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

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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:

- Explain how FEI is replacing FEG in model energy codes and standards, including ASHRAE 90.1-2019 and ASHRAE 189.1-2020.
- Apply FEI for sizing and selecting fans for Constant Speed (CS) and Variable Air Volume (VAV) systems.
- Describe how to find FEI ratings from manufacturers.

FEI Outline

- FEI Basics
- FEI in ASHRAE 90.1 and 189.1
- How to Specify AMCA Certified FEI Ratings
- FEI in CV and VAV Systems
- AMCA Resources for FEI

Fan Energy Index Basics

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

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

FEI – Fan Energy Index

- Defined in AMCA 208:

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

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

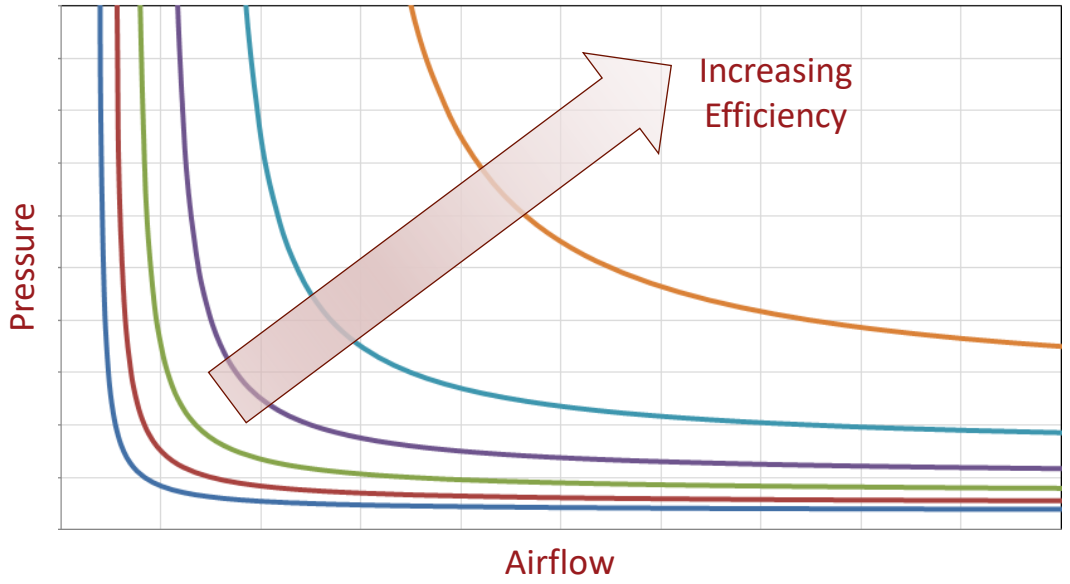
- FEP *ref* and FEP calculated at the same airflow and pressure
- FEI is a relative measure of power required for a given duty point – relative to the Reference Fan

