
Q-PAC™

Air Movement Systems with ECM Technology

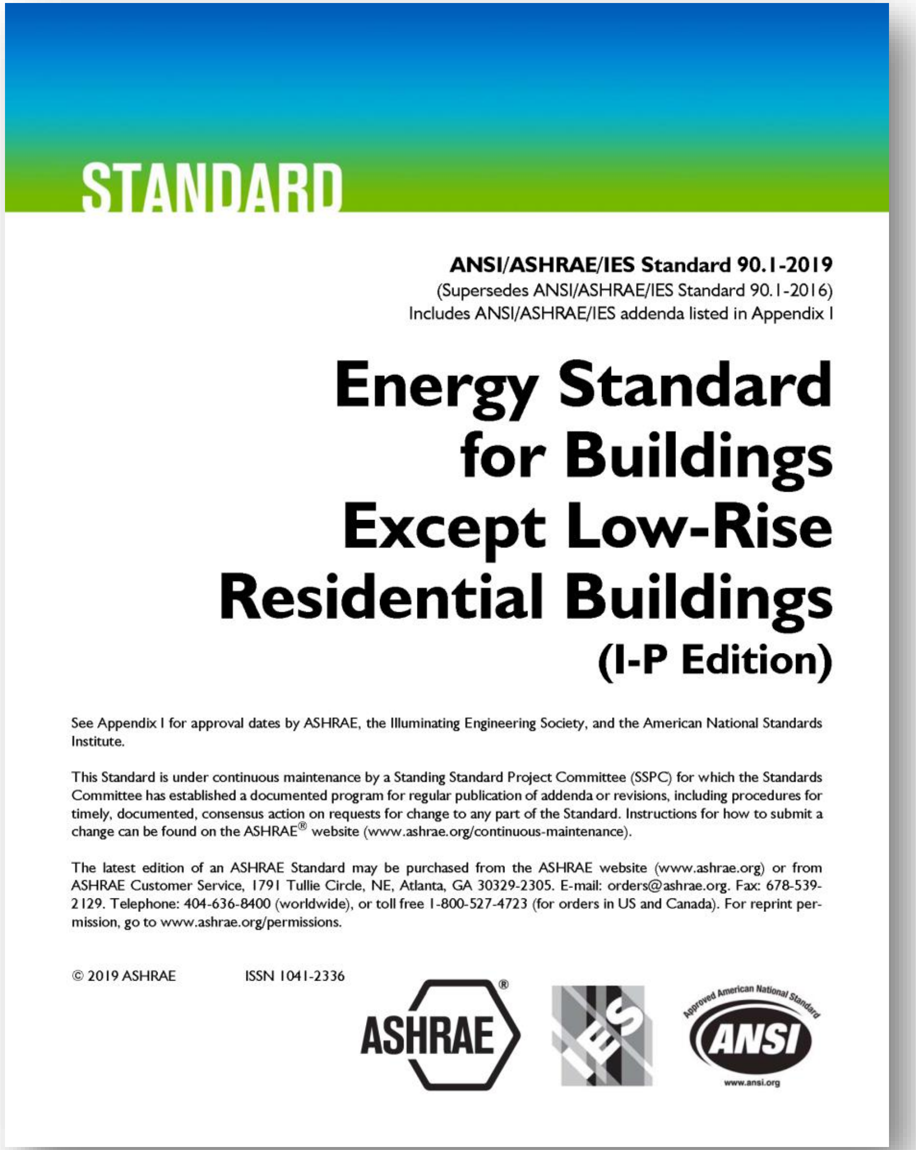
CONTENT
AGENDA

Presenter Intro

- MASc in Mechanical Engineering
- Professional Engineer
- Chair of ASHRAE TC 5.5; Air-to-Air Energy Recovery Equipment
- Member of ASHRAE TC 5.1; Fans
- Member of ASHRAE Standard 62.1: Ventilation Committee
- Sales and Applications Engineer
- ASHRAE British Columbia Past President

Drivers of Efficiency: Codes and Standards

- **ASHRAE 90.1: Energy Standard for Buildings**
- ASHRAE 90.1 is the basis of International Energy Conservation Code that is adopted by most US States and Canadian Provinces
- Revised every 3 years
- Standard 90.1 is a minimum efficiency code
- Other codes like LEED and ASHRAE 189 are more stringent


STANDARD

ANSI/ASHRAE/IES Standard 90.1-2019
(Supersedes ANSI/ASHRAE/IES Standard 90.1-2016)
Includes ANSI/ASHRAE/IES addenda listed in Appendix I

Energy Standard for Buildings Except Low-Rise Residential Buildings (I-P Edition)

See Appendix I for approval dates by ASHRAE, the Illuminating Engineering Society, and the American National Standards Institute.

This Standard is under continuous maintenance by a Standing Standard Project Committee (SSPC) for which the Standards Committee has established a documented program for regular publication of addenda or revisions, including procedures for timely, documented, consensus action on requests for change to any part of the Standard. Instructions for how to submit a change can be found on the ASHRAE® website (www.ashrae.org/continuous-maintenance).

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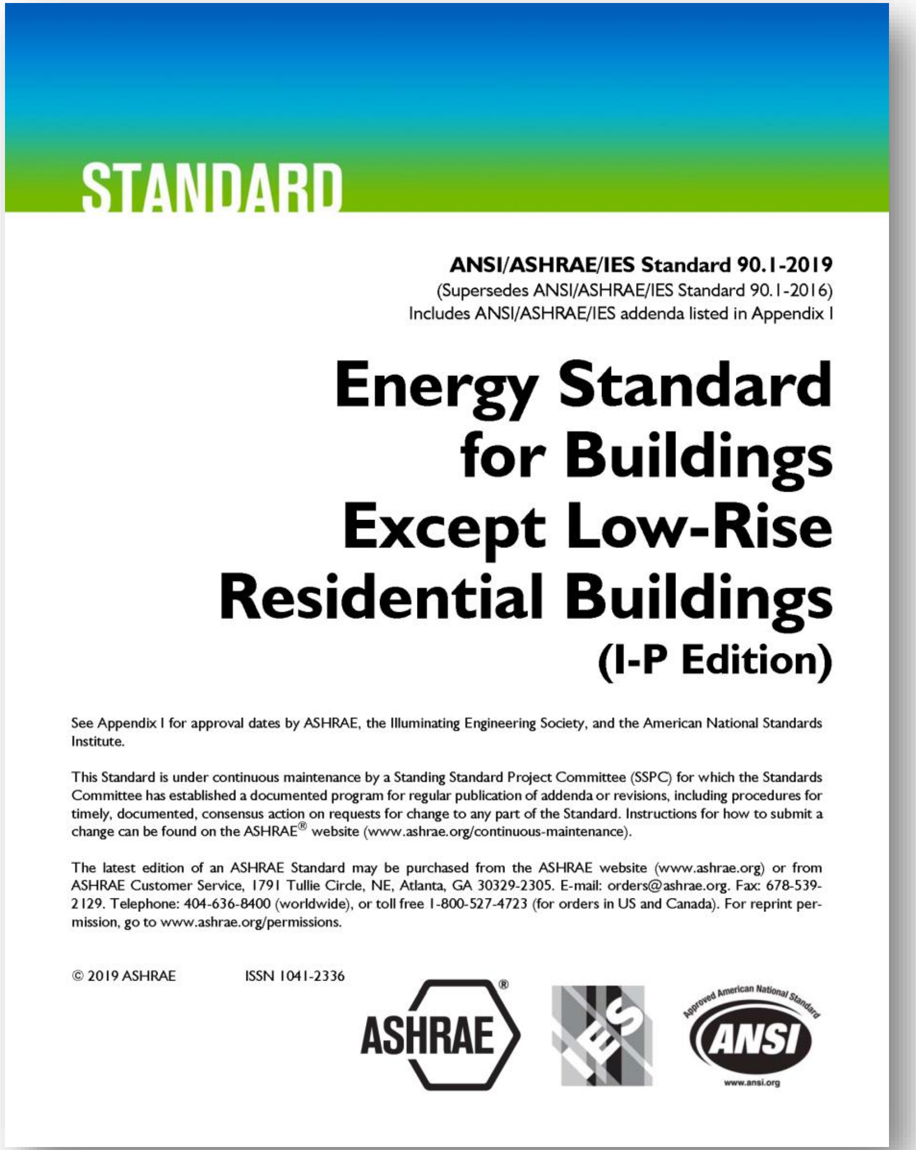
Drivers of Efficiency:

Michigan Energy Conservation Code

- Current Michigan ECC based on ASHRAE 90.1-2013
- Being revised in 2022 to update to ASHRAE 90.1-2019 (with updates)



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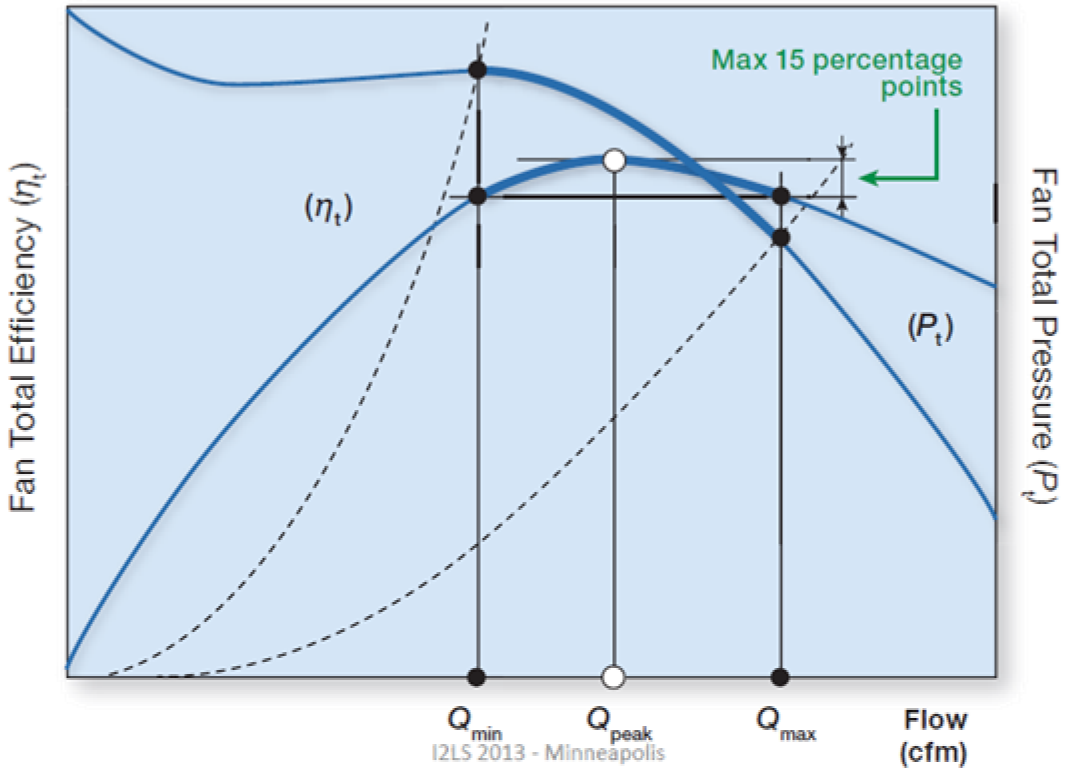
ASHRAE 90.1-2013:

6.5.3.1.3 Fan Efficiency. Fans shall have a fan efficiency grade (FEG) of 67 or higher based on manufacturers' certified data, as defined by AMCA 205. The total efficiency of the fan at the design point of operation shall be within 15 percentage points of the maximum total efficiency of the fan.

Fan Efficiency Grade (FEG) is a unique metric only valid at peak efficiency, does not address efficiency at part load



I2LS 2013 - Minneapolis

ASHRAE 90.1-2013

ASHRAE 90.1-2019:
What changed in 2019 revision

ASHRAE 90.1-2019:

Each fan and *fan array* shall have a *fan energy index (FEI)* of 1.00 or higher. Each fan and *fan array* used for a *variable-air-volume system* that meets the requirements of Section 6.5.3.2.1 shall have an *FEI* of 0.95 or higher. The *FEI* for *fan arrays* shall be calculated in accordance with AMCA 208 Annex C.

Fan Energy Index (FEI) addresses efficiency at operating point

FEI is the best metric to compare fan efficacies at any operating point

ASHRAE 90.1-2019:
What changed in 2019 revision

ASHRAE 90.1-2019:

EC motors are exempt from nameplate HP limitations:

a. For each fan less than 6 bhp, the selected fan motor shall be no larger than the first available motor with a *nameplate rating* greater than 1.5 times the bhp.

