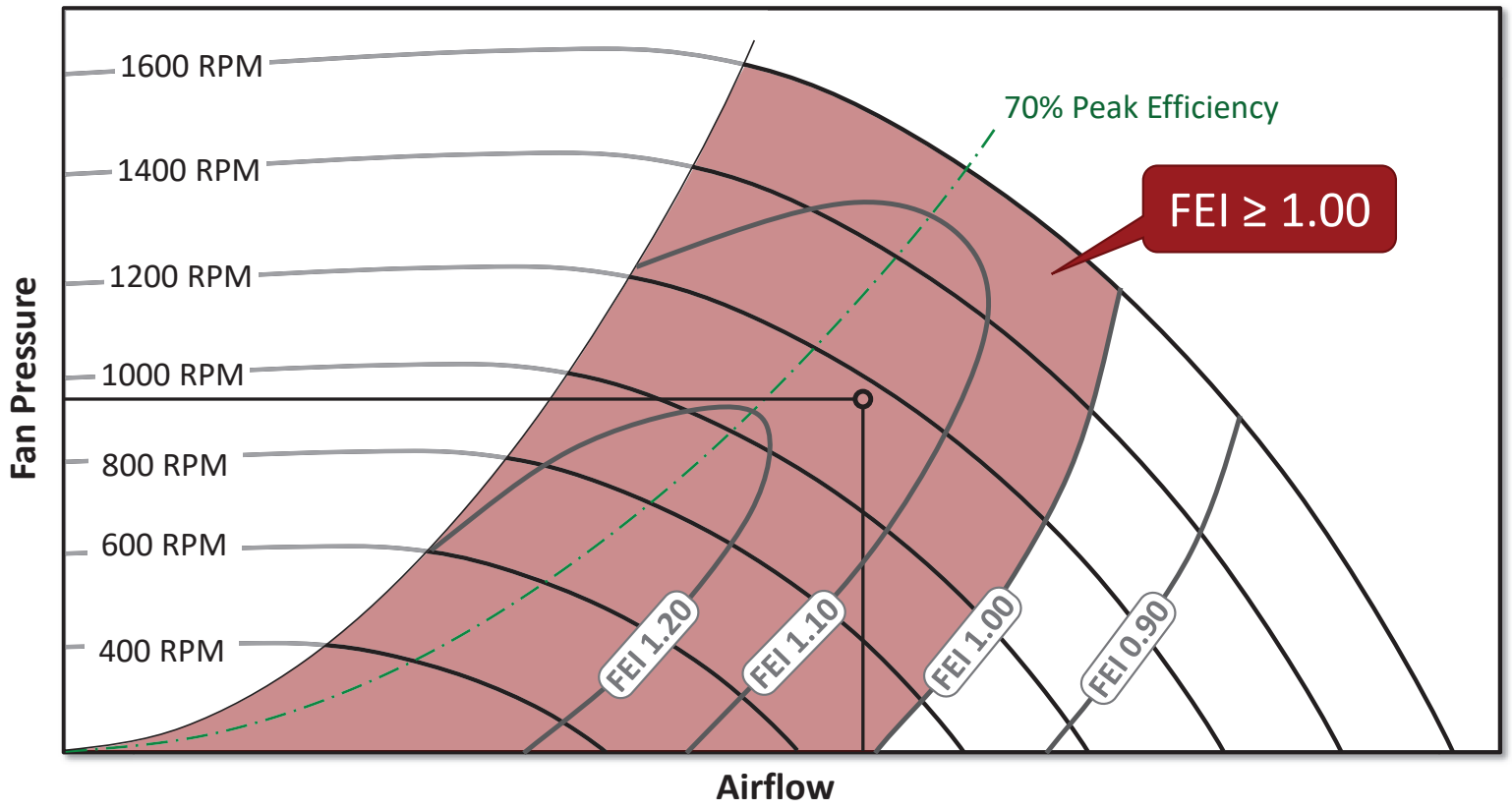

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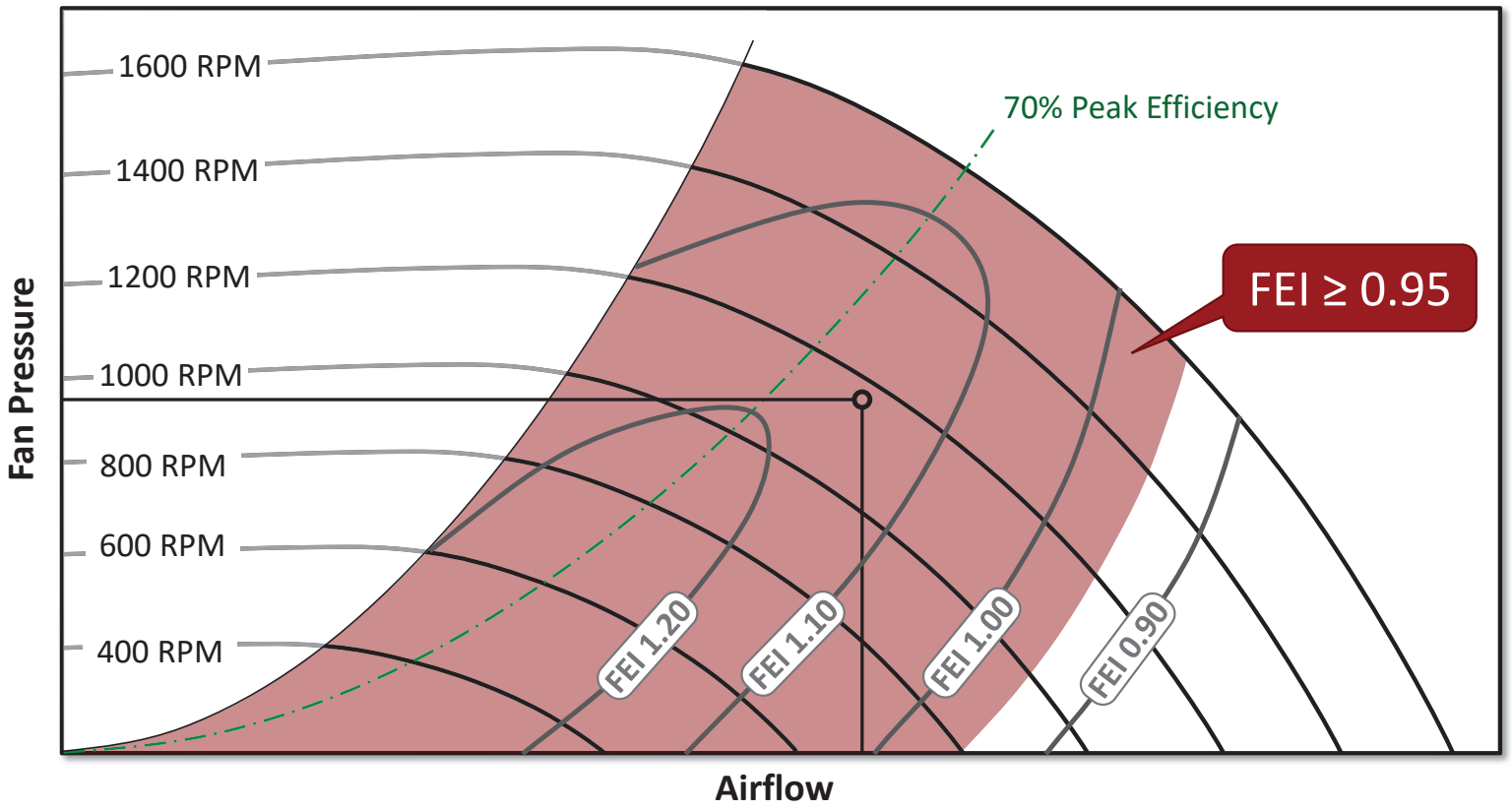


FEI Improves Fan Selections

Enables comparisons of:

- Different fan types
- Different fan sizes
- Different motor and drive combinations

All at the same design duty point!