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

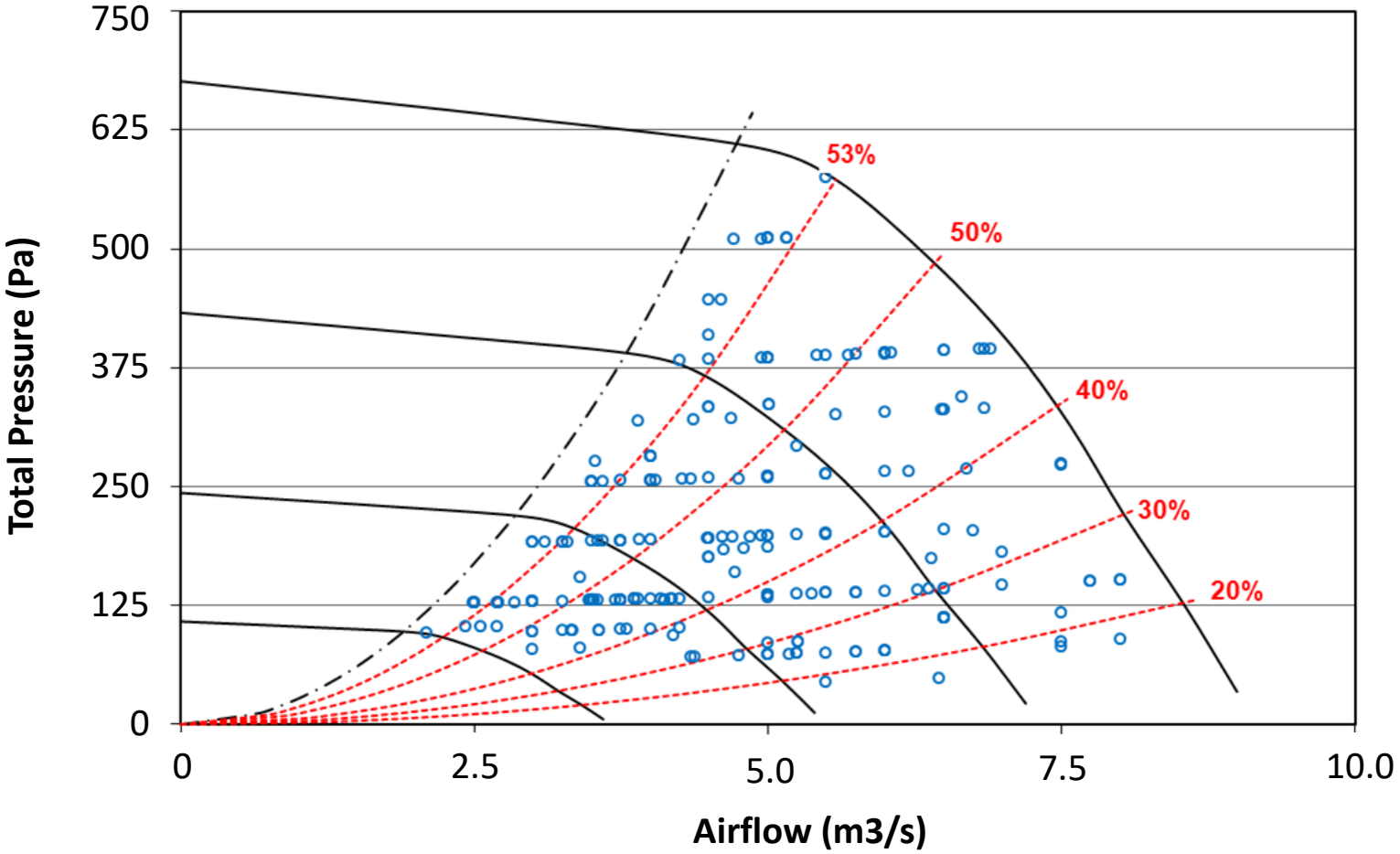
2. Fixed in time



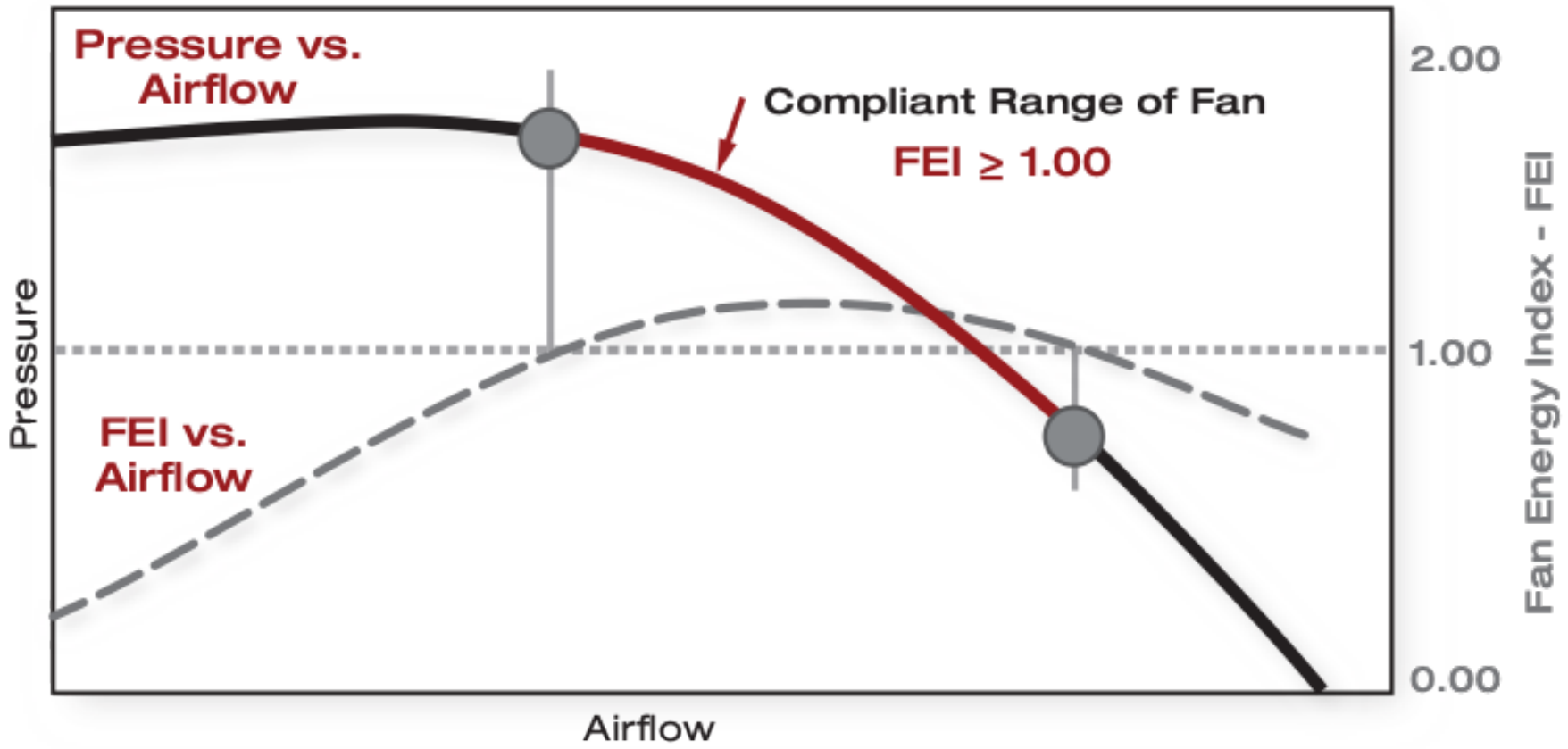
Fan Selection

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

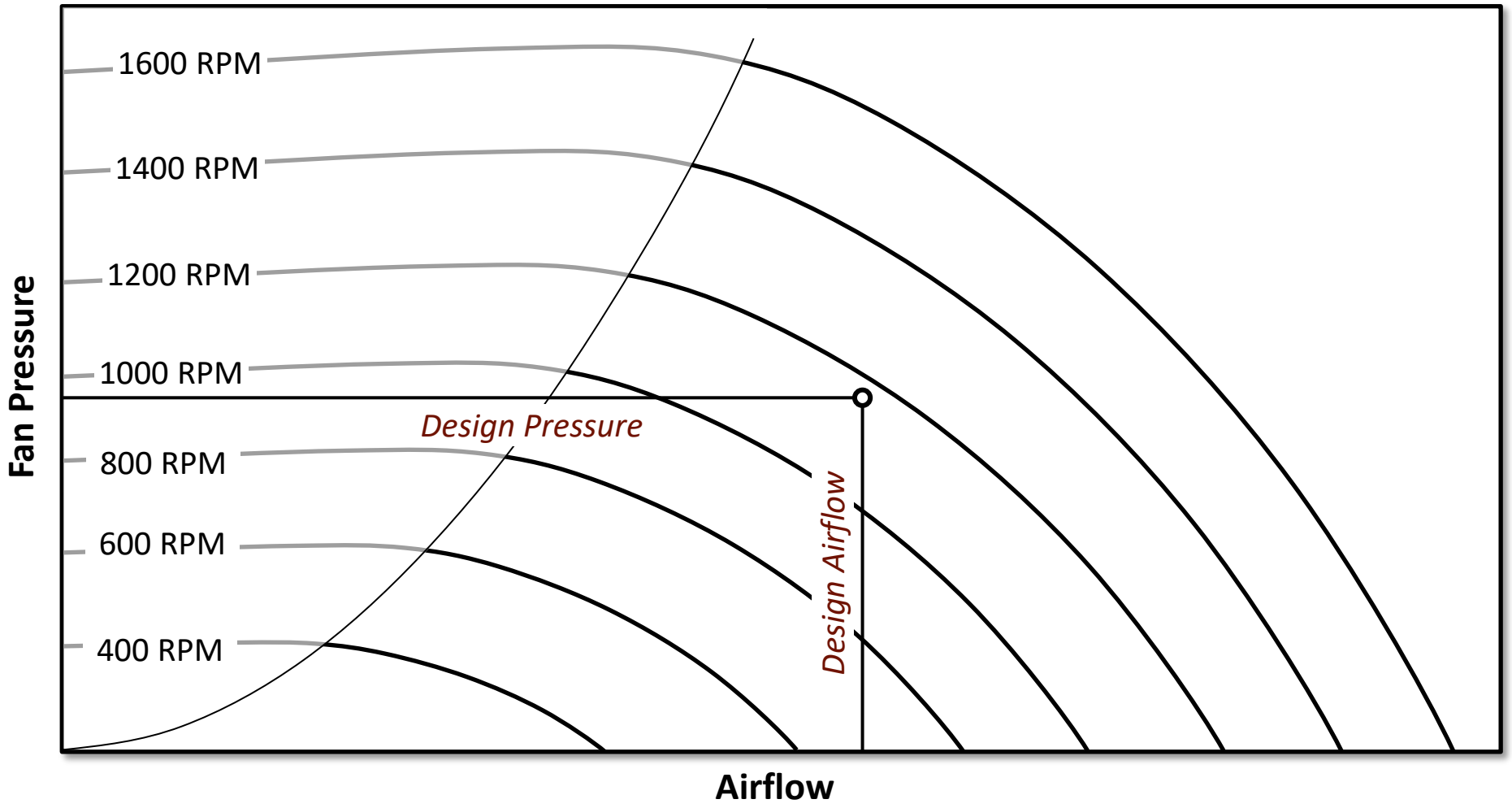
Square Inline Fan – Size 30
295 Actual Fan Selections