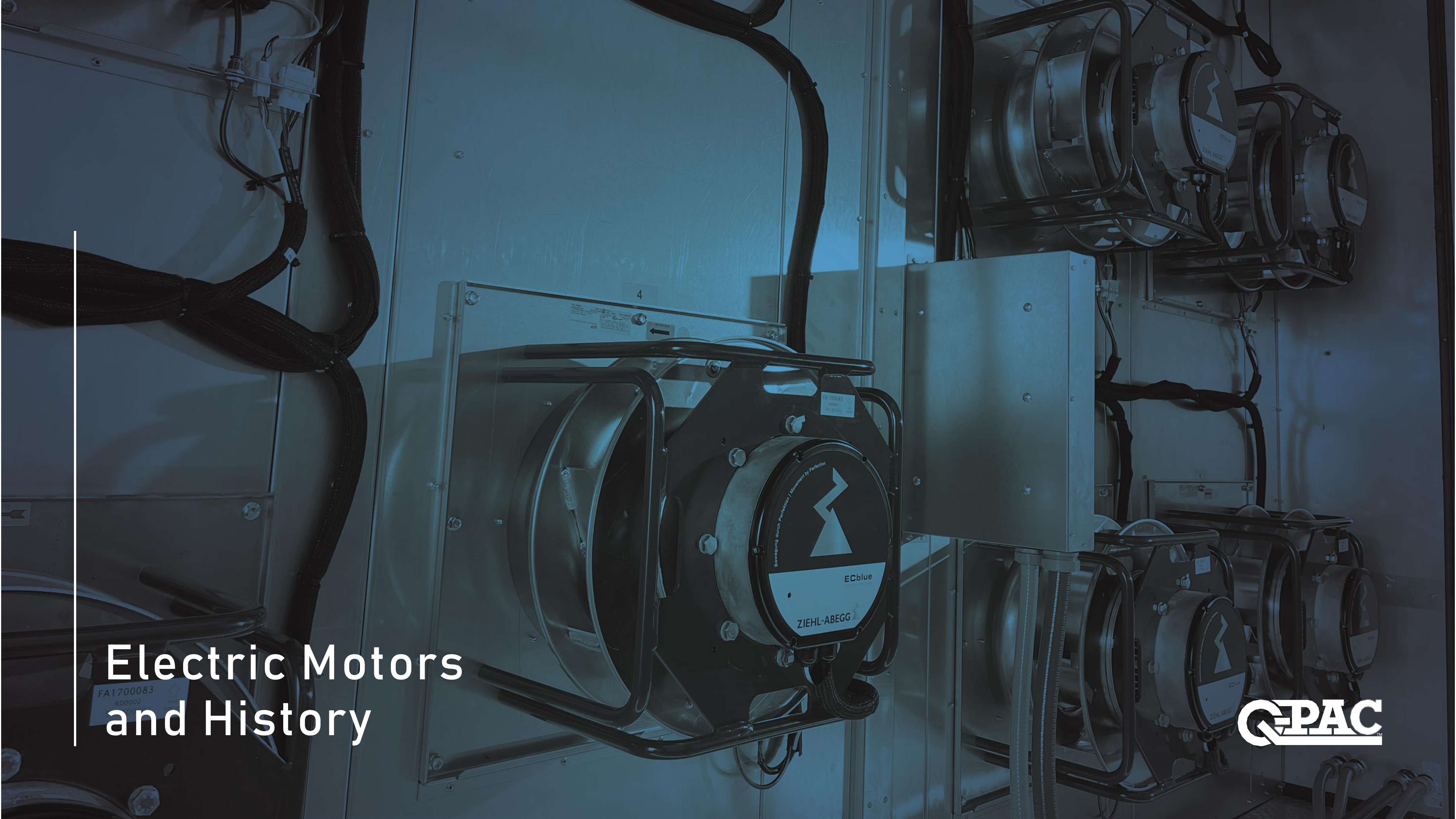
b. For each fan 6 bhp and larger, the selected fan motor shall be no larger than the first available motor with a *nameplate rating* greater than 1.3 times the bhp.

Exceptions to 6.5.3.1.2

1. *Motors* equipped with electronic speed *control devices* to vary the fan airflow as a function of load.

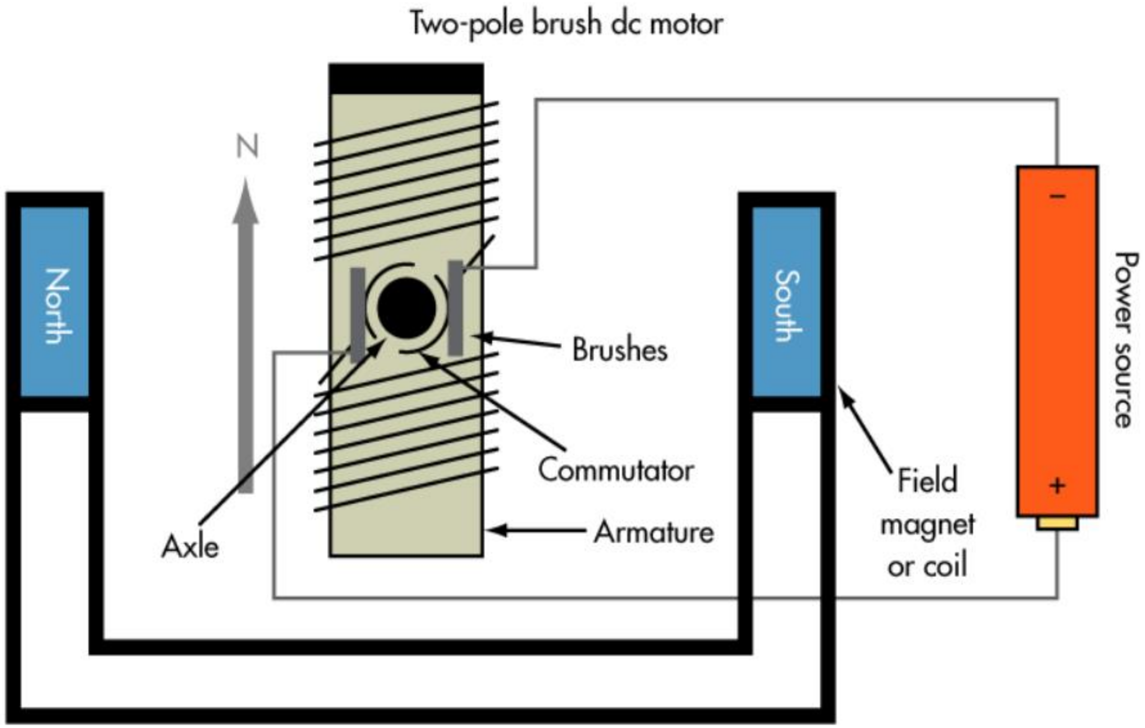
Reason: EC motors are highly efficient at part-load

Electric Motors and History



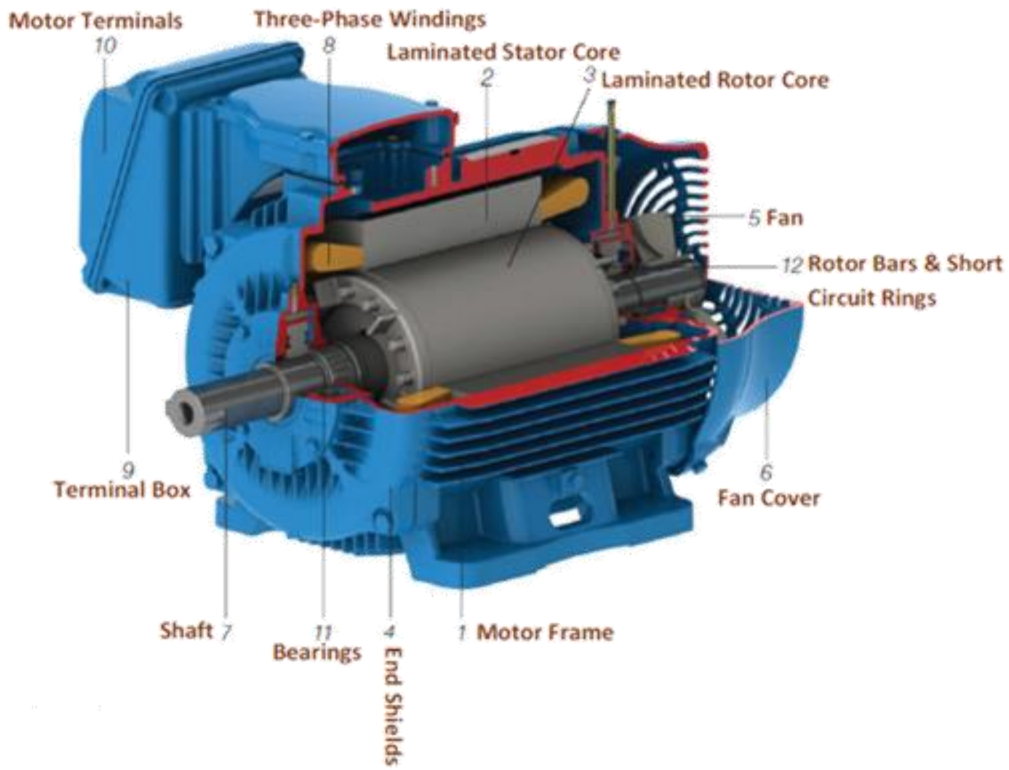
Electric Motors: Brushed DC Motors

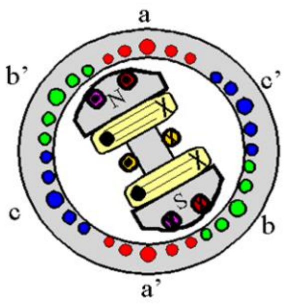
- The oldest form of motor technology
- Permanent magnet stator pole
- Rotor poles vary in polarities
- “Brushes” make contact with a commutator to change polarity in rotor



Electric Motors: AC Induction Motors

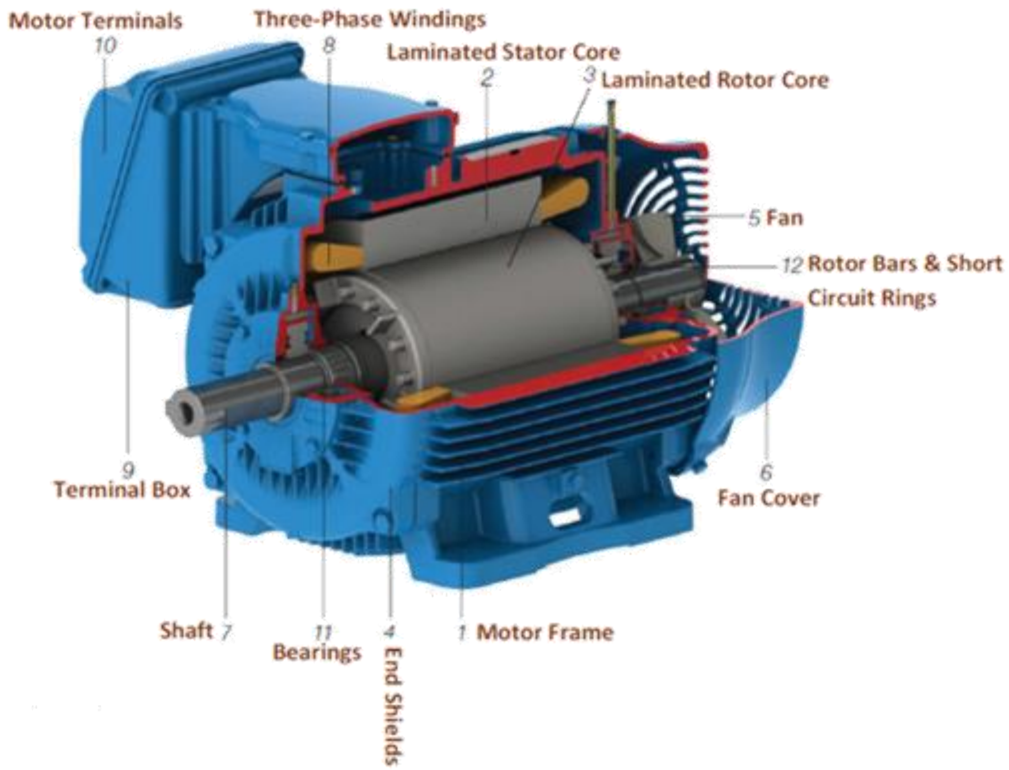
- Nominal RPM based on electrical frequency and number of poles
- Asynchronous
- As load increases, motor rpm "slips"
- Slippage provides the torque
- Once there is a magnetic force created in rotor, the rotor "chases" the rotating field in the stator