FEI Examples – Stand Alone Fans

Utility set:

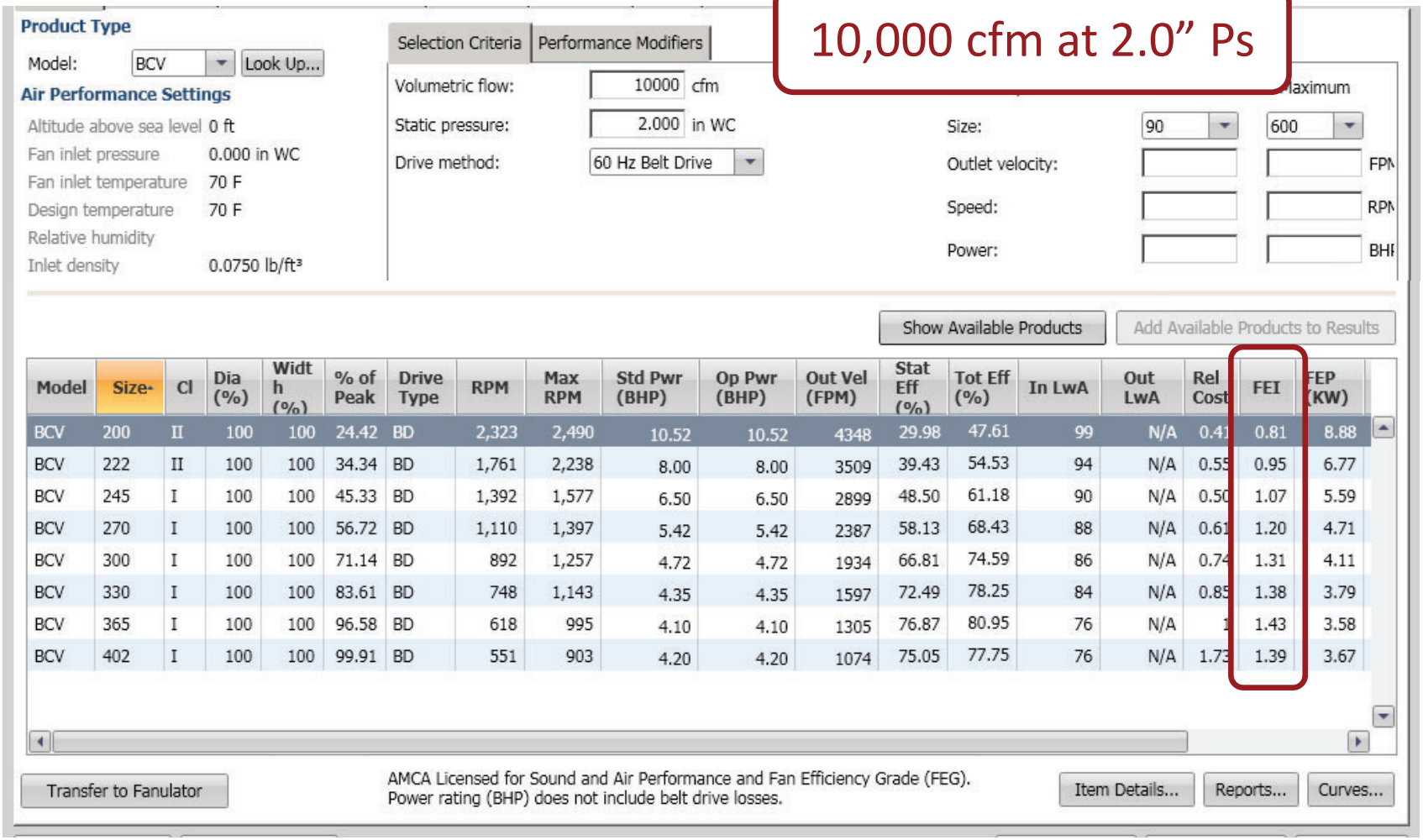
- 10,000 cfm at 2.0” wg static pressure

Sidewall prop fan:

- 20,000 cfm at 0.25” wg static pressure

Utility Set

10,000 cfm at 2.0” Ps



Product Type

Model: BCV Look Up...