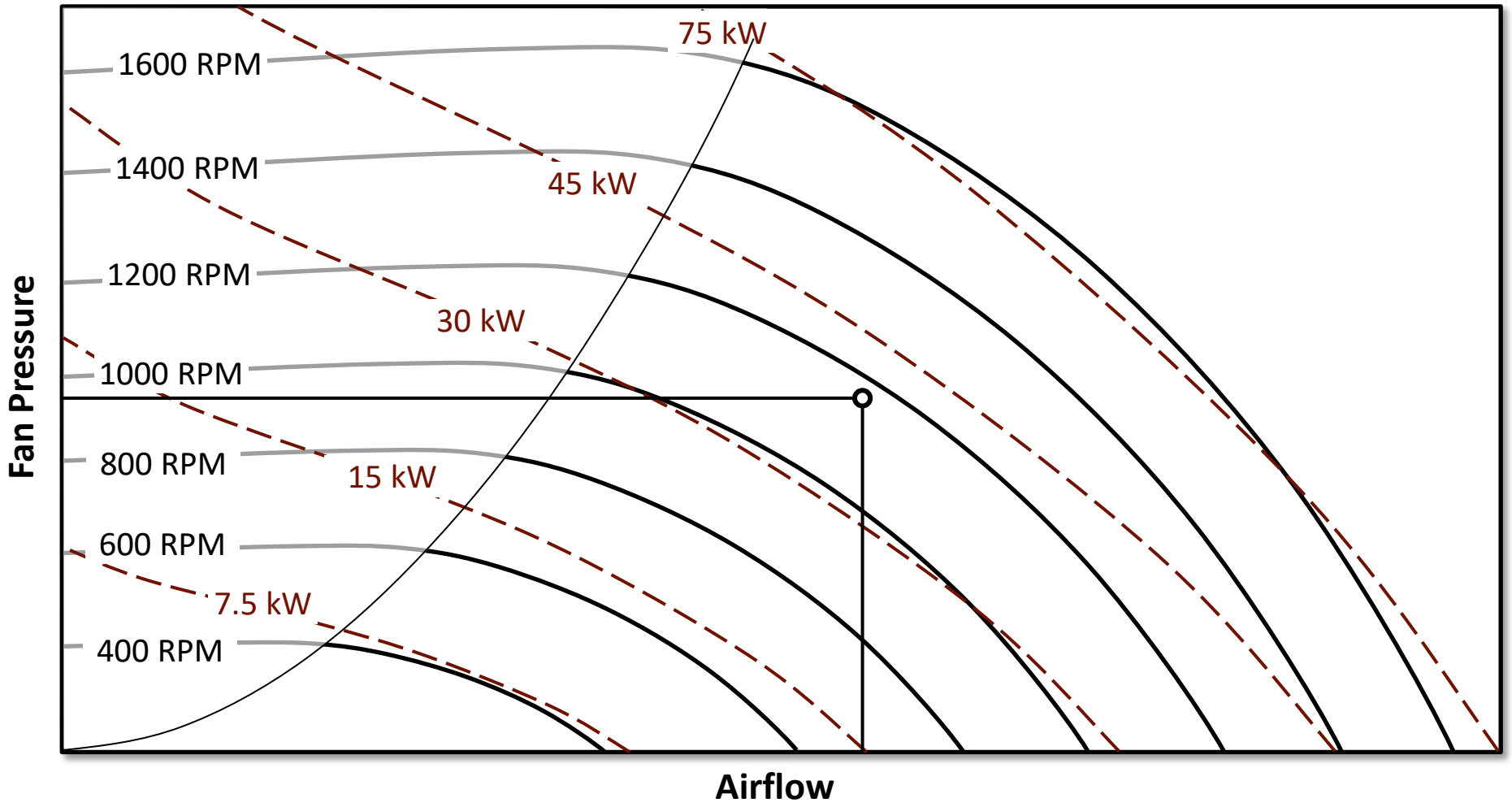
FEI ≥ 1.00 Defines Compliant Range for Selection



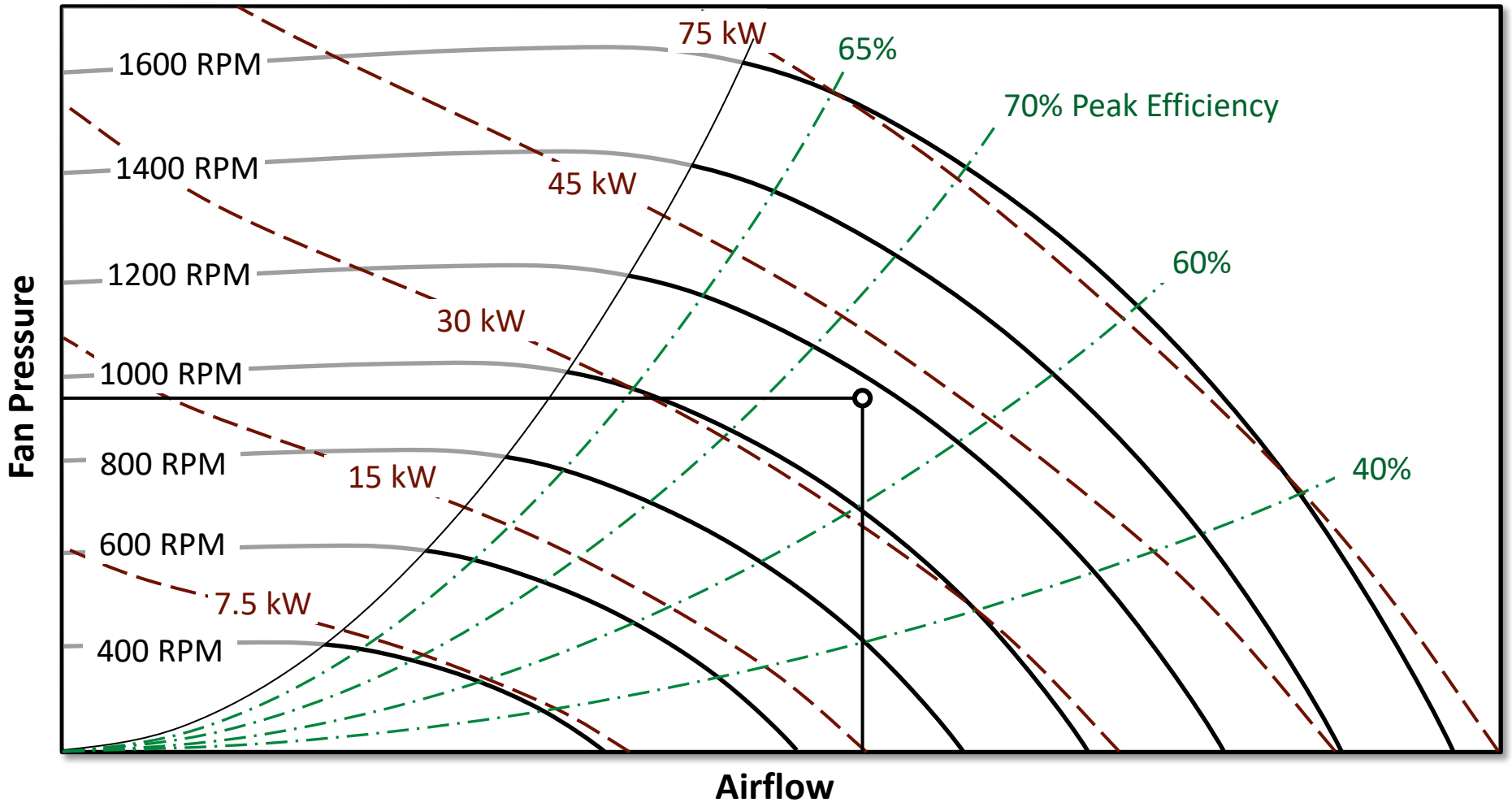
Fan Selection Using Multiple Speed Fan Curves