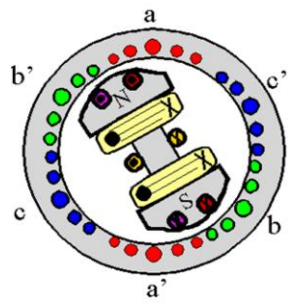




Electric Motors: AC Induction Motors

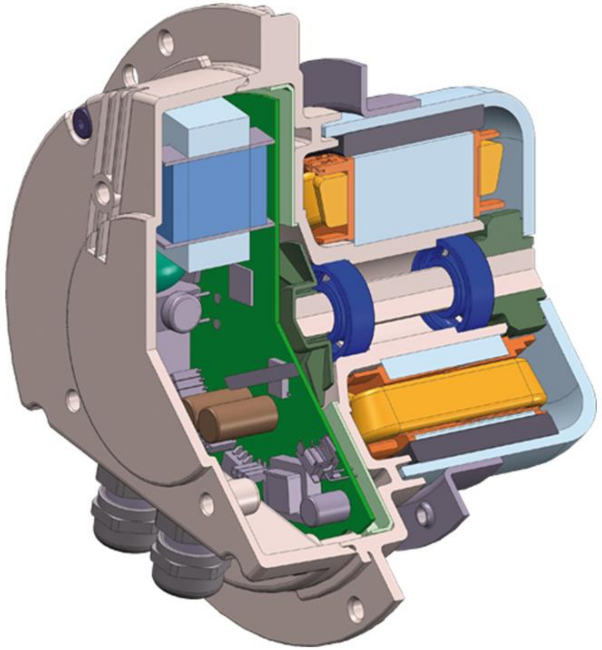
- Simple construction
- Simple maintenance
- No commutator or slip rings
- Low Price
- Asynchronous
- Good efficiency at peak load
- Familiar – served well for decades
- Stand-alone fixed speed
- Require VFD for speed modulation





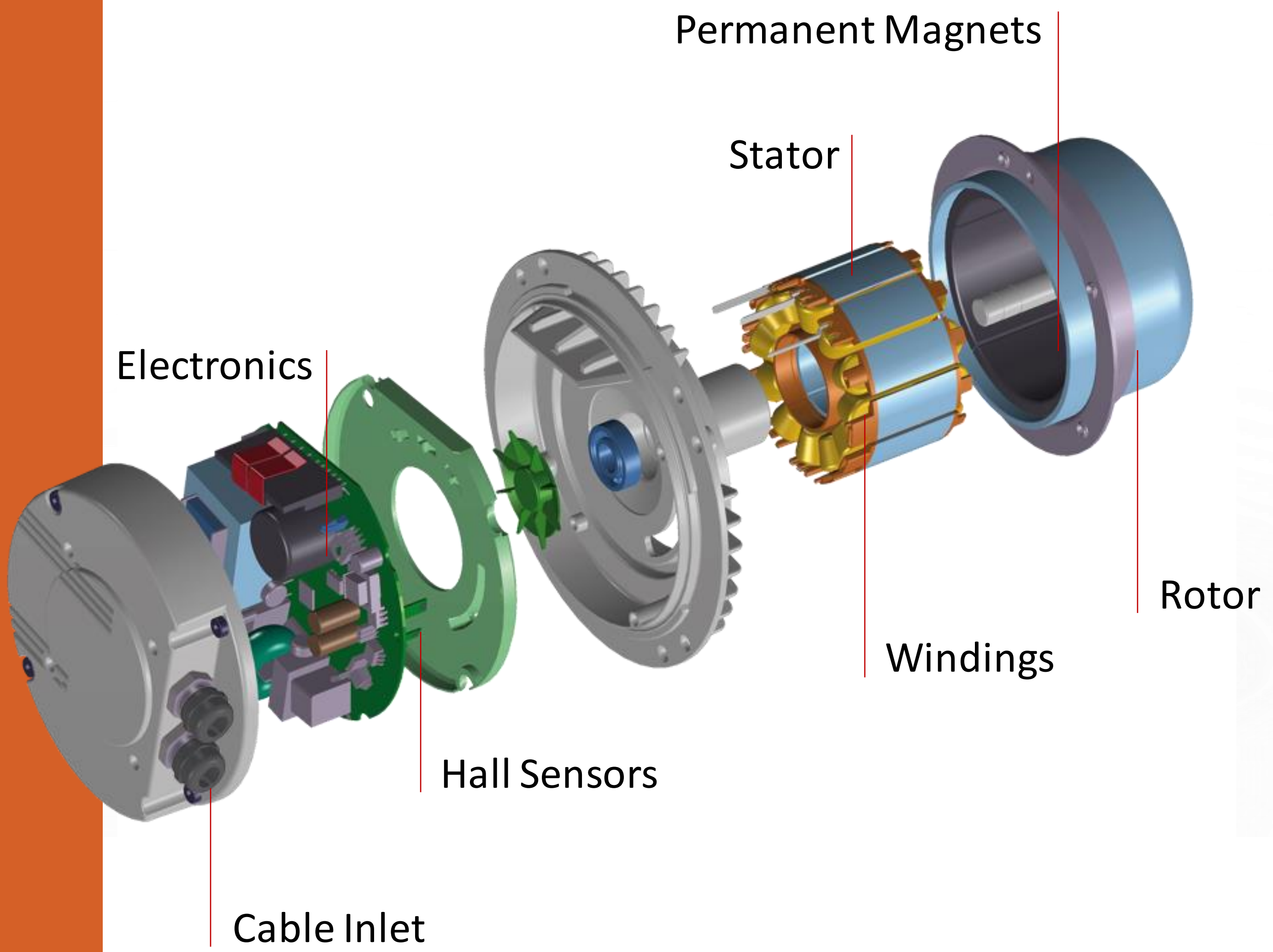
EC Motors: History and Operation

- ECM: Electronically Commutated Motor
- History in 1960’s locomotive motors
- DC Native Motor (incoming AC is rectified to DC)
- Utilize Permanent Magnets

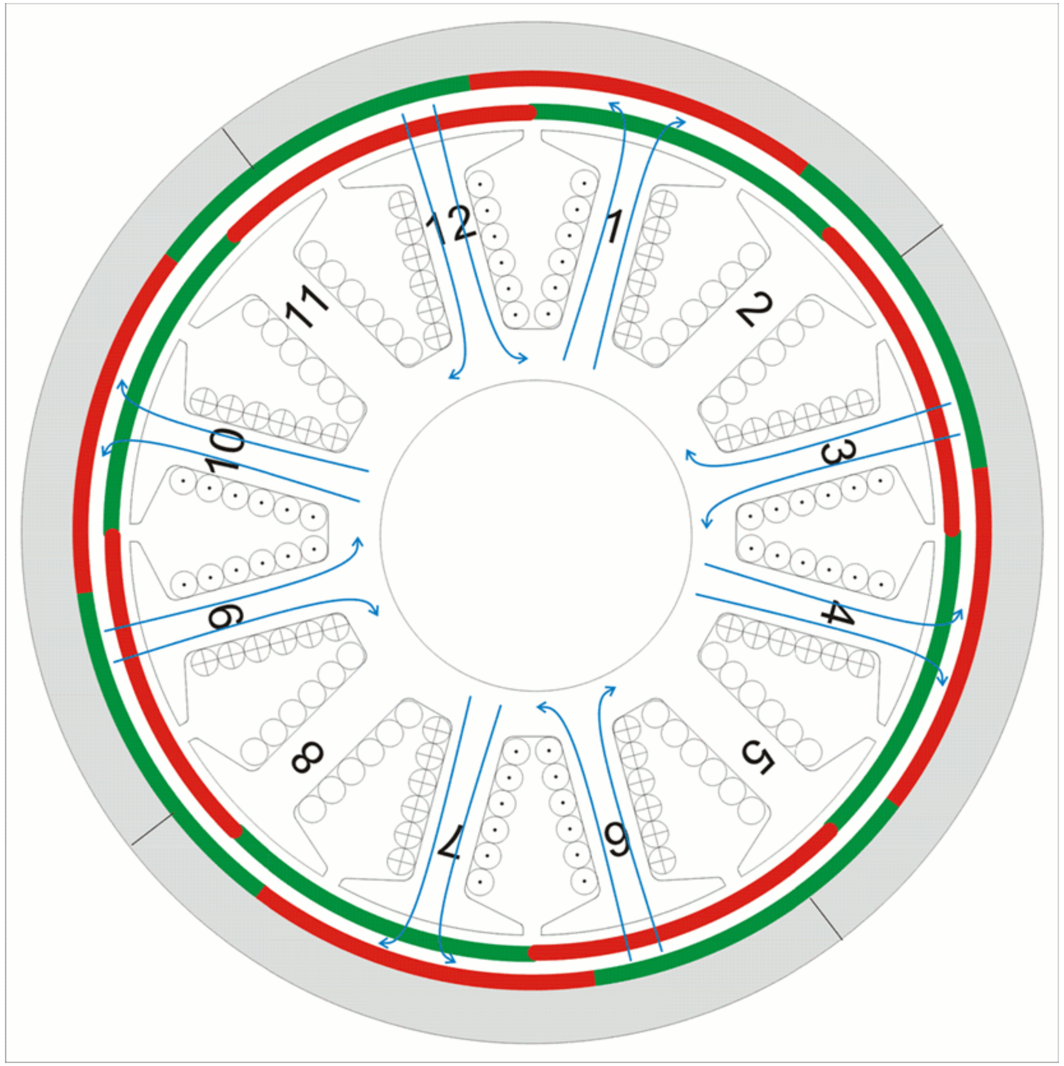


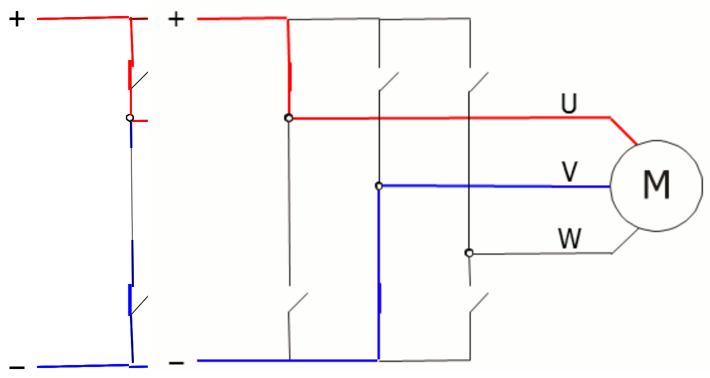
EC Motors: History and Operation

- Takes in AC power and converts to DC
- Output DC is switched on and off in different poles in the stator
- Switching is done through transistors
- Stator magnetic field creates a simultaneous push/pull on the magnet in the rotor
- Hall effect sensors indicate motor position to controller



EC Motors: History and Operation

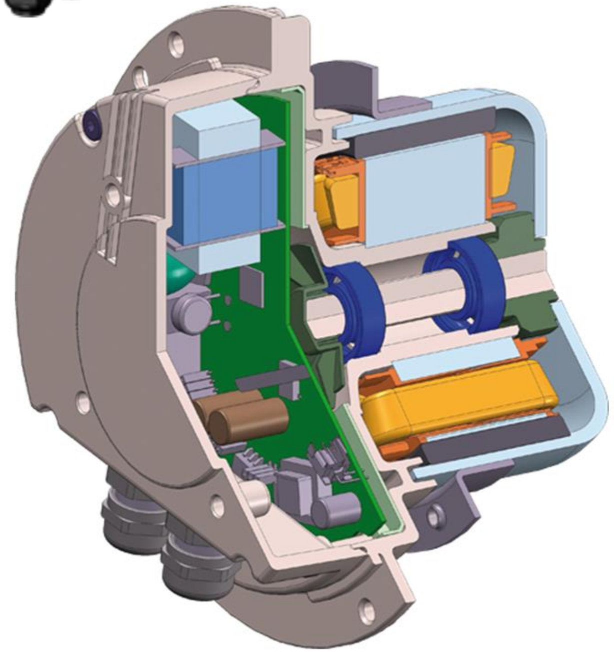




EC Fan Systems: Benefits

EC Motors: Benefits

- Better efficiency throughout range of operation
- Compact footprint
- Dust-proof and watertight – IP54
- No bearing currents: **no shaft grounding required**
- Wider operating range than induction motors
- Maintenance benefits