Air Performance Settings

Altitude above sea level	0 ft
Fan inlet pressure	0.000 in WC
Fan inlet temperature	70 F
Design temperature	70 F
Relative humidity	
Inlet density	0.0750 lb/ft³

Selection Criteria | Performance Modifiers

Volumetric flow: 10000 cfm

Static pressure: 2.000 in WC

Drive method: 60 Hz Belt Drive

Maximum

Size: 90 600

Outlet velocity: FPM

Speed: RPM

Power: BHP

Show Available Products | Add Available Products to Results

Model	Size	Cl	Dia (%)	Width (%)	% of Peak	Drive Type	RPM	Max RPM	Std Pwr (BHP)	Op Pwr (BHP)	Out Vel (FPM)	Stat Eff (%)	Tot Eff (%)	In LwA	Out LwA	Rel Cost	FEI	FEP (KW)
BCV	200	II	100	100	24.42	BD	2,323	2,490	10.52	10.52	4348	29.98	47.61	99	N/A	0.41	0.81	8.88
BCV	222	II	100	100	34.34	BD	1,761	2,238	8.00	8.00	3509	39.43	54.53	94	N/A	0.55	0.95	6.77
BCV	245	I	100	100	45.33	BD	1,392	1,577	6.50	6.50	2899	48.50	61.18	90	N/A	0.50	1.07	5.59
BCV	270	I	100	100	56.72	BD	1,110	1,397	5.42	5.42	2387	58.13	68.43	88	N/A	0.61	1.20	4.71
BCV	300	I	100	100	71.14	BD	892	1,257	4.72	4.72	1934	66.81	74.59	86	N/A	0.74	1.31	4.11
BCV	330	I	100	100	83.61	BD	748	1,143	4.35	4.35	1597	72.49	78.25	84	N/A	0.85	1.38	3.79
BCV	365	I	100	100	96.58	BD	618	995	4.10	4.10	1305	76.87	80.95	76	N/A	1	1.43	3.58
BCV	402	I	100	100	99.91	BD	551	903	4.20	4.20	1074	75.05	77.75	76	N/A	1.73	1.39	3.67

Transfer to Fanulator

AMCA Licensed for Sound and Air Performance and Fan Efficiency Grade (FEG).
Power rating (BHP) does not include belt drive losses.

Item Details... | Reports... | Curves...

Sidewall Prop Fan

- 20,000 cfm at 0.25” static pressure

Model	Drive	Volume	SP	Power	Motor	RPM	Max (Fan)	OVEL	TSPD	SE	TE	Pts From	FEG	FEI	UnitWT
		CFM	inwc	HP	HP		RPM	fpm	fpm			PeakTE			lbs
36XLWH	Belt	20000	.25	3.51	5.00	825	895	2715	7883	24%	68%	0%	71	1.05	195
42XLWH	Belt	20000	.25	2.66	3.00	555	870	2006	6175	32%	64%	0%	67	1.37	246
48XLWH	Belt	20000	.25	2.11	3.00	432	650	1558	5471	40%	65%	3%	71	1.70	294
54XLWH	Belt	20000	.25	1.98	2.00	330	611	1234	4686	43%	59%	9%	71	1.81	313
60XLWH	Belt	20000	.25	1.90	2.00	259	550	1001	4085	45%	56%	15%	75	1.88	338
42XMWH	Belt	20000	.25	2.56	3.00	653	821	2006	7265	33%	66%	3%	71	1.42	245
48XMWH	Belt	20000	.25	1.96	2.00	491	726	1558	6218	43%	70%	0%	71	1.82	269
54XMWH	Belt	20000	.25	1.86	2.00	356	558	1234	5056	46%	63%	7%	71	1.92	320
60XMWH	Belt	20000	.25	1.46	1.50	299	530	1001	4716	58%	73%	2%	80	2.40	305