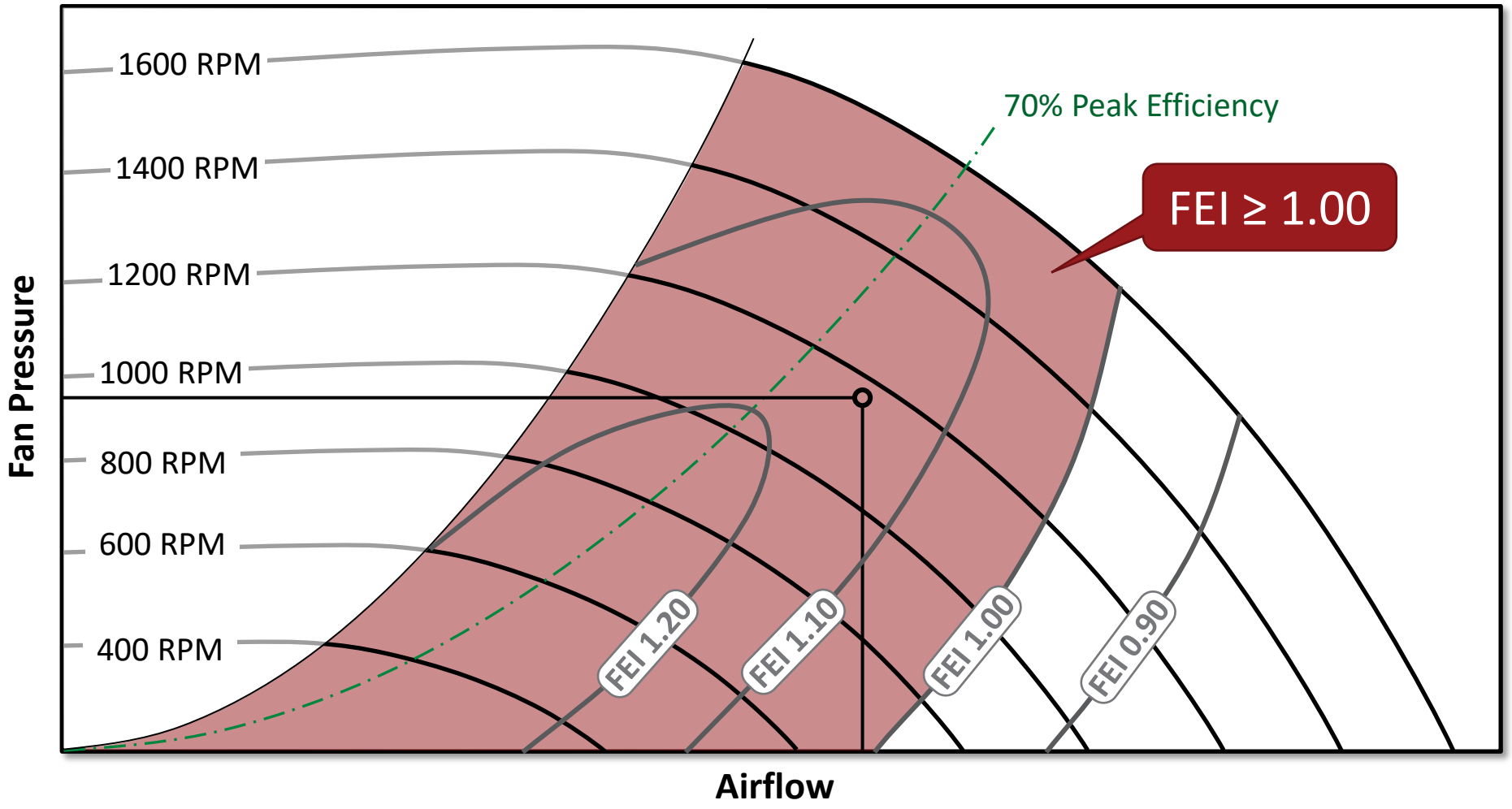
Fan Selection Using Multiple Speed Fan Curves



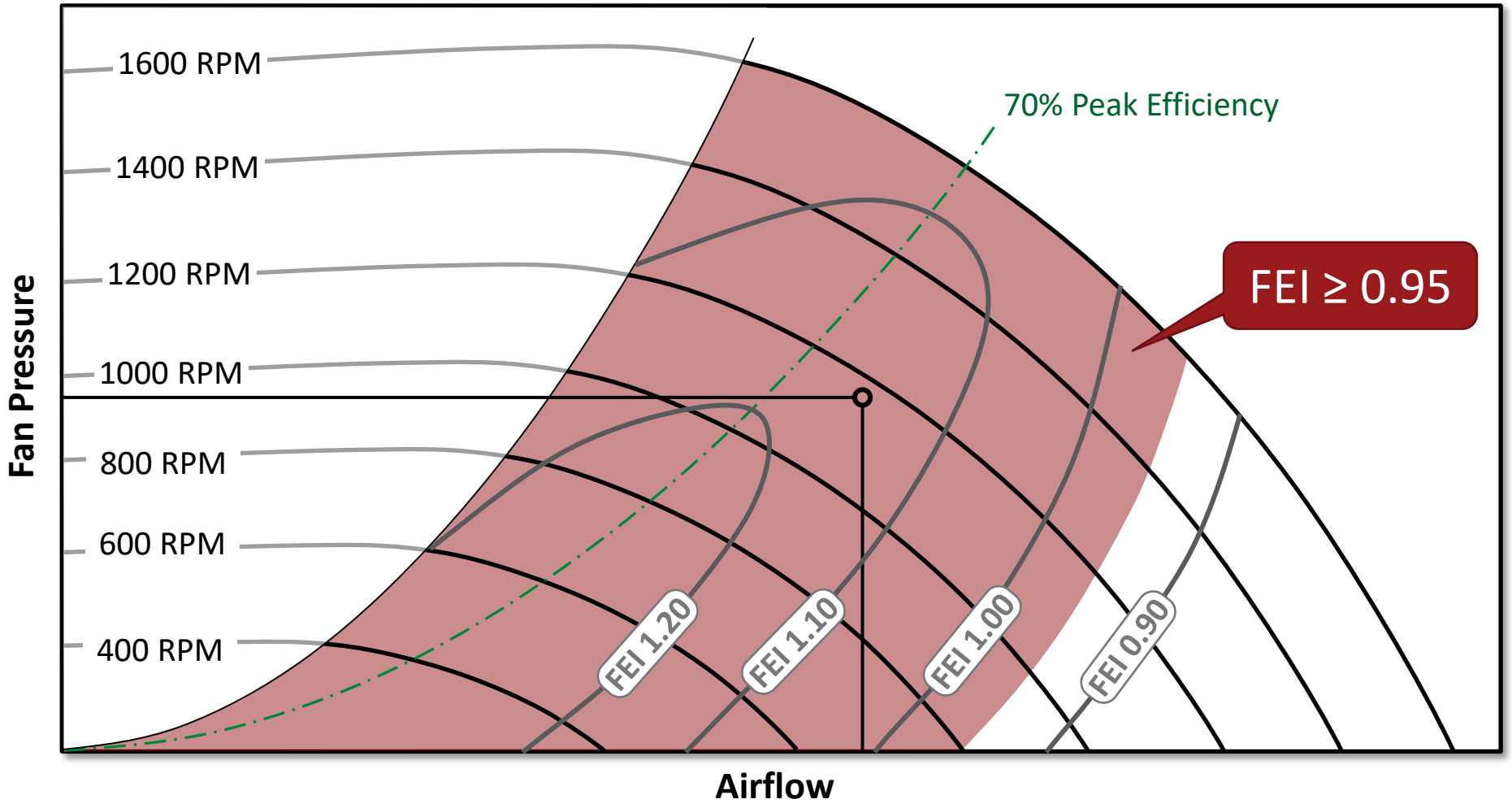
Fan Selection Using Multiple Speed Fan Curves



Fan Selection Using Multiple Speed Fan Curves



Fan Selection Using Multiple Speed Fan Curves



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:

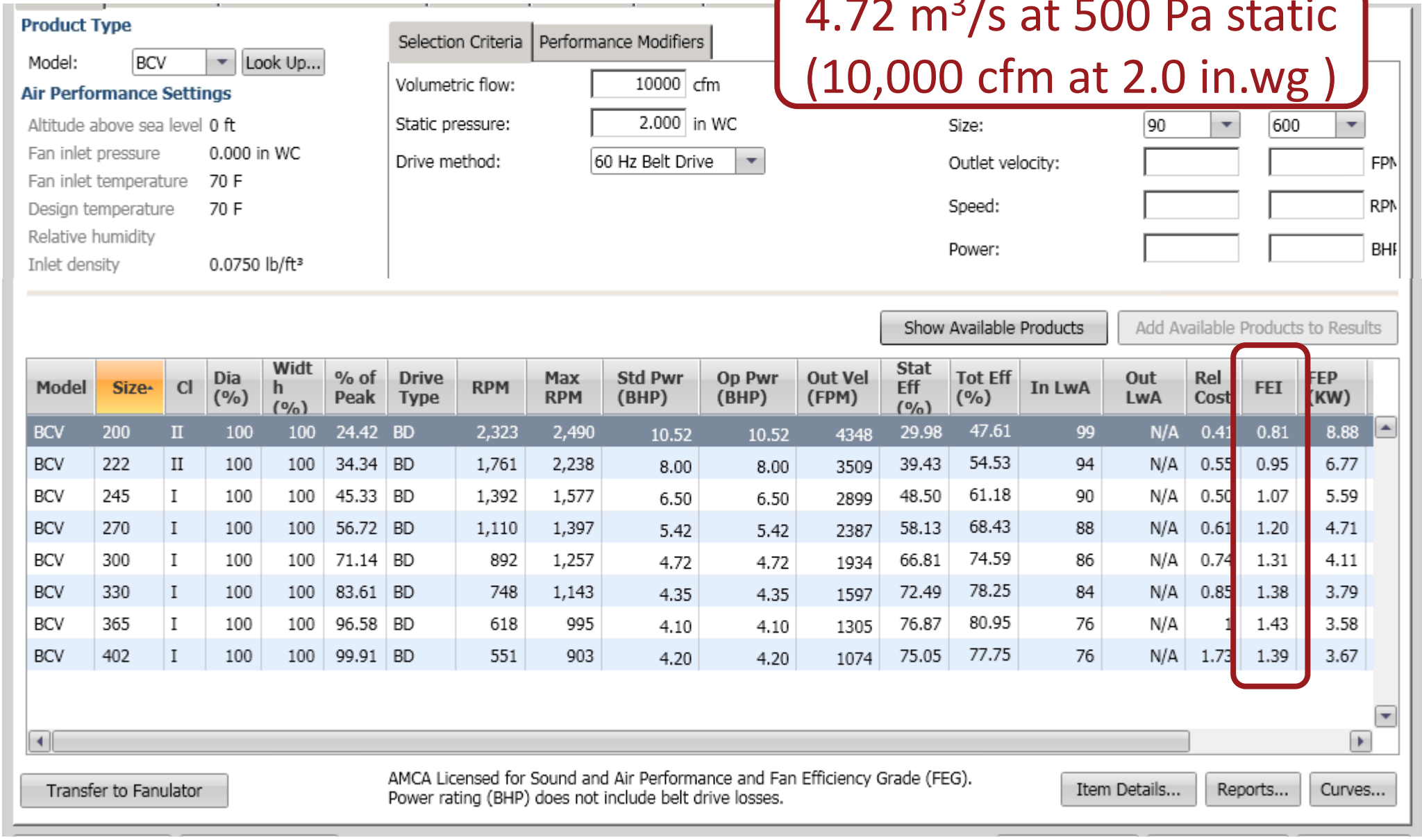
- 4.72 m^3/s (10,000 cfm)
- 500 Pa (2.0 in.wg) static pressure
- Sea level (standard atmospheric pressure)