EC Motors:
Efficiency

Reported	BHP	Input Power
Bearing Losses	2%	Included
VFD Losses	4 - 8%	N/A
Part Load Efficiency	Significant	Minor
Actual KW Consumed	BHP -10 – 15%	Input Power

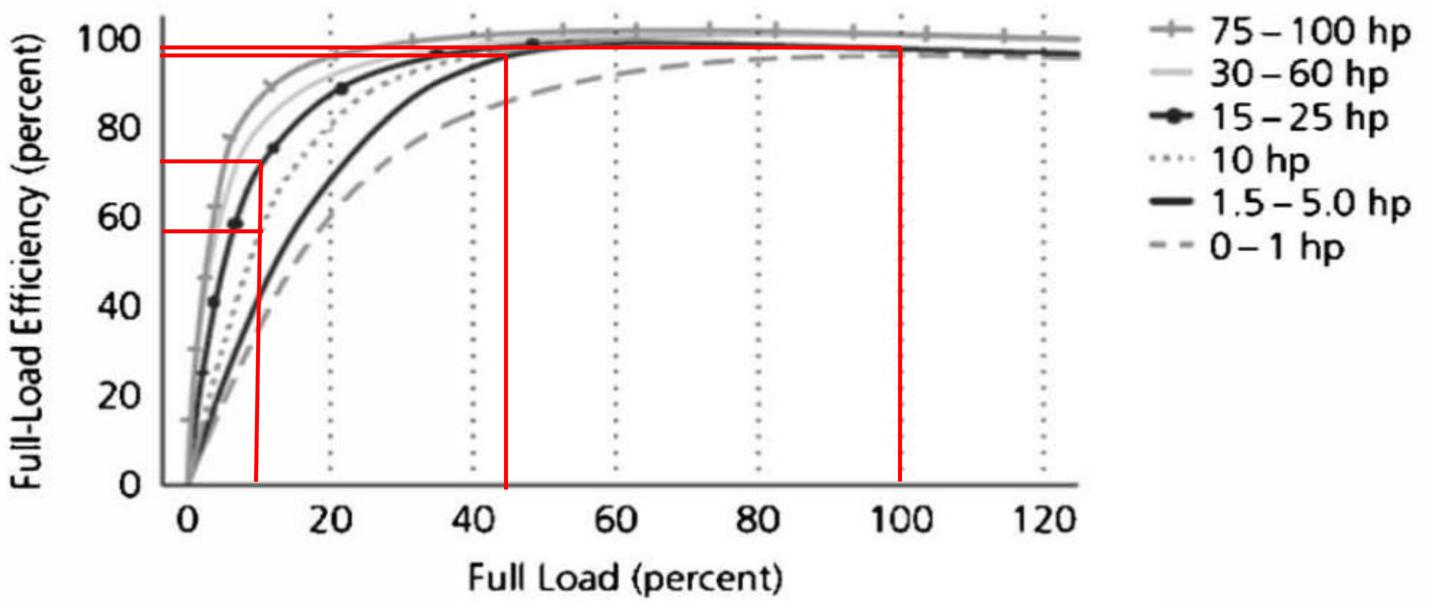
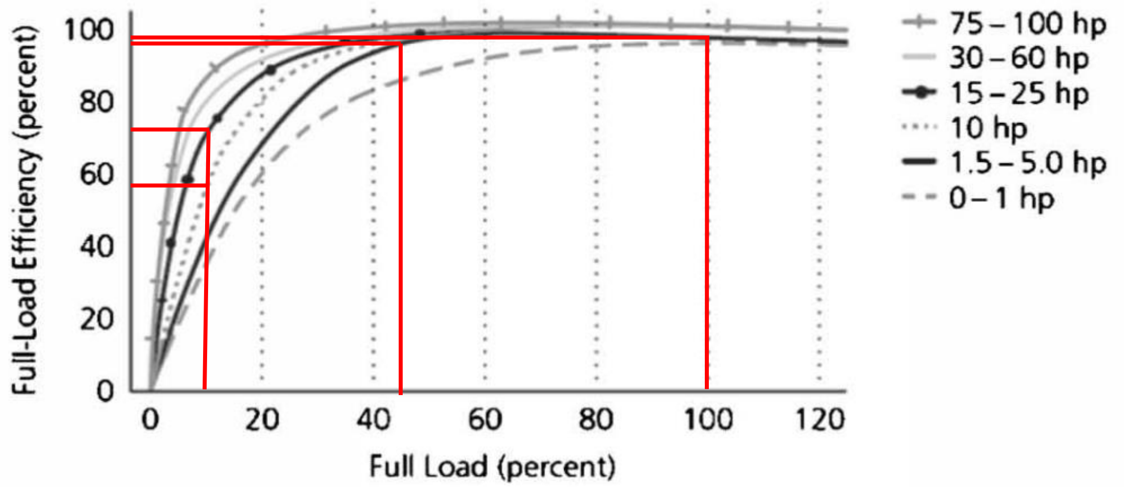


Fig. 1. Induction motor efficiency as a function of load (Natural Resources Canada 2004)

AC Induction Motors: Part-load Efficiency

- EC motors are highly efficient especially at part-load
- Load ~ $(CFM)^3$
- At 50% CFM, Load is 12.5% of full load
- At 75% CFM, Load is 41% of full load
- A 25hp AC motor is 72% efficient at 50% CFM
- A 10hp AC motor is 55% efficient at 50% CFM



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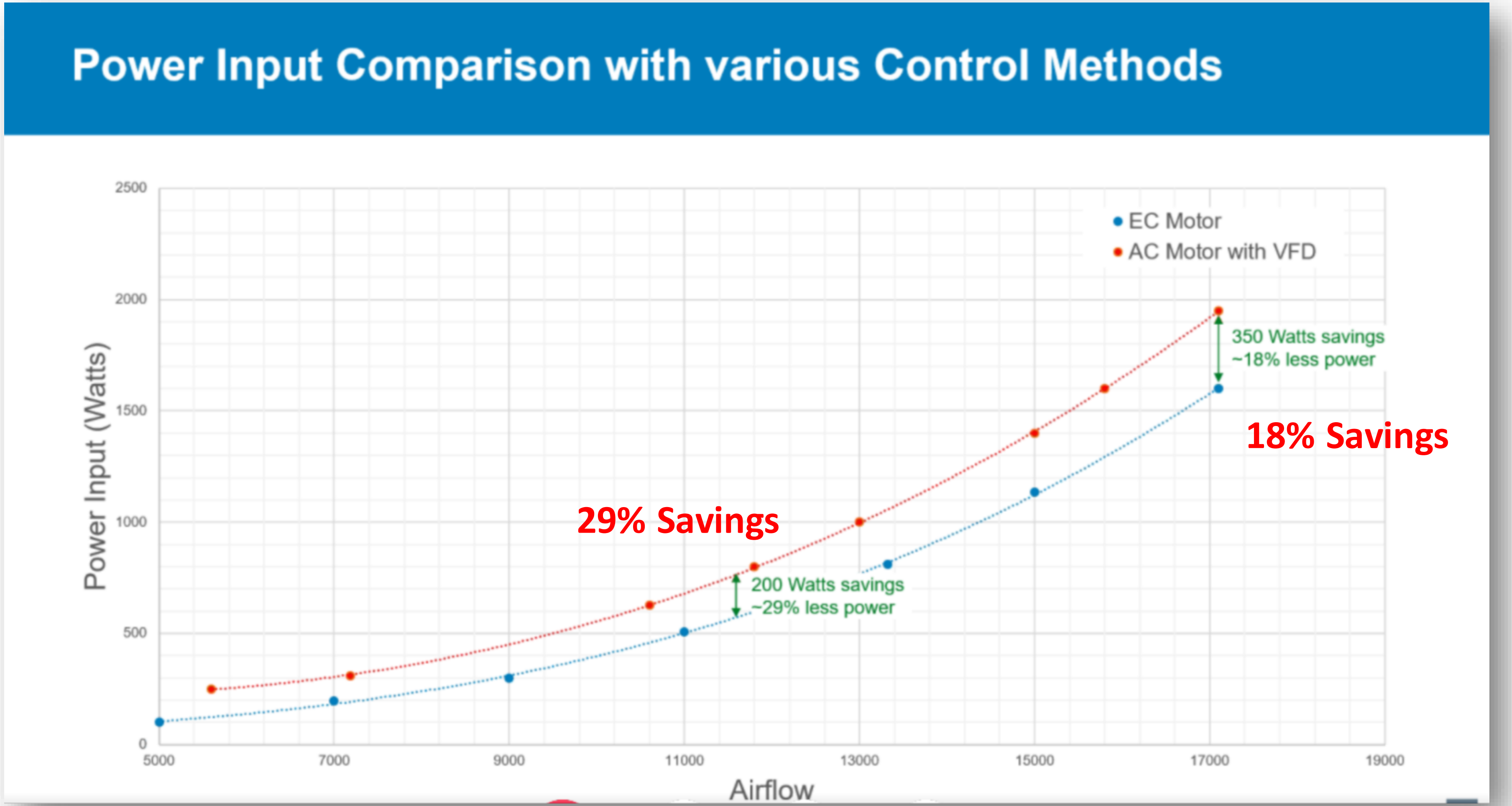
AC Induction Motors: Part-load Efficiency

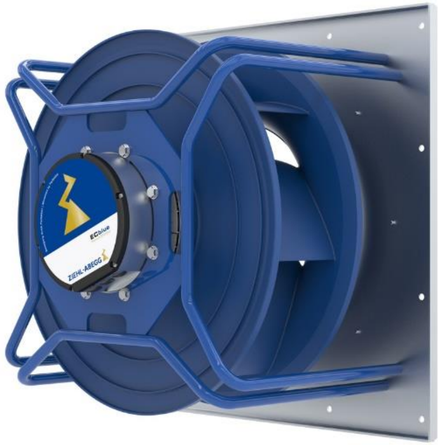


AC Induction Motors: Part-load Efficiency

EC Fans:
Fan Blade Design

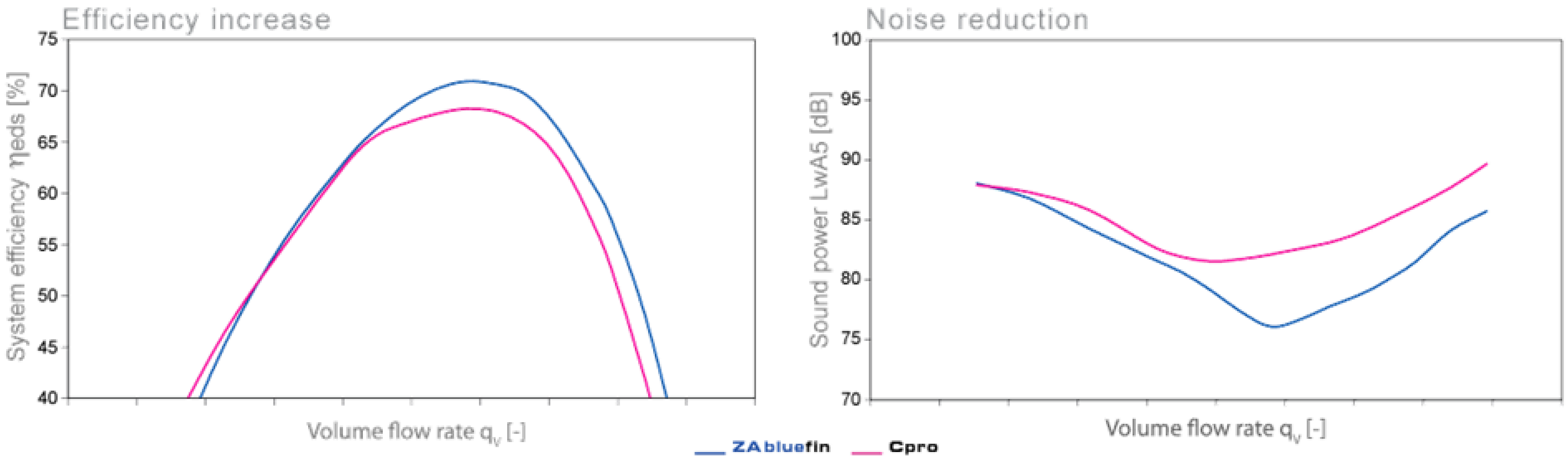
Aluminum, Steel or Composite blades

Slight performance advantage for composite blade (light weight/complex shape)
= increased efficiency + better acoustic performance