Sidewall Prop Fan

- 10,000 cfm at 0.25” static pressure

Model	Drive	Volume	SP	Power	Motor	RPM	Max (Fan)	OVEL	TSPD	SE	TE	Pts From	FEG	FEI	UnitWT
		CFM	inwc	HP	HP		RPM	fpm	fpm			PeakTE			lbs
24XLWH	Belt	10000	.25	2.16	3.00	1380	1398	2993	8806	20%	64%	1%	67	0.88	147
30XLWH	Belt	10000	.25	1.34	1.50	768	1061	1939	6132	32%	62%	1%	67	1.38	118
36XLWH	Belt	10000	.25	1.07	1.50	550	895	1357	5255	40%	59%	9%	71	1.70	142
42XLWH	Belt	10000	.25	1.16	1.50	421	870	1003	4684	37%	47%	17%	67	1.58	188
48XLWH	Belt	10000	.25	1.32	1.50	373	650	779	4723	33%	37%	30%	71	1.40	228
54XLWH	Belt	10000	.25	1.30	1.50	283	611	617	4019	33%	36%	32%	71	1.41	272
60XLWH	Belt	10000	.25	1.61	2.00	247	550	500	3896	26%	28%	43%	75	1.16	338
30XMWH	Belt	10000	.25	1.24	1.50	988	1175	1939	7889	35%	67%	1%	71	1.49	121
36XMWH	Belt	10000	.25	.919	1	627	948	1357	5991	47%	69%	3%	-	1.95	142
42XMWH	Belt	10000	.25	.861	1	444	821	1003	4940	50%	63%	6%	-	2.07	188
48XMWH	Belt	10000	.25	1.05	1.50	394	726	779	4989	41%	47%	22%	71	1.73	234
54XMWH	Belt	10000	.25	1.13	1.50	296	558	617	4203	38%	42%	28%	71	1.62	279
60XMWH	Belt	10000	.25	1.03	1.50	261	530	500	4116	42%	45%	30%	80	1.77	305

Benefits of FEI

Clarity

- FEI includes effect of losses from fans, motors, and drives
- FEI rating allows instant identification of compliance

Flexibility

- Fan selections allow variety of fan types, sizes, motors, and drives
- Facilitates consideration of budget, acoustics, form factor, etc.

Simplicity

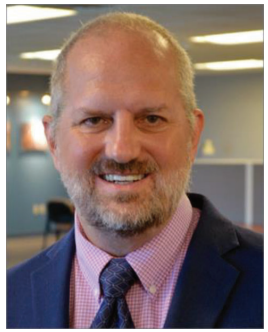
- Intuitive metric that directly reflects power consumed by the fan