Sidewall prop fan:

- 9.44 m^3/s (20,000 cfm)
- 63 Pa (0.25 in.wg) static pressure
- Sea level (standard atmospheric pressure)

…apologies for the inch-pound units for following examples…

4.72 m^3/s at 500 Pa static
(10,000 cfm at 2.0 in.wg)



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

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

9.44 m^3/s at 63 Pa static pressure (20,000 cfm at 0.25 in.wg)

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

9.44 m^3/s at 63 Pa static pressure (20,000 cfm at 0.25 in.wg)

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

FEI Example – Fans Embedded in Equipment

Air handler supply fan:

- Direct drive plenum fan
- 3.78 m^3/s at 750 Pa static pressure (8000 cfm at 3.0 in.wg)
- FEI ≥ 1.00

Supply Fan – 8000 cfm @ 3”

type [-]	article no. [-]	q_V ft³/min	p_{sF} in.wg.	p_F in.wg.	SFP [-]	P_{SFP} [Ws/m³]	FEG [%]	FEI [-]	P_{sys} W	$\eta_{sF,sys}$ [%]	$\eta_{F,sys}$ [%]
GR63C-6DM.I2.CR*	115211/HA03	8000.0	3.000	3.238	3	1152	85	1.45	4350	64.9	70.0

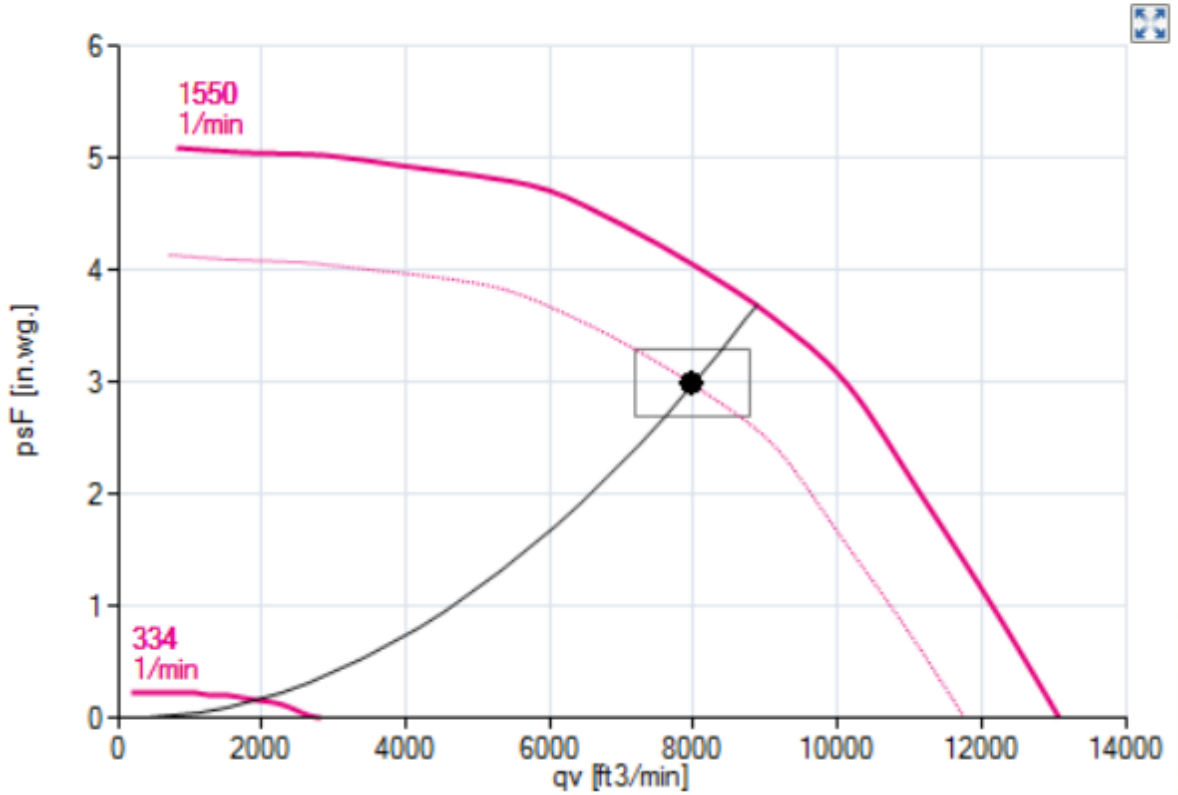
FEI = 1.45… Size 63C is good selection

q_V	p_{sF}
ft³/min	in.wg.
8000.0	3.000

- add to watch list
- performance curve
- Life-Cycle-Costs
- drawing
- nominal values
- product information
- specification sheet
- SFP class

air performance | measurement density 0.072 [lbs/ft³]

measured in standard nozzle in installation type A according to ISO 5801



Supply fan – 8000 cfm @ 3”

type [-]	article no. [-]	q_V ft³/min	p_{sF} in.wg.	p_F in.wg.	SFP [-]	P_{SFP} [Ws/m³]	FEG [%]	FEI [-]	P_{sys} W	$\eta_{sF,sys}$ [%]	$\eta_{F,sys}$ [%]
GR56C-4DM.G2.CR*	115208/HA03	8000.0	3.000	3.377	3	1176	85	1.42	4440	63.5	71.5