EC Fans: Fan Blade Static Efficiency

- Injection molded composite
- Steel/Aluminum
- Bionic, corrugated blade edge
- Corrugated fin
- V-Shape trailing edge
- Improved efficiency and reduced noise

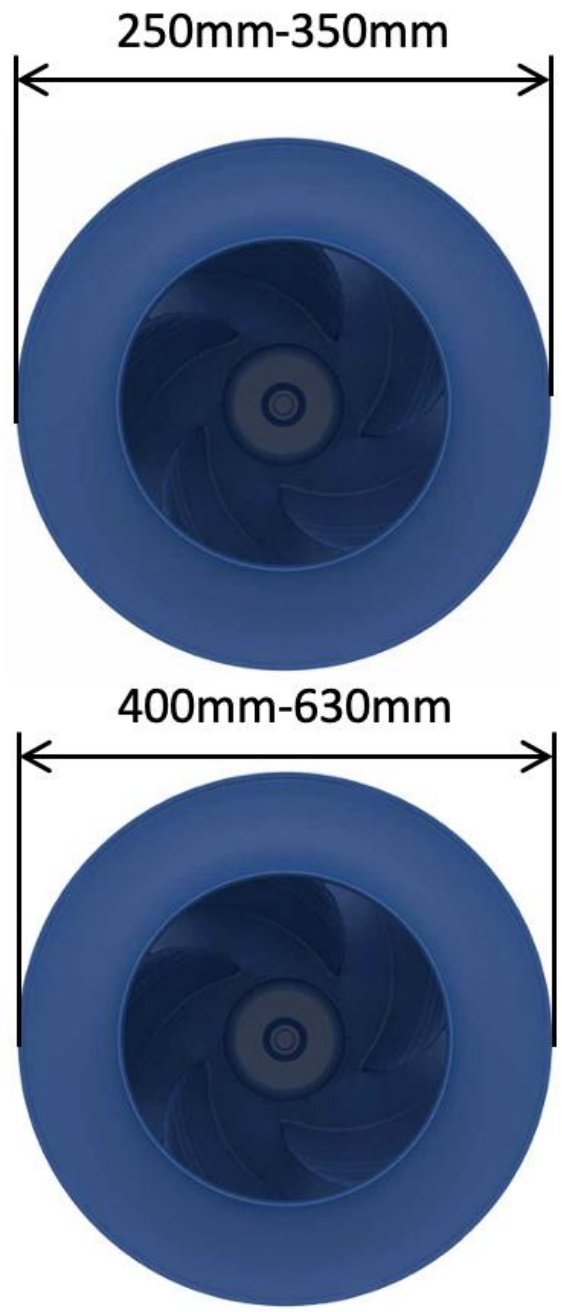


EC Fans:
Fan Blade Design

250mm (10”) to 630 mm (25”)

EC Fans: Vibration

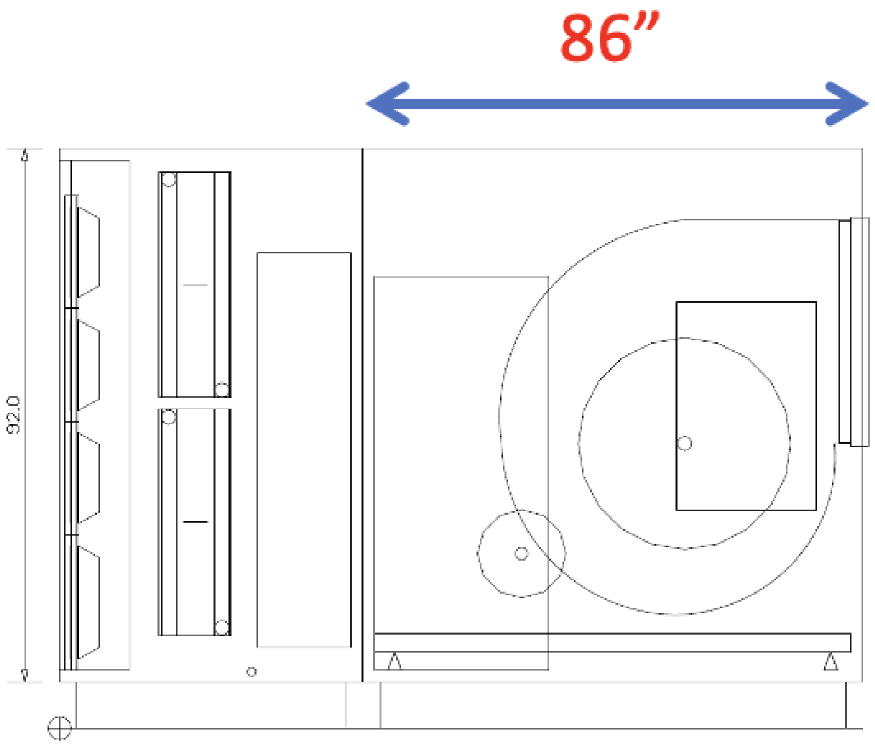
- Fan wheels 250mm-350mm: G6.3/BV3
- Fan wheels 400mm-630mm: G2.5/BV4

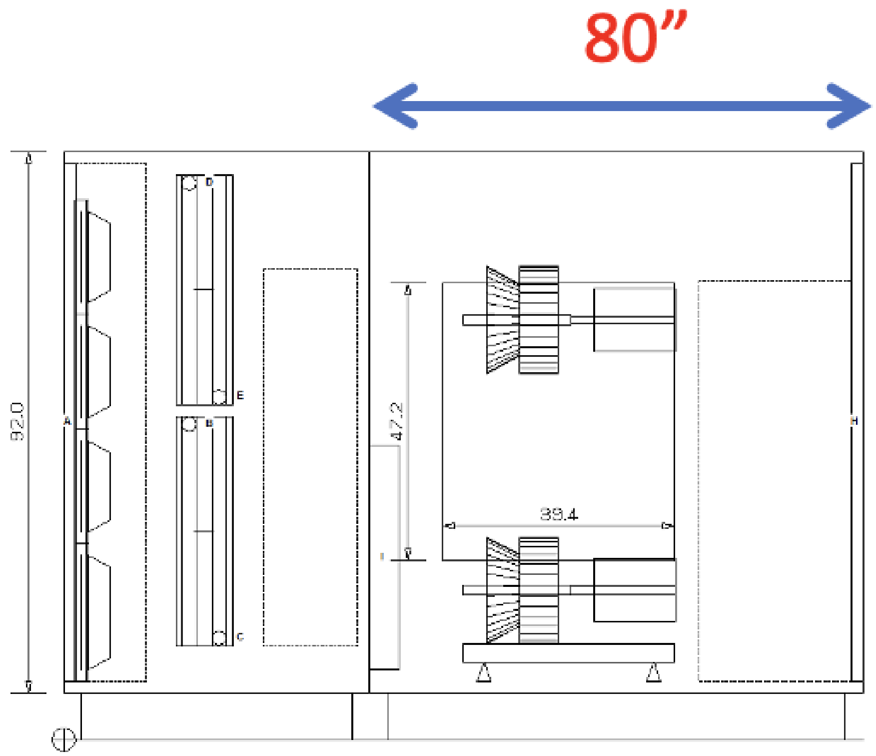


EC Fans: Vibration; AMCA 204 Fan Categories

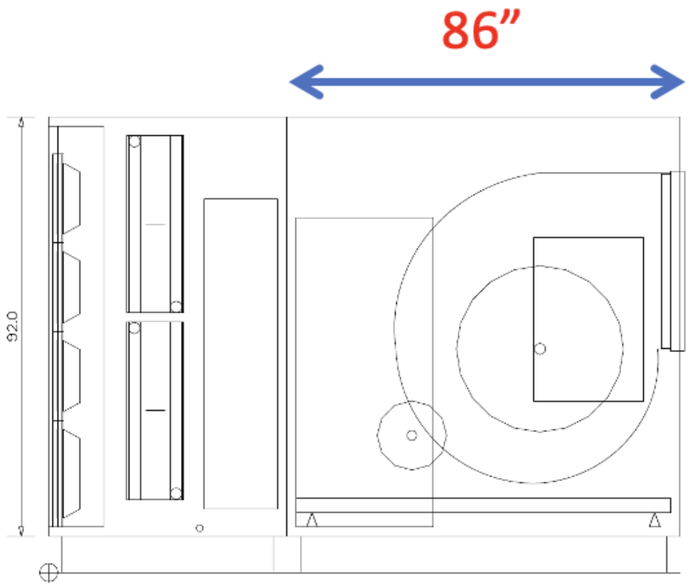
Table 6.1—Fan Application Categories for Balance and Vibration

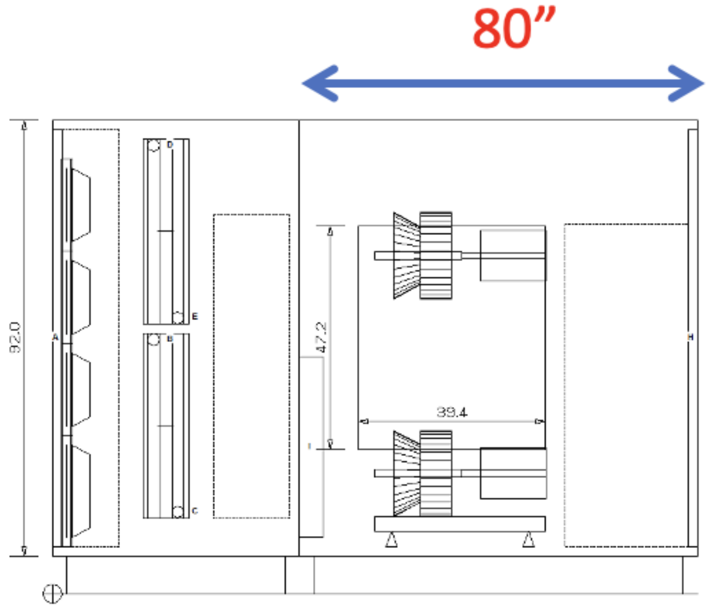
Application	Examples	Driver Power Limits, kW (hp)	Fan Application Category, BV
Residential	Ceiling fans, attic fans, window air-conditioning unit	≤ 0.15 (0.2) > 0.15 (0.2)	BV-1 BV-2
HVAC and agricultural	Building ventilation and air-conditioning systems; commercial systems	≤ 3.7 (5.0) > 3.7 (5.0)	BV-2 BV-3
Industrial process and power generation etc.	Baghouse, scrubber, mine, conveying, boilers, combustion air, pollution control, wind tunnels	≤ 298 (400) > 298 (400)	BV-3 BV-4
Transportation and marine	Locomotives, trucks, automobiles	≤ 15 (20) > 15 (20)	BV-3 BV-4
Transit and tunnel	Subway emergency ventilation, tunnel fans, garage ventilation	≤ 75 (100) > 75 (100)	BV-3 BV-4
	Tunnel jet fans	ALL	BV-4
Petrochemical process	Hazardous gases, process fans	≤ 37 (50) > 37 (50)	BV-3 BV-4
Computer chip manufacturer	Clean room	ALL	BV-5