Greater energy savings

- Net result is greater energy savings and lower lifecycle cost

FEI in Codes, Standards and Regulations

Jeff Boldt



FEI in Codes, Standards & Regulations

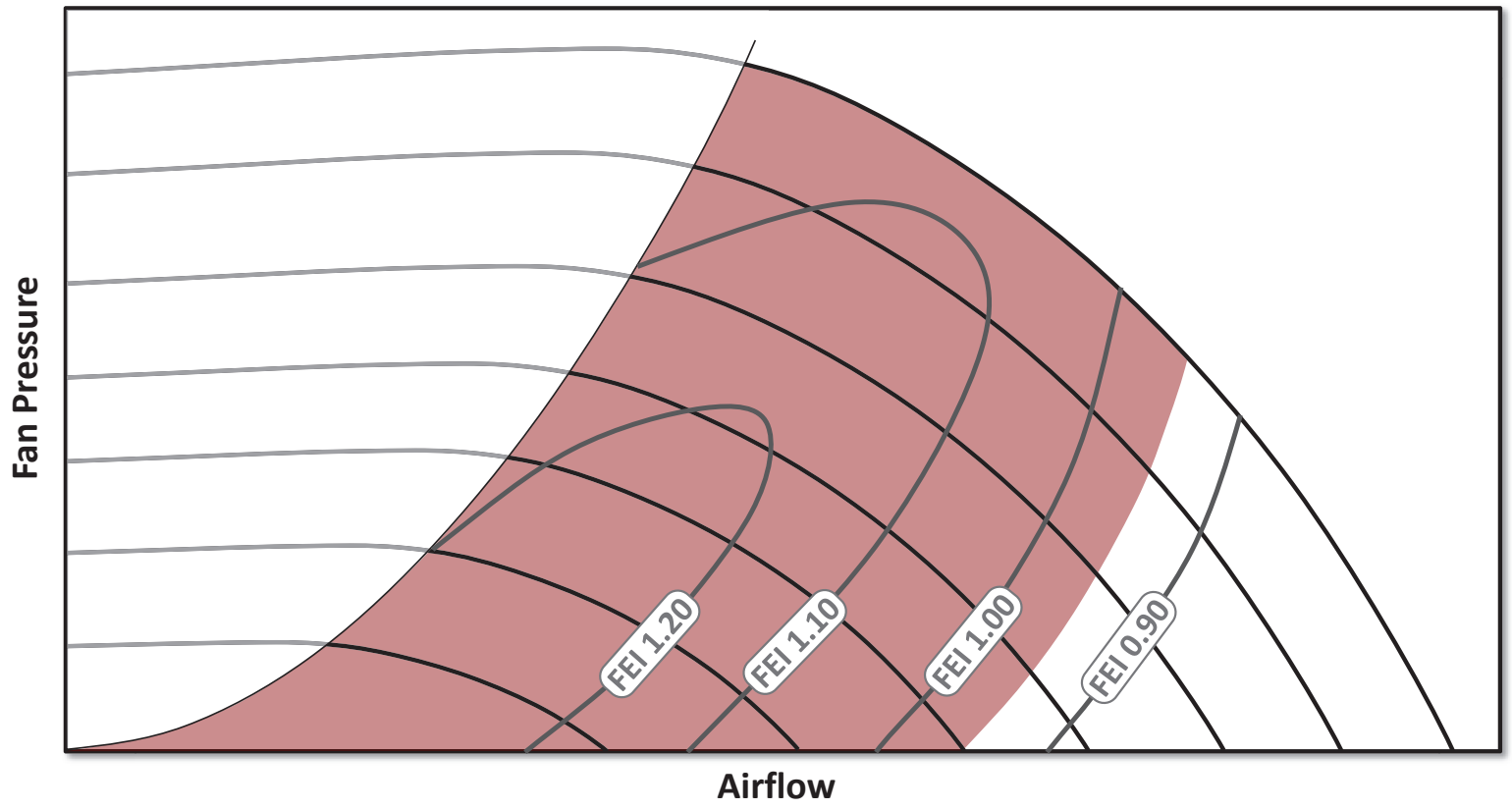
- Model energy **standard** → ASHRAE 90.1 - 2019
- Model energy **code** → International Energy Conservation Code (IECC) - 2021
- Model high-performance building (green) building **standard/code** → ASHRAE 189.1 / Intl. Green Construction Code (IGCC) -2020
- **State** building energy **codes** → California Title 24; states that adopt ASHRAE 90.1 or IECC
- **Federal** efficiency **regulations** → U.S. Dept. of Energy
- **State** appliance **regulations** → California Title 20

DONE
NEARLY DONE
PROGRESSING
STALLED

Baseline ASHRAE 90.1 and IECC Language

- FEI ≥ 1.00;
- FEI ≥ 0.95 for VAV
- FEI calculated at “fan system design conditions”
- Covered
  - Standalone fans (including PRVs) ≥ 1.00 HP (0.89 kW)
  - Embedded fans and fan arrays > 5.0 HP (4.1 kW)
- Exempt
  - Fans embedded in equipment that is regulated or 3rd party-certified for air performance or energy performance
  - Reversible tunnel ventilation fans
  - Fans for high temperatures, explosive atmospheres, high temperatures, or emergency conditions
  - Ceiling fans
  - Fans not in scope of AMCA 208