FEI = 1.42… Size 56C is also a good selection

q_V	p_{sF}
ft³/min	in.wg.
8000.0	3.000

add to watch list

performance curve

Life-Cycle-Costs

drawing

nominal values

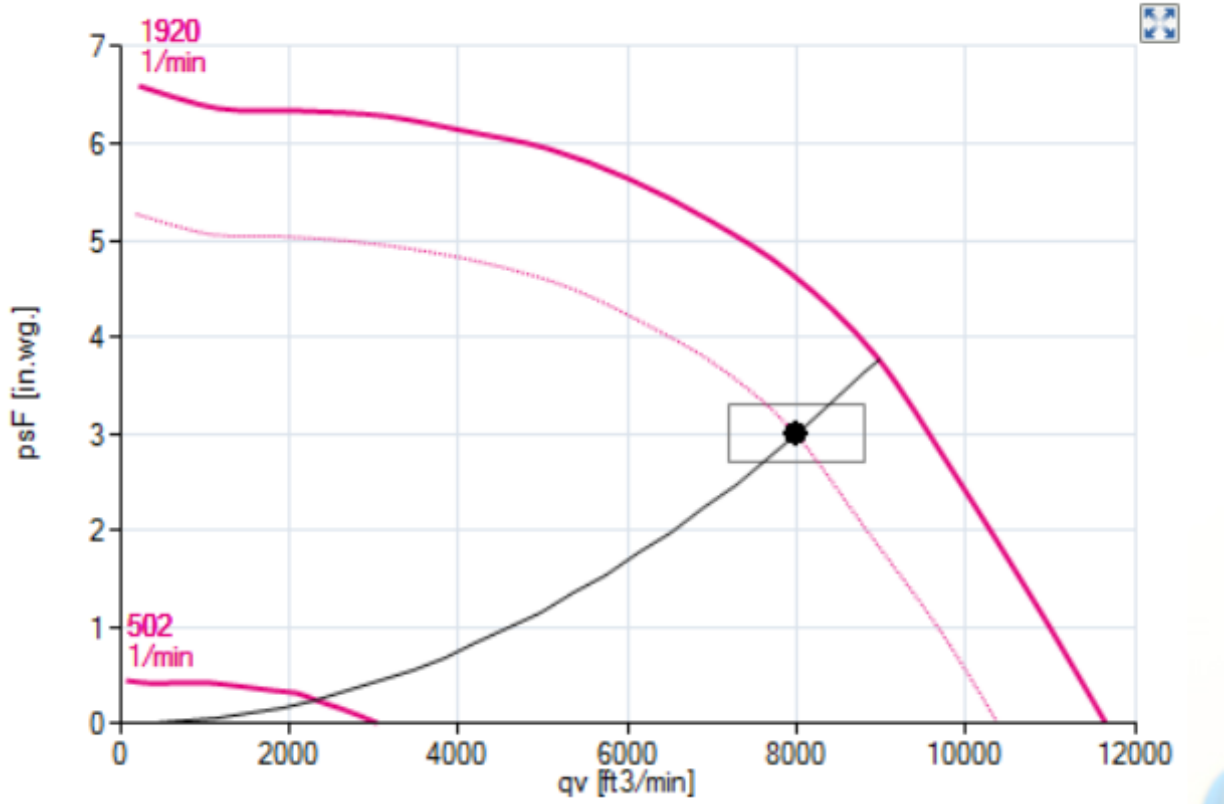
product information

specification sheet

SFP class

air performance | measurement density 0.072 [lbs/ft³]

measured in standard nozzle in installation type A according to ISO 5801



Supply fan – 8000 cfm @ 3”

type [-]	article no. [-]	q_V ft³/min	p_{sF} in.wg.	p_F in.wg.	SFP [-]	P_{SFP} [Ws/m³]	FEG [%]	FEI [-]	P_{sys} W	$\eta_{sF,sys}$ [%]	$\eta_{F,sys}$ [%]
GR50C-4DM.G2.CR*	115204/HA03	8000.0	3.000	3.579	4	1271	85	1.32	4799	58.8	70.1

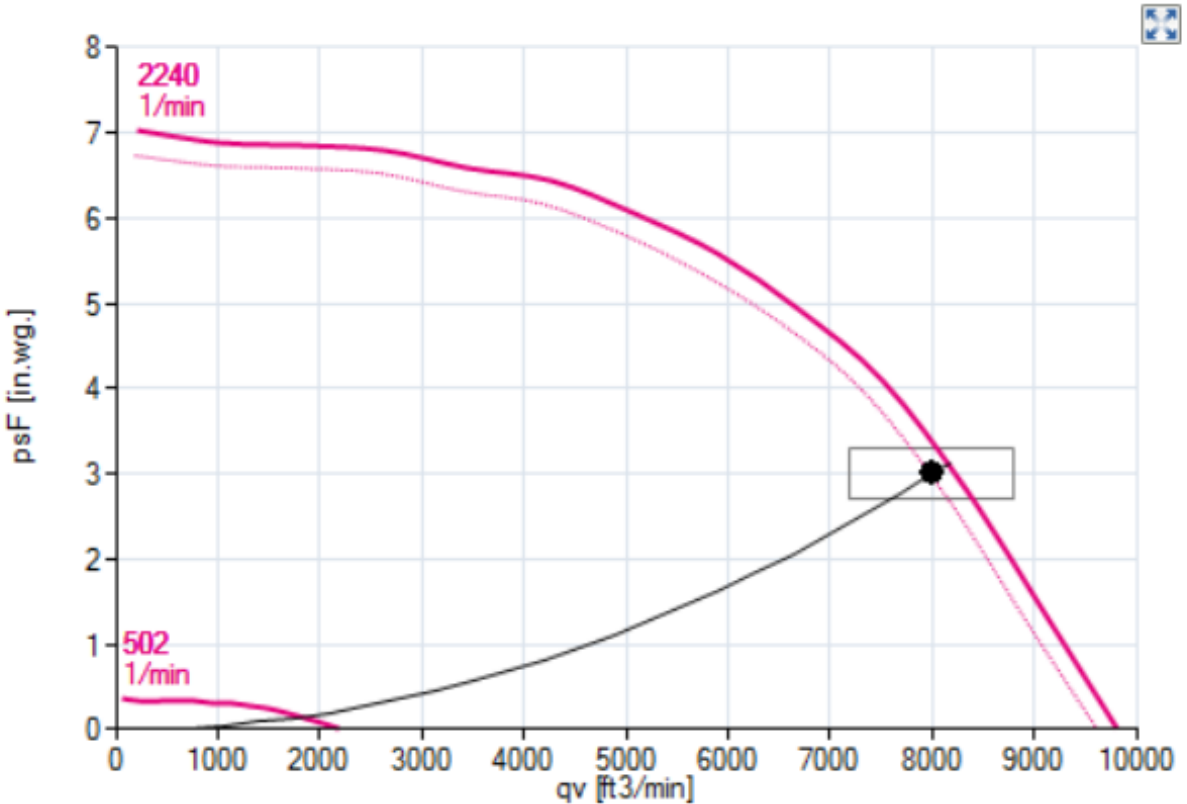
FEI = 1.32… Size 50C is the smallest fan that works

q_V	p_{sF}
ft³/min	in.wg.
8000.0	3.000

- add to watch list
- performance curve
- Life-Cycle-Costs
- drawing
- nominal values
- product information
- specification sheet
- SFP class

air performance | measurement density 0.072 [lbs/ft³]

measured in standard nozzle in installation type A according to ISO 5801



FEI Example – Fans Embedded in Equipment

How about the return fan?

- Direct drive plenum fan
- 3.78 m^3/s at 250 Pa static pressure (8000 cfm at 1.0 in.wg)
- FEI ≥ 1.00

Return Fan – 8000 cfm @ 1”

type [-]	article no. [-]	q_V ft³/min	p_{sF} in.wg.	p_F in.wg.	SFP [-]	P_{SFP} [Ws/m³]	FEG [%]	FEI [-]	P_{sys} W	$\eta_{sF,sys}$ [%]	$\eta_{F,sys}$ [%]
GR50C-4DM.G2.CR*	115204/HA03	8000.0	1.000	1.579	3	752	85	0.95	2838	33.1	52.3