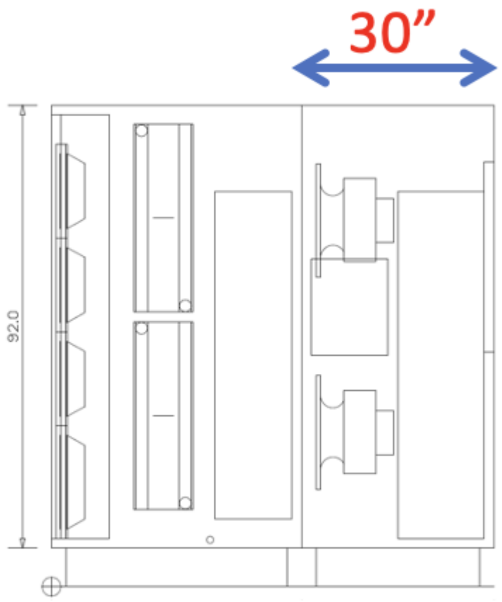




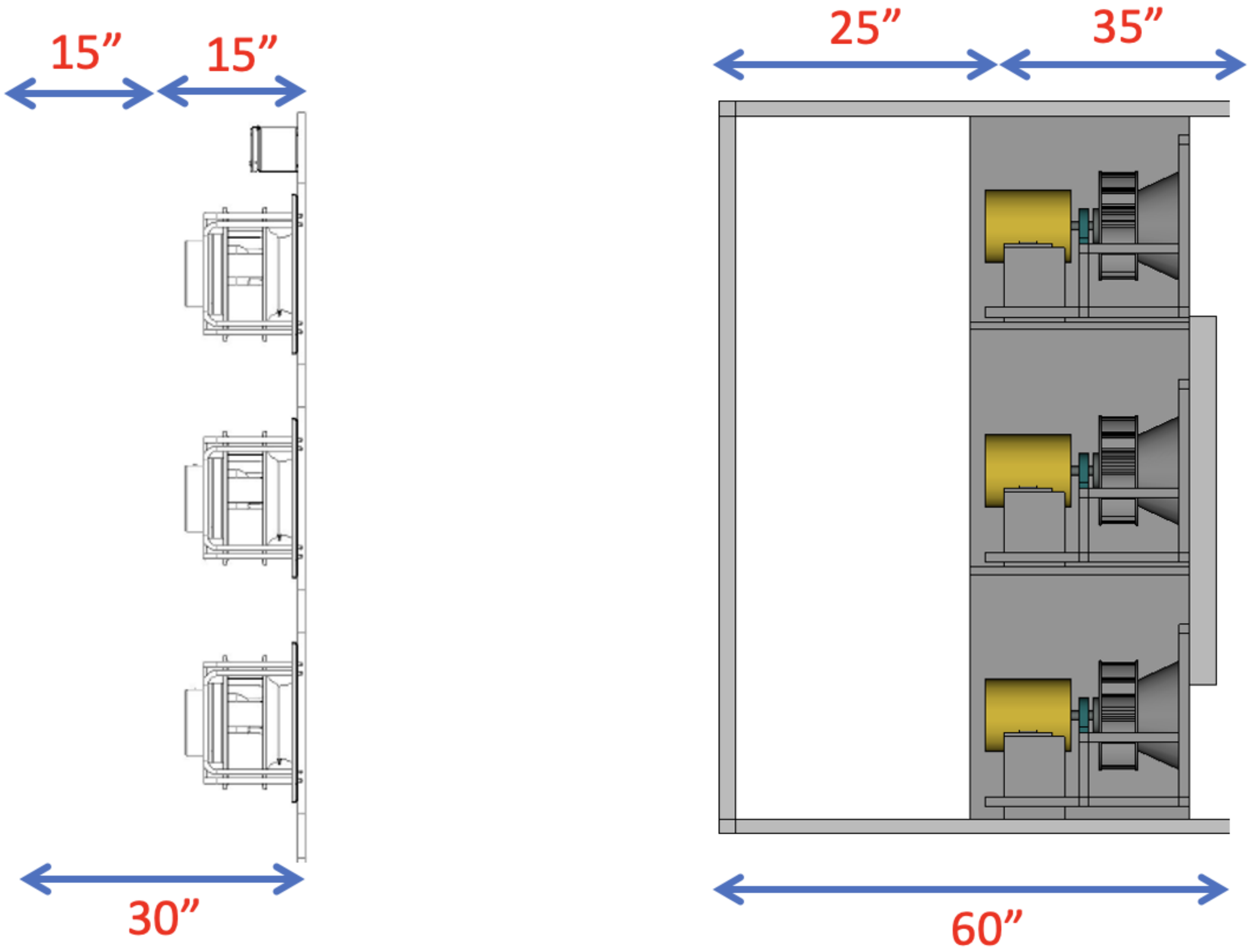
EC Fans: Footprint







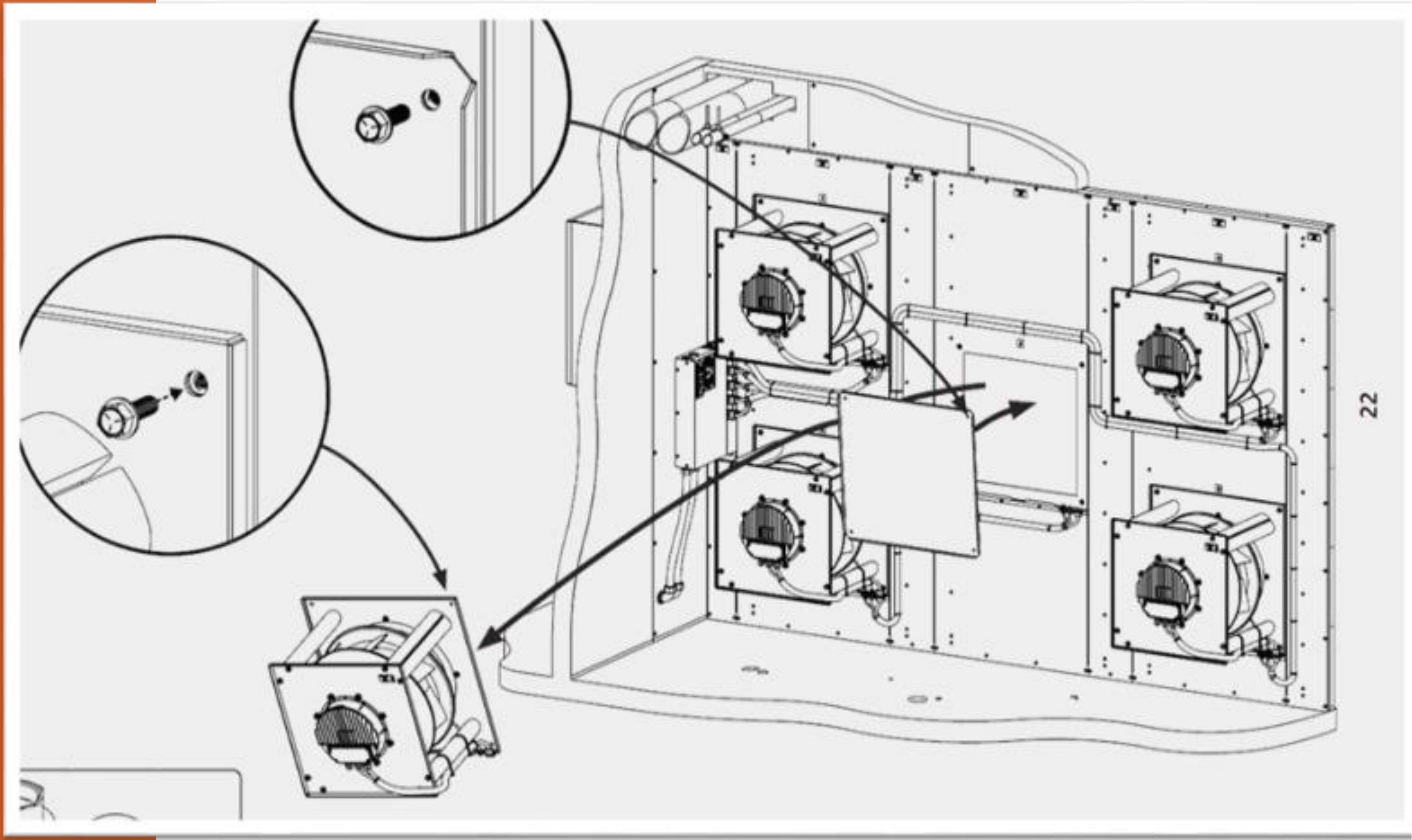
EC Fans: Footprint



EC Fans: Footprint vs Direct Drive Plenum Fans

EC Fan Systems: Backdraft Dampers

- No fan cycling required with EC fan arrays (high part-load efficiency)
- Fans run continuously at all times
- BD dampers not required at operation
- Failed fans can easily be covered until replaced



EC Fan Systems: Installation

Kitted Solution: all components fit through 24"x24" door

Light Weight: all components can be carried by one person

Fast Installation: a 5-fan array can be installed in 5 hours or less

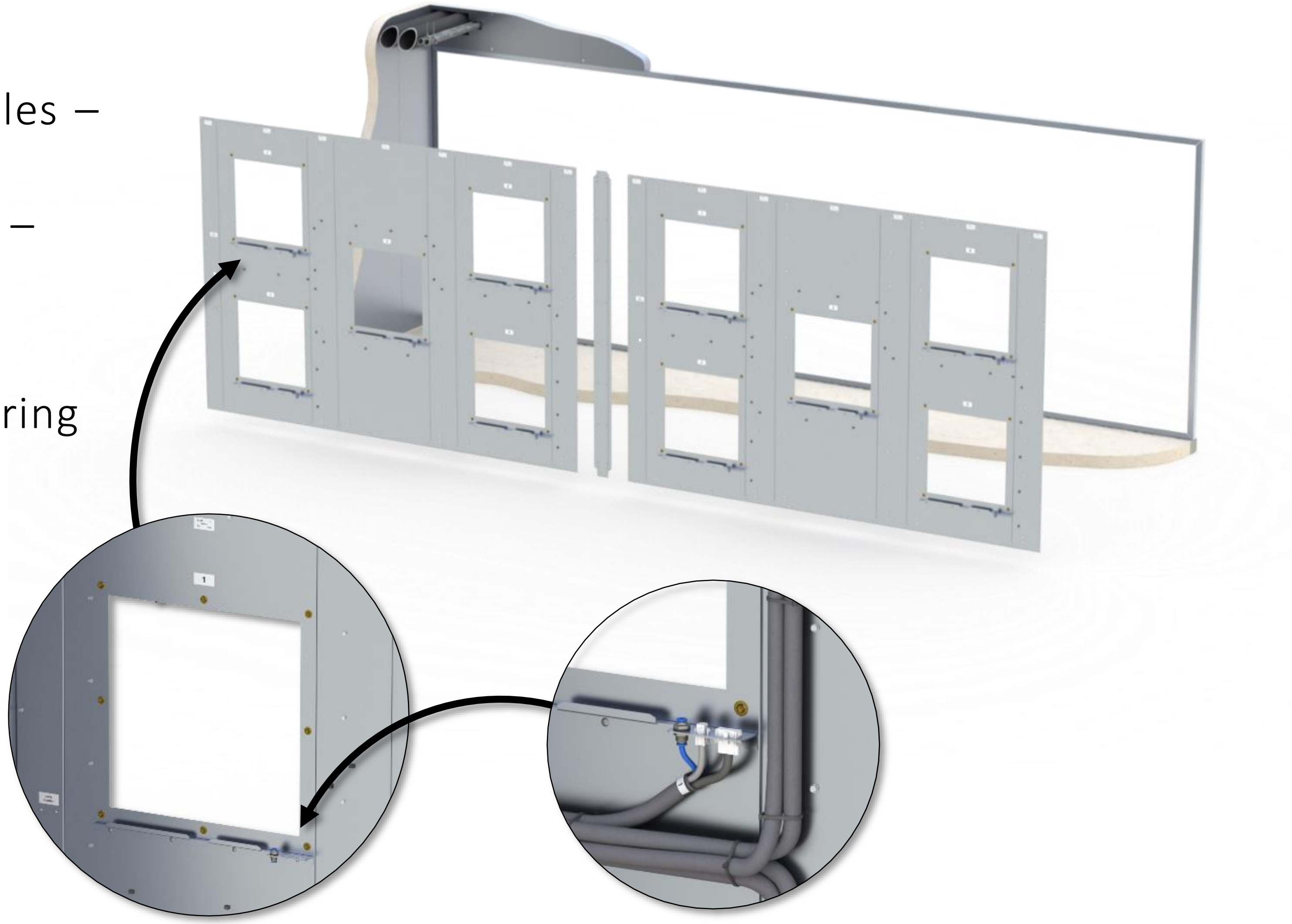
EC Fan Systems: Installation

Conventional Induction with VFD

ECM

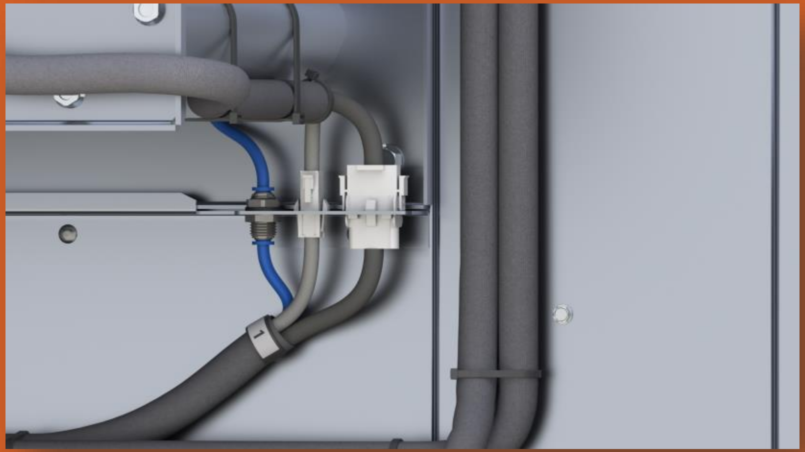
EC Fan Systems: Installation

- EC fans are bolted on modular bulkhead wall
- One or more Fan Integrator Modules – consisting of a set of interlocking panels and up to 9 fan assemblies – joined by couplers to form larger systems
- Fan Ledges for supporting fans during installation