FEI > 0.95 Defines Compliant “Bubbles” for Variable Fan Speeds



Green/Stretch Codes

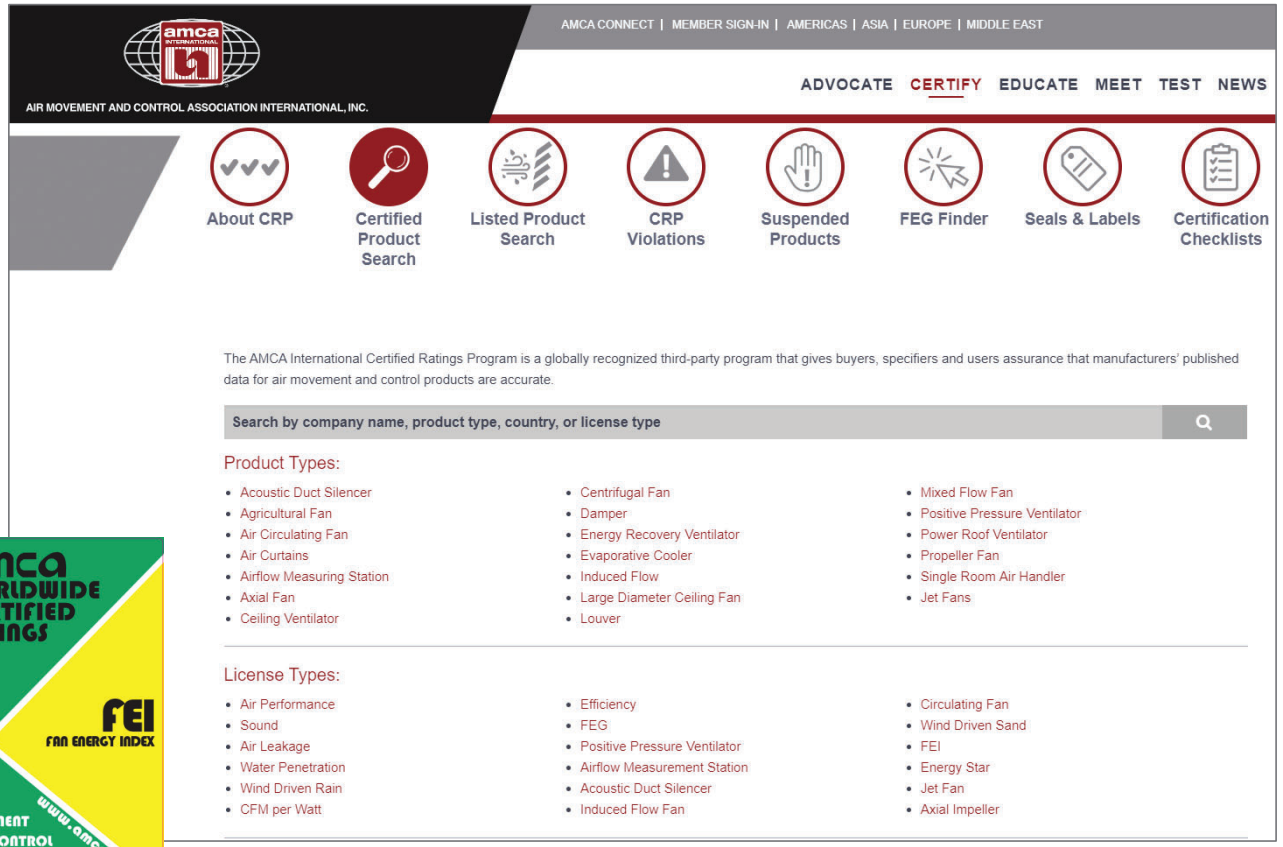
- ASHRAE 189.1-2020 and IgCC 2021
- FEI ≥ 1.10 for covered fans
- No new exemptions from baseline
- No removal of exemptions from baseline
- Level does not change for constant or variable speed

Specifying Certified FEI Ratings

- IMEG specifies AMCA certified ratings for fan performance, FEI, fan noise, louver & damper performance, etc.
- We've been to the AMCA HQ lab and are very confident that fans that AMCA certifies will perform to their published data (if we don't create system effects situations).

AMCA Certified FEI Ratings

- AMCA certifying fans and manufacturer software for FEI
  - 285 product lines thus far
- Check for FEI certifications at **www.amca.org/certify**
  - Click on “Certified Product Search” and search by “license type”
- Ratings found using manufacturer’s sizing/selection software



AMCA Certified Ratings Program (CRP)

amca INTERNATIONAL

Applying FEI in Constant Speed and VAV Systems

Michael Ivanovich

Sizing/Selection Example

- ASHRAE 90.1-2019:
  - FEI ≥ 1.00 at fan system design conditions (duty point)
  - FEI ≥ 0.95 for VAV