FEI = 0.95… Size 50C is not an acceptable choice

q_V	p_{sF}
ft³/min	in.wg.
8000.0	1.000

add to watch list

performance curve

Life-Cycle-Costs

drawing

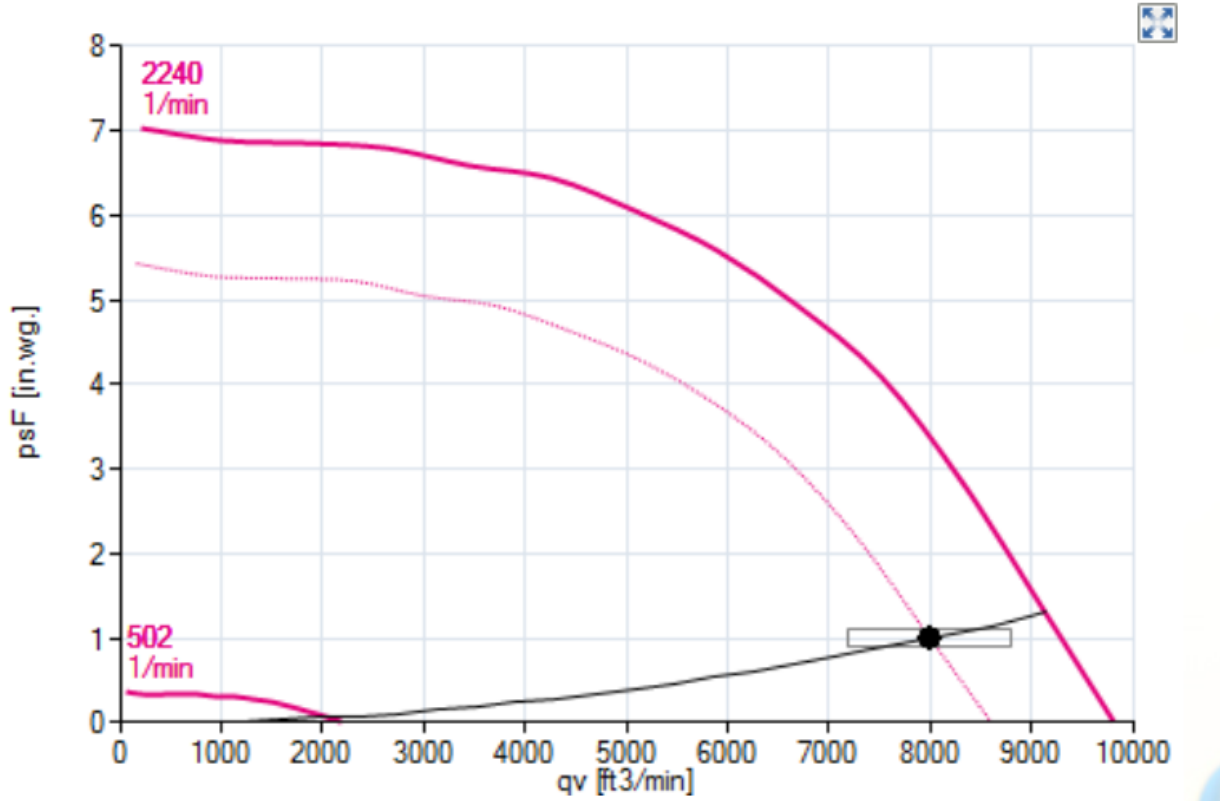
nominal values

product information

specification sheet

SFP class

measured in standard nozzle in installation type A according to ISO 5801



Return Fan – 8000 cfm @ 1”

type [-]	article no. [-]	q_V ft³/min	p_{sF} in.wg.	p_F in.wg.	SFP [-]	P_{SFP} [Ws/m³]	FEG [%]	FEI [-]	P_{sys} W	$\eta_{sF,sys}$ [%]	$\eta_{F,sys}$ [%]
GR56C-6DM.H2.CR*	115207/HA03	8000.0	1.000	1.377	2	600	85	1.19	2267	41.5	57.1

FEI = 1.19… Size 56C is a good selection

q_V	p_{sF}
ft³/min	in.wg.
8000.0	1.000

add to watch list

performance curve

Life-Cycle-Costs

drawing

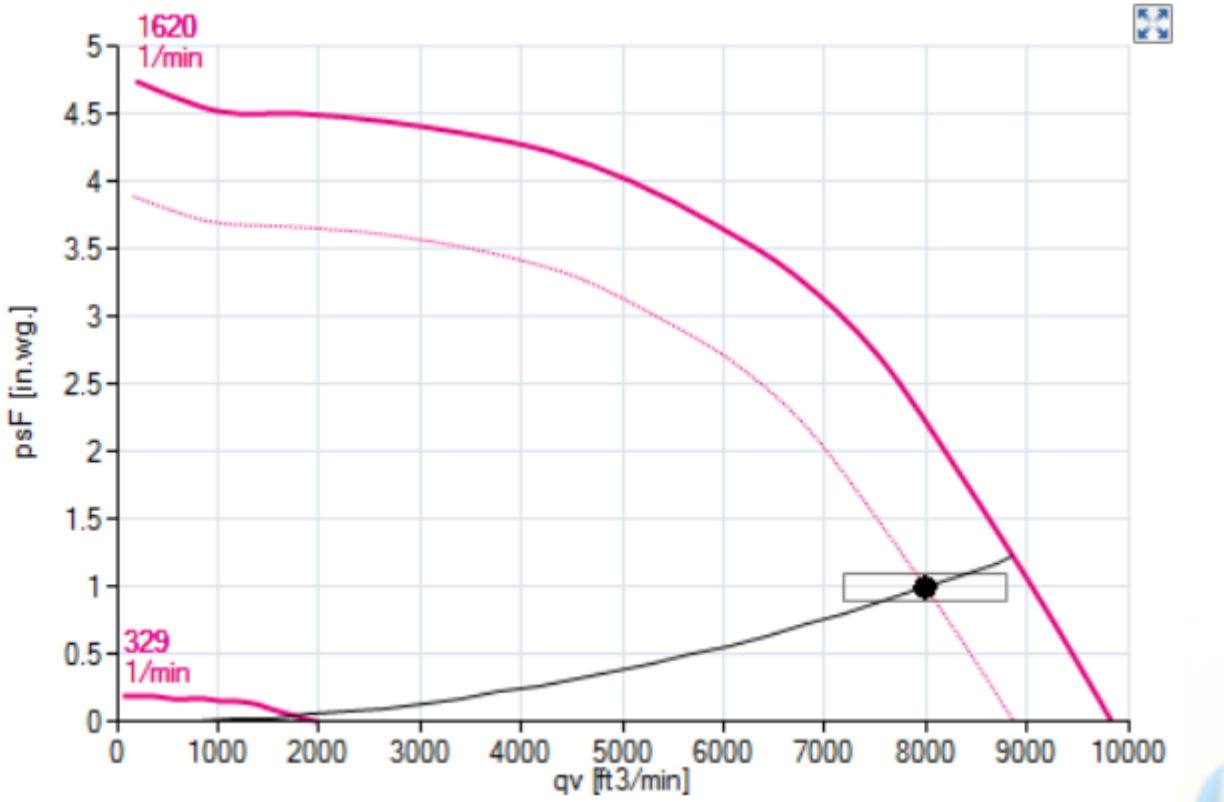
nominal values

product information

specification sheet

SFP class

measured in standard nozzle in installation type A according to ISO 5801



Return fan – 8000 cfm @ 1”

type [-]	article no. [-]	q_V ft³/min	p_{sF} in.wg.	p_F in.wg.	SFP [-]	P_{SFP} [Ws/m³]	FEG [%]	FEI [-]	P_{sys} W	$\eta_{sF,sys}$ [%]	$\eta_{F,sys}$ [%]
GR63C-6DM.I2.CR*	115211/HA03	8000.0	1.000	1.238	2	513	85	1.39	1938	48.5	60.1