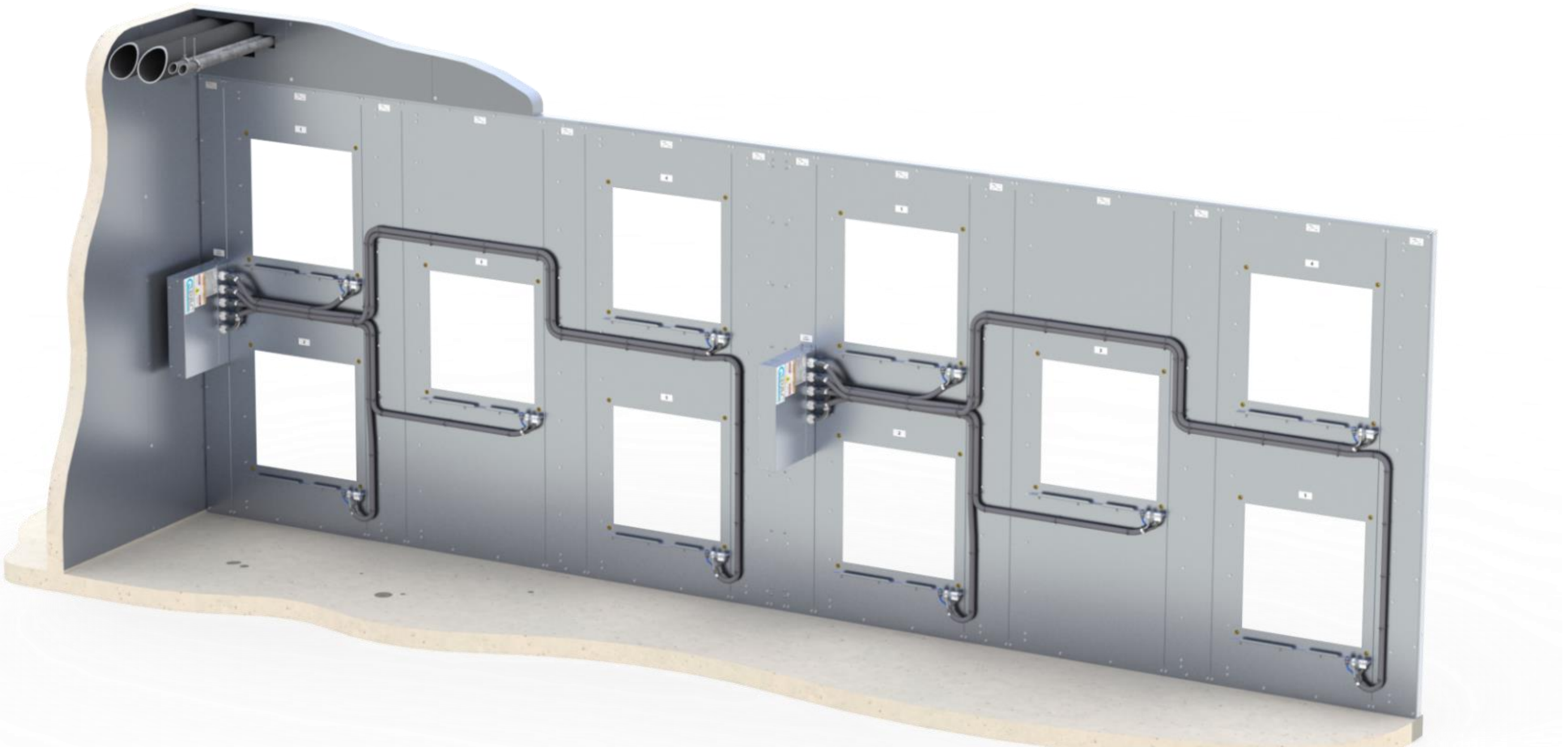
EC Fan Systems: Installation

- Fan systems are **plug and play**



EC Fan Systems: Installation

Internal junction box (Quick Connect Box) for ease installation

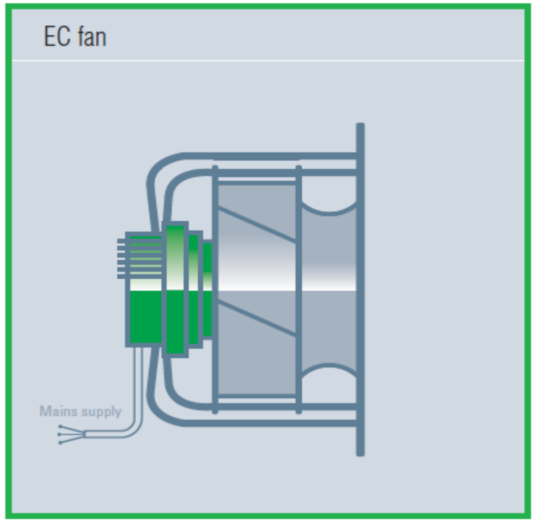


QUICK CONNECT BOX

- Design enables faster and easier fan system installation and startup, serving as a single point connection between the Control Panel and each set of fans
- Enables fan interchangeability
- Daisy chain connections between fans are *not necessary*
- Modbus *not required* for communication between the
- Overcurrent protection for each fan motor
- Allows for individual fan status and air volume monitoring

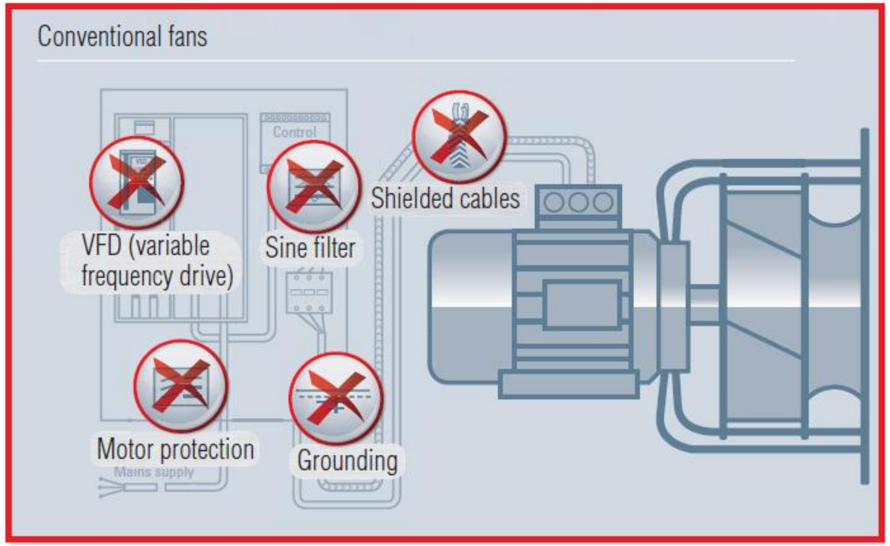
ECM

- Built in controls/electronics
- No special cabling
- No belts



Conventional Induction w/VFD

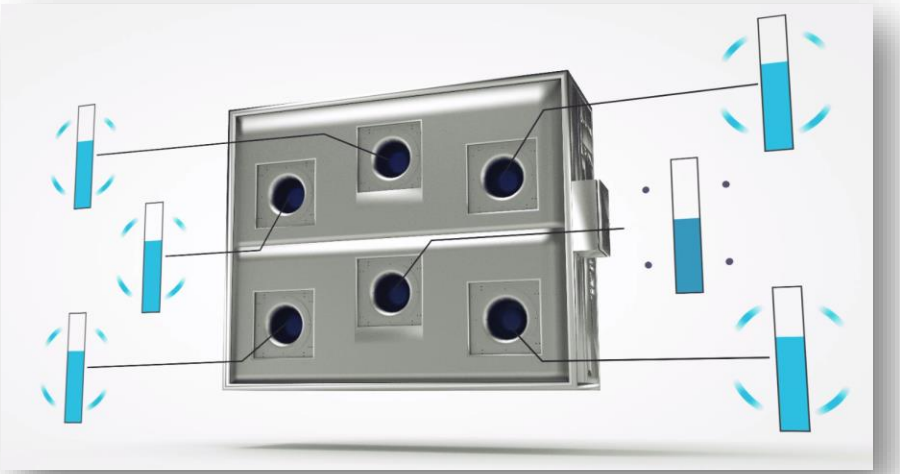
- VFD is separate to motor
- No Special shielded cables from VFD to motor
- No belts

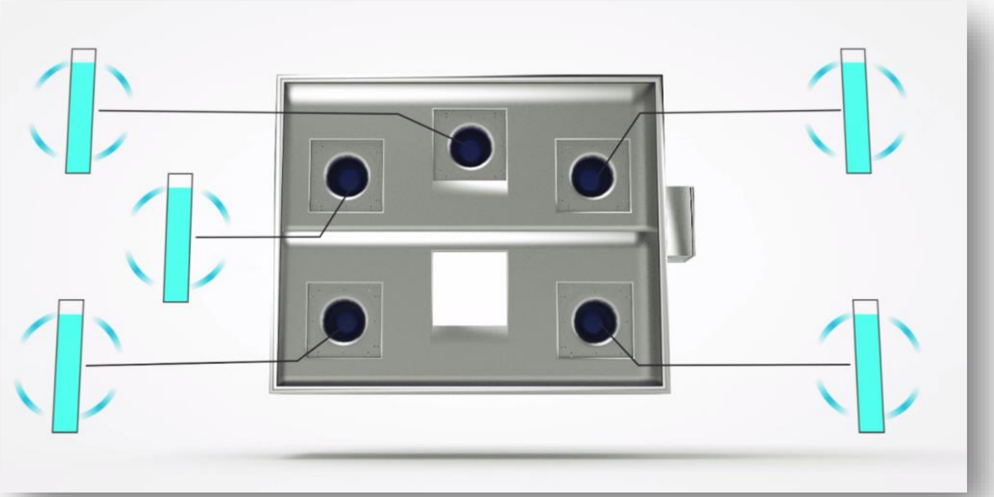


EC Fan Systems: Maintenance

EC Fan Systems: Other Benefits

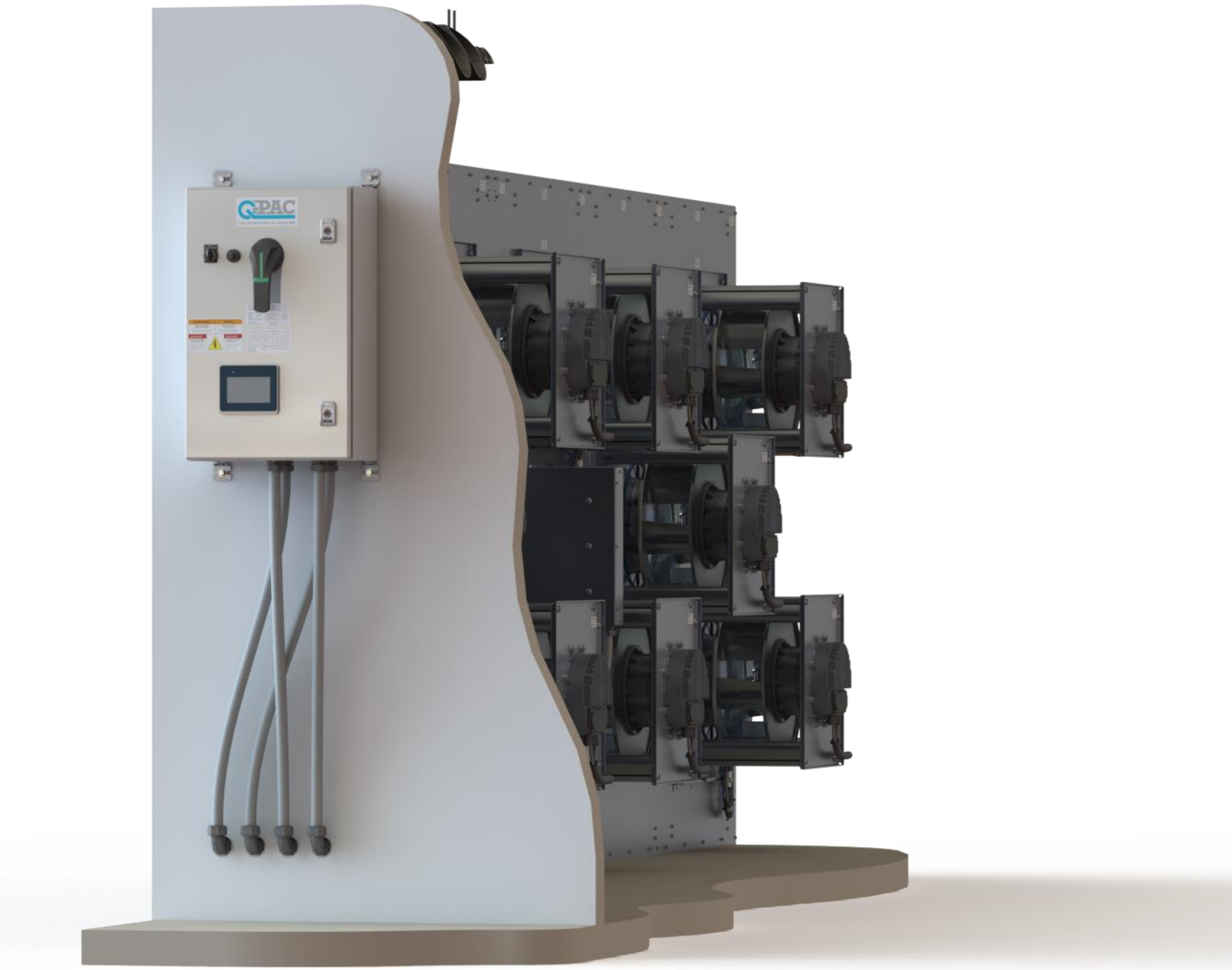
- Flexibility
- Redundancy
- No VFD's
- 10"+ of total static pressure