  - **Air flow rate**: 18,000 cfm (8.50 m^3/s)
  - **Air pressure (static):** 5.4 in. w.g. (1,345 pascal)
  - **Air density:** Standard (sea level)

  - For constant flow, duty point is at 100% flow
  - For VAV, hypothetical duty points are:
    - **40% flow:** 7,200 cfm (4.25 m^3/s)
    - **70% flow:** 12,800 cfm (5.95 m^3/s)
    - **100% flow:** 18,000 cfm (8.50 m^3/s)

Example Constant Flow

Impeller diameter in (mm)	Fan Impeller Type (all double width)	FEI @ 100% Flow
18 (464)	Airfoil	0.90
20 (508)	Airfoil	1.05
22 (565)	Airfoil	1.13
24 (622)	Airfoil	1.23
27 (686)	Airfoil	1.21
18 (464)	Backward inclined	0.82
20 (508)	Backward inclined	0.93
22 (565)	Backward inclined	1.05
24 (622)	Backward inclined	1.16
27 (686)	Backward inclined	1.17

Which Selection is Best?

Impeller diameter in (mm)	Fan Impeller Type (all double width)	FEI @ 40% Flow	FEI @ 70% Flow	FEI @ 100% Flow
18 (464)	Airfoil	1.05	0.89	0.90
20 (508)	Airfoil	1.17	1.06	1.05
22 (565)	Airfoil	1.21	1.15	1.13
24 (622)	Airfoil	1.24	1.25	1.23
27 (686)	Airfoil	1.20	1.23	1.21
16 (406)	Backward inclined	1.05	0.83	OVERSPEED
18 (464)	Backward inclined	1.02	0.90	0.82
20 (508)	Backward inclined	1.11	0.94	0.93
22 (565)	Backward inclined	1.21	1.12	1.05
24 (622)	Backward inclined	1.22	1.18	1.16
27 (686)	Backward inclined	1.19	1.20	1.17

Guidance for VAV Systems

- Because slowing a fan's rotational speed generally increases the FEI rating:
  - Best duty point for VAV is hottest day of year, needing 100% airflow.
  - Select fan to have an acceptable FEI rating at the 100% flow rate.
  - This will ensure fan is compliant at loads below 100% flow rate.
- If the fan meets the FEI requirement at the peak condition:
  - Fan likely to meet the FEI requirement at lower flow conditions.
- Ensure fan will avoid surge and overspeed at all operating points.

What is the Right Selection?

- All fans with FEI ≥ 1.00 (CS) or 0.95 (VAV) are compliant.
- Free to consider other decision criteria:
  - Form factor
  - Weight
  - Budget
  - Energy cost
  - Acoustics
  - Availability

Resources

- **AMCA International**: *www.amca.org*
- **AMCA Certified FEI ratings**: *www.amca.org/certify*
- **ANSI/AMCA Publications & Standards:** *www.amca.org/store* (available for purchase)

  > 208-18: Calculation of the Fan Energy Index

- **AMCA microsite for FEI training, technical papers, PowerPoints, and regulatory status**: *www.amca.org/fei*
- **ASHRAE 90.1-2019:** *www.ashrae.org/bookstore*

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 following this webinar.

If you viewed the webinar as a group and only one person registered for the webinar link, please email Lisa Cherney (lcherney@amca.org) for a group sign-in sheet today. Completed sheets must be returned to Lisa by tomorrow, May 21.

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?

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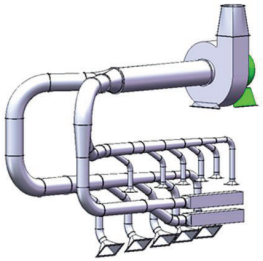

Ventilation & Fan
Consulting Service

NEXT PROGRAM

Join us for our next AMCA *insite* Pop-Up Webinar:

- Thursday, May 21
- 2:00-3:00 p.m. CDT
- ***TOPIC: Basics of Large Diameter Ceiling Fans***
- Presenter: Christian Taber, Principal Engineer - Codes and Standards, LEED AP BD+C, HBDP, BEMP, CEM

>> For additional webinar dates go to: *www.amca.org/webinar*