FEI = 1.39… Size 63C is a good selection

q_V	p_{sF}
ft³/min	in.wg.
8000.0	1.000

add to watch list

performance curve

Life-Cycle-Costs

drawing

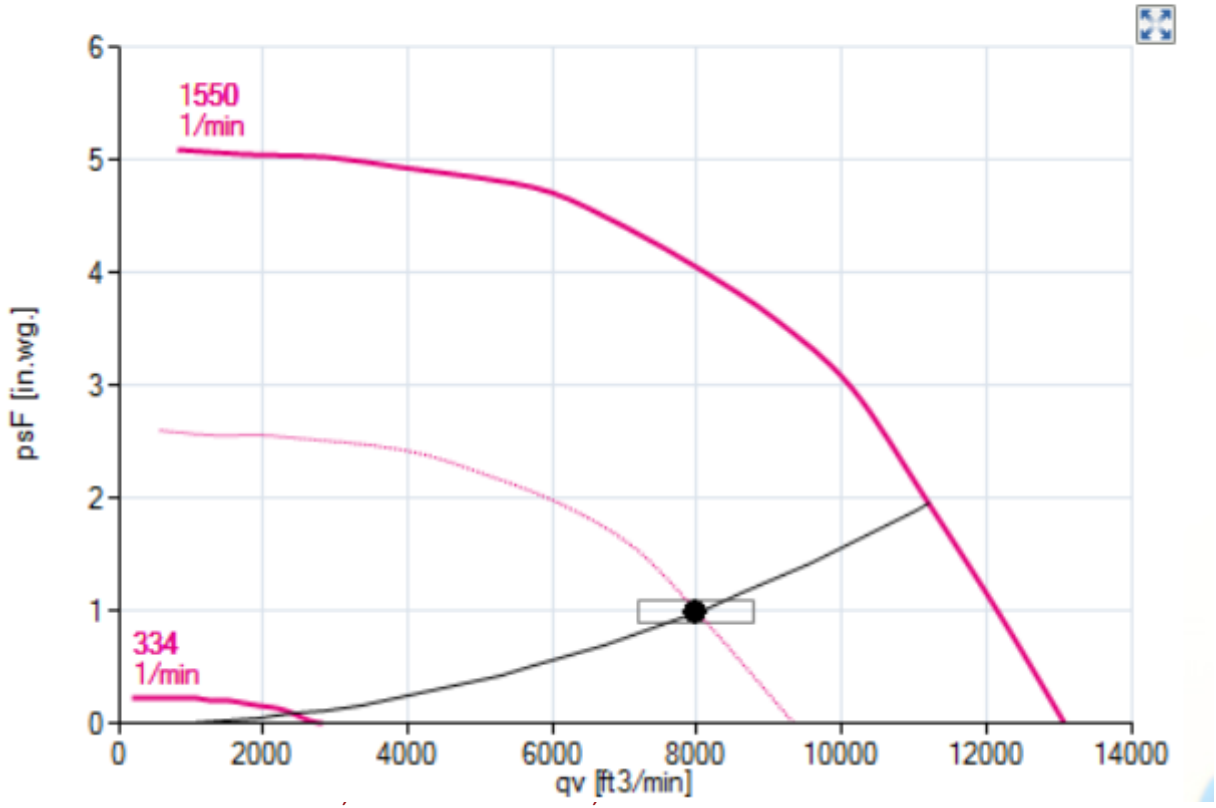
nominal values

product information

specification sheet

SFP class

measured in standard nozzle in installation type A according to ISO 5801



FEI Example – Fans Embedded in Equipment

Fan Size	Supply Fan		Return Fan	
	FEP (kW)	FEI	FEP (kW)	FEI
50C	4.80	1.32	2.83	0.95
56C	4.44	1.42	2.27	1.19
63C	4.35	1.45	1.94	1.39

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

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

  New: Florida, Oregon
- **Federal** efficiency **regulations** → U.S. Dept. of Energy
- **State** appliance **regulations** → California Title 20

DONE
NEARLY DONE
PROGRESSING
STALLED

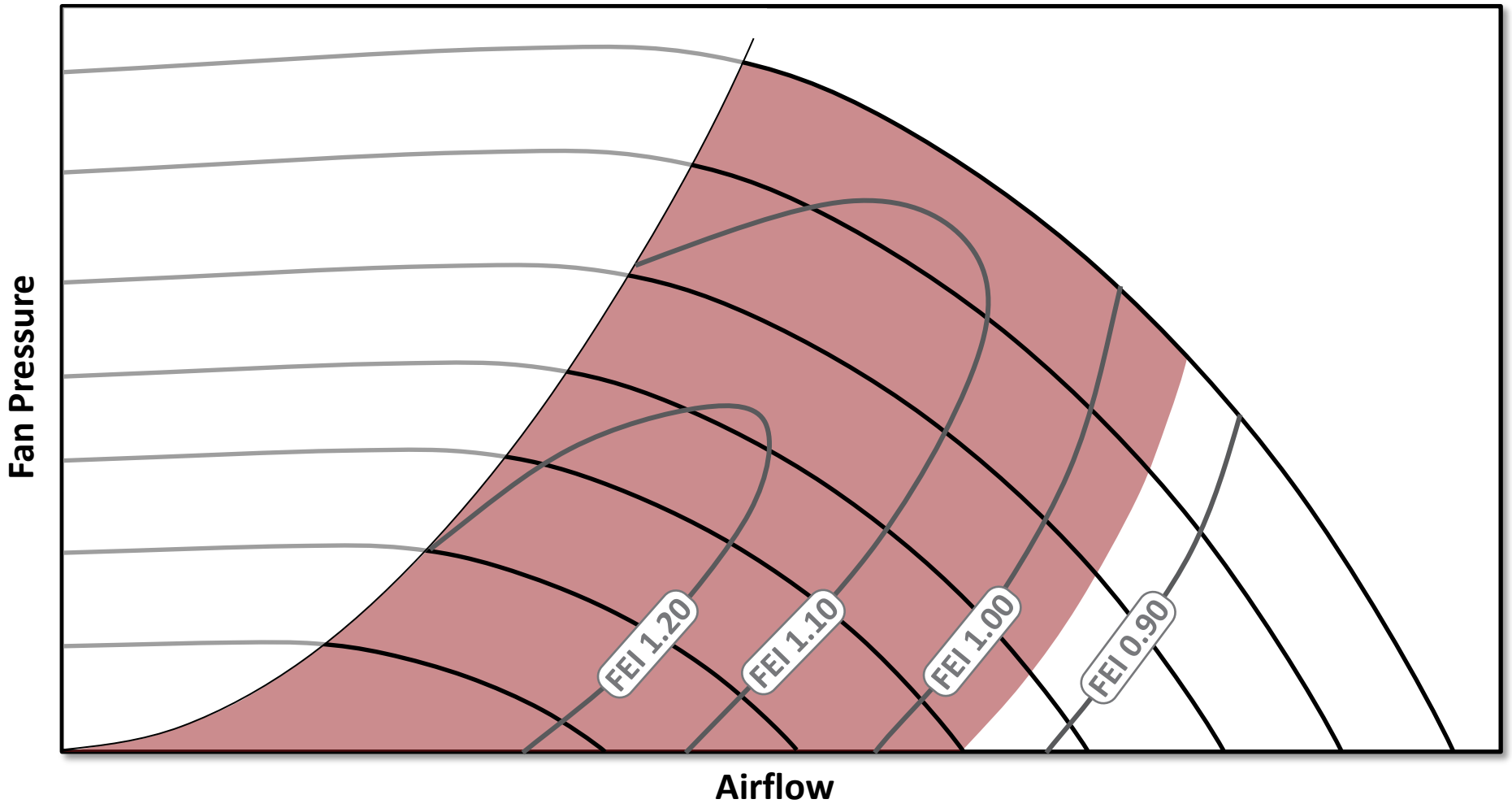
Baseline ASHRAE 90.1 and IECC Language

- 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

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)

Applying FEI in Constant Speed and VAV Systems

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: 8.50 m^3/s (18,000 cfm)
  - Air pressure (static): 1,350 pascal (5.4 in.wg)
  - Air density: Standard (sea level)

  - For constant flow, duty point is at 100% flow
  - For VAV, hypothetical duty points are:
    - 40% flow: 4.25 m^3/s (7,200 cfm)
    - 70% flow: 5.95 m^3/s (12,800 cfm)
    - 100% flow: 8.50 m3/s (18,000 cfm)

Example Constant Flow

FEI ≥ 1.00

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

Example VAV

FEI ≥ 0.95

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*
- **AMCA Publications & Standards**: *www.amca.org/store* (Available for purchase)
  - > **ANSI/AMCA 208-18**: Calculation of the Fan Energy Index
- **AMCA microsite for FEI training, technical papers, PowerPoints, and regulatory status**: *www.amca.org/fei*

Questions?

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Copies of today's presentation available for download at amca.org/Bahrain

Thank you for your participation!