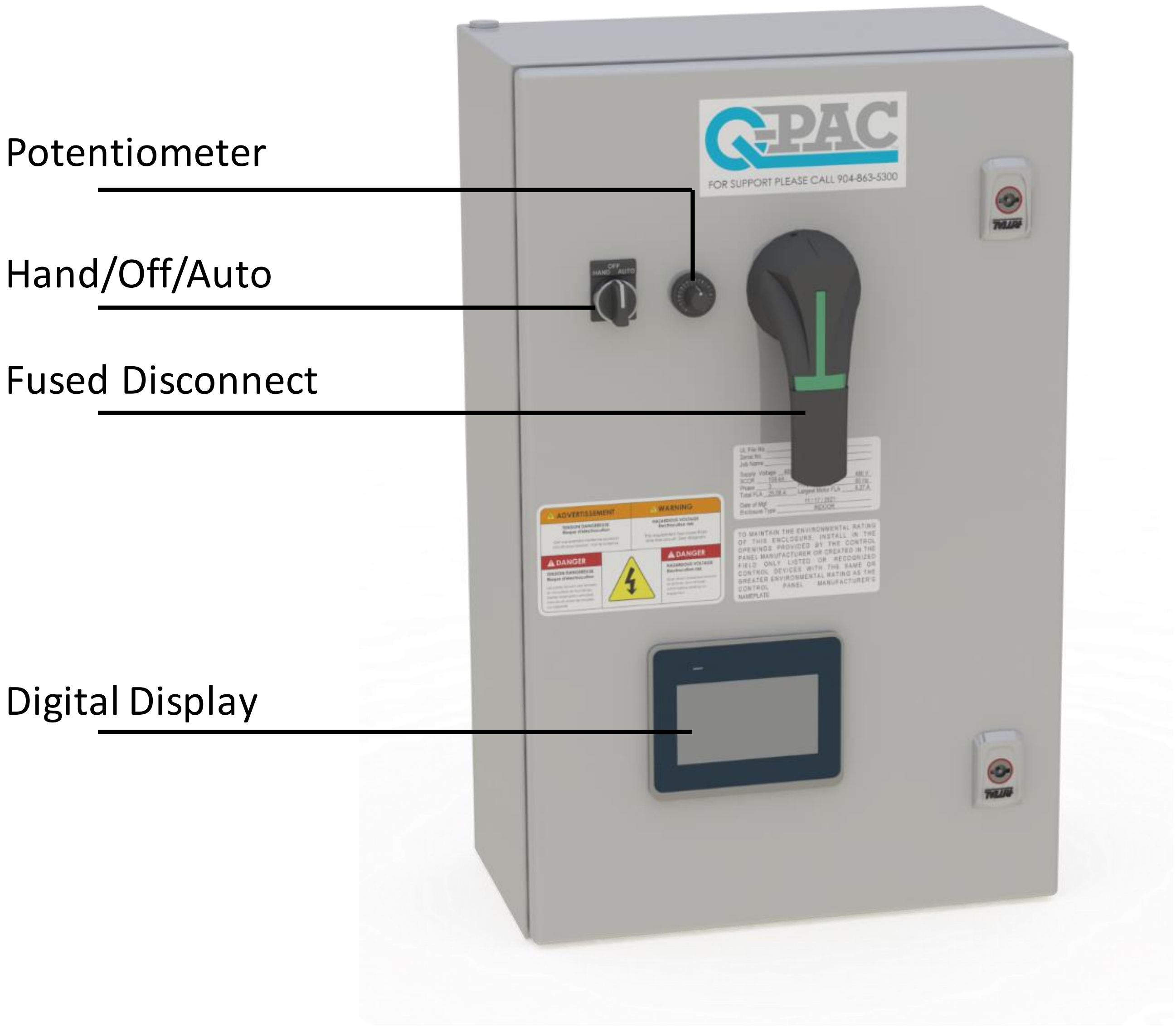


Controls

- Centrally controlled/powered
- BACnet compatible
- Flow rate/Static pressure monitoring
- Power monitoring in addition to hand off auto
- Safety/Interlock
- Individual fan alarms
- Digital display
- Speed control through digital/analogue signal

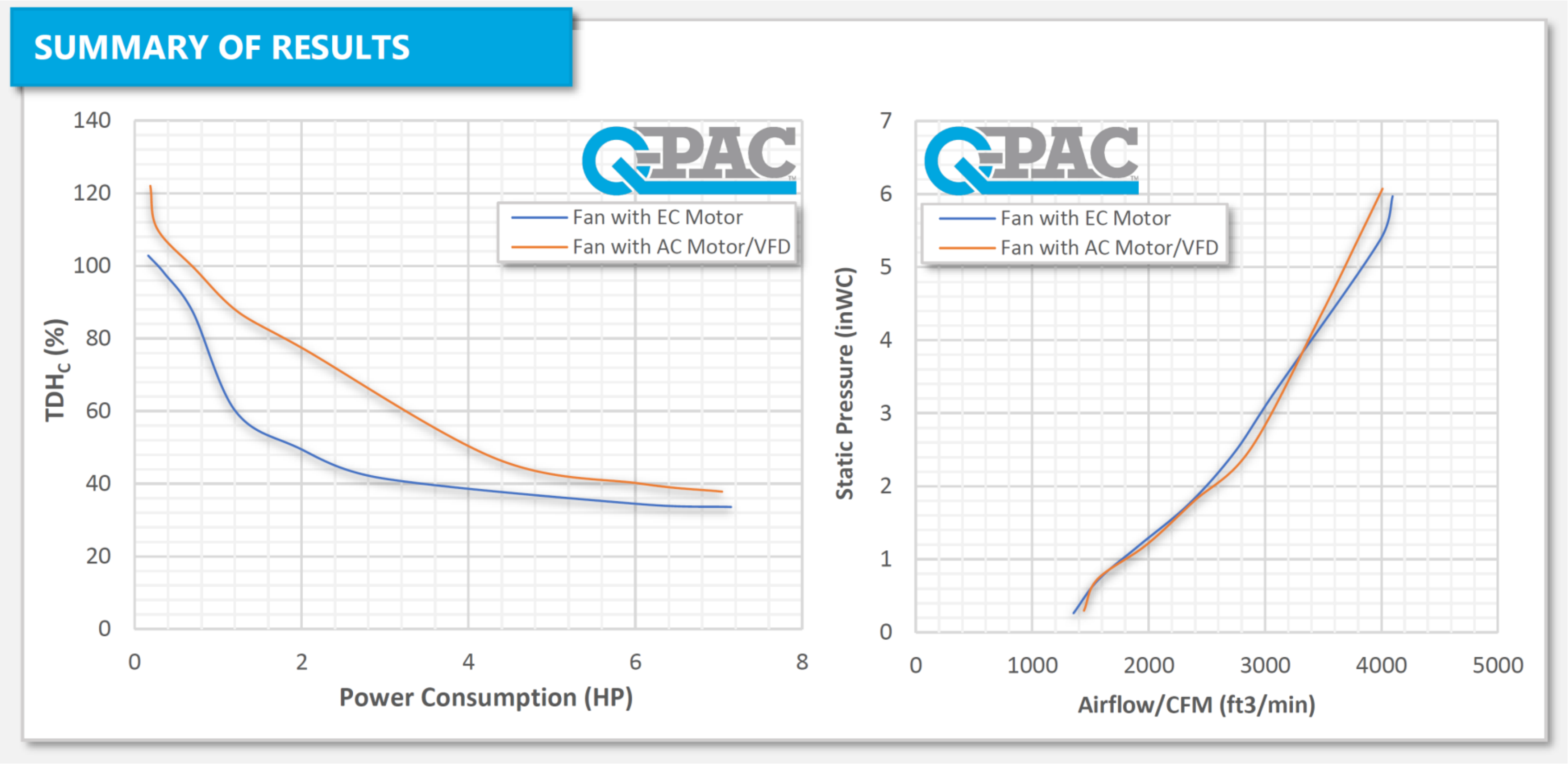


Controls


Potentiometer
Hand/Off/Auto
Fused Disconnect
Digital Display
Q-PAC
FOR SUPPORT PLEASE CALL 904-863-5300

Harmonics

ECM harmonic levels compared to AC Induction motors (no harmonic filters)

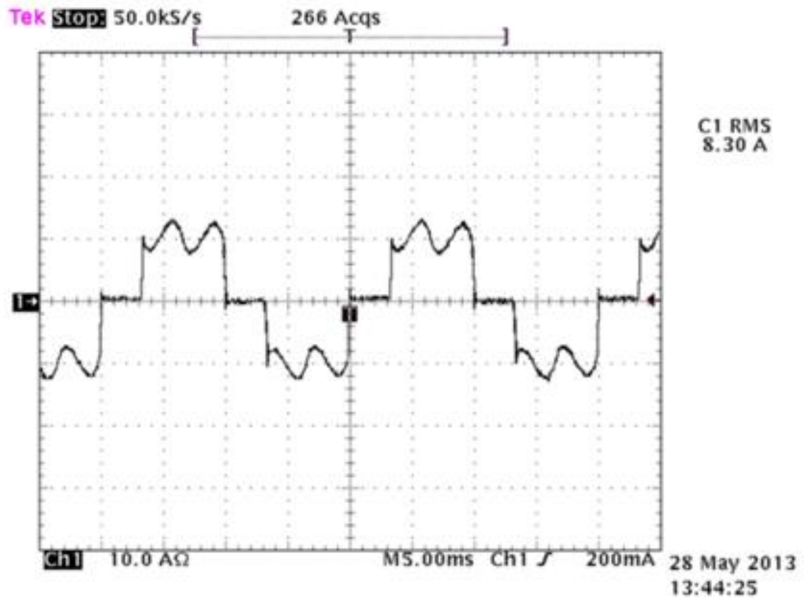


Follow IEEE 519 Recommendations:
--Measure Total Harmonic Distortion at Building's PCC (Point of Common Coupling)
--Apply filtration as necessary at PCC—NOT individual load points.

Harmonics Mitigation

- Integrated Line Reactors
- Passive Harmonic Filters
- Active Harmonic Filters

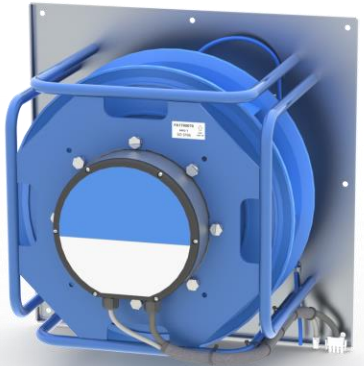
Line current harmonics with dc-link-choke



EC fans w their integrated drive

THD(i) approx. 33.5%

Power Factor approx. 0.94%



ebmpapst

rosenberg ECOFIT ETRI THE AIR MOVEMENT GROUP

ZIEHL-ABEGG

EC Fan Manufacturers: Commercial Products

440-480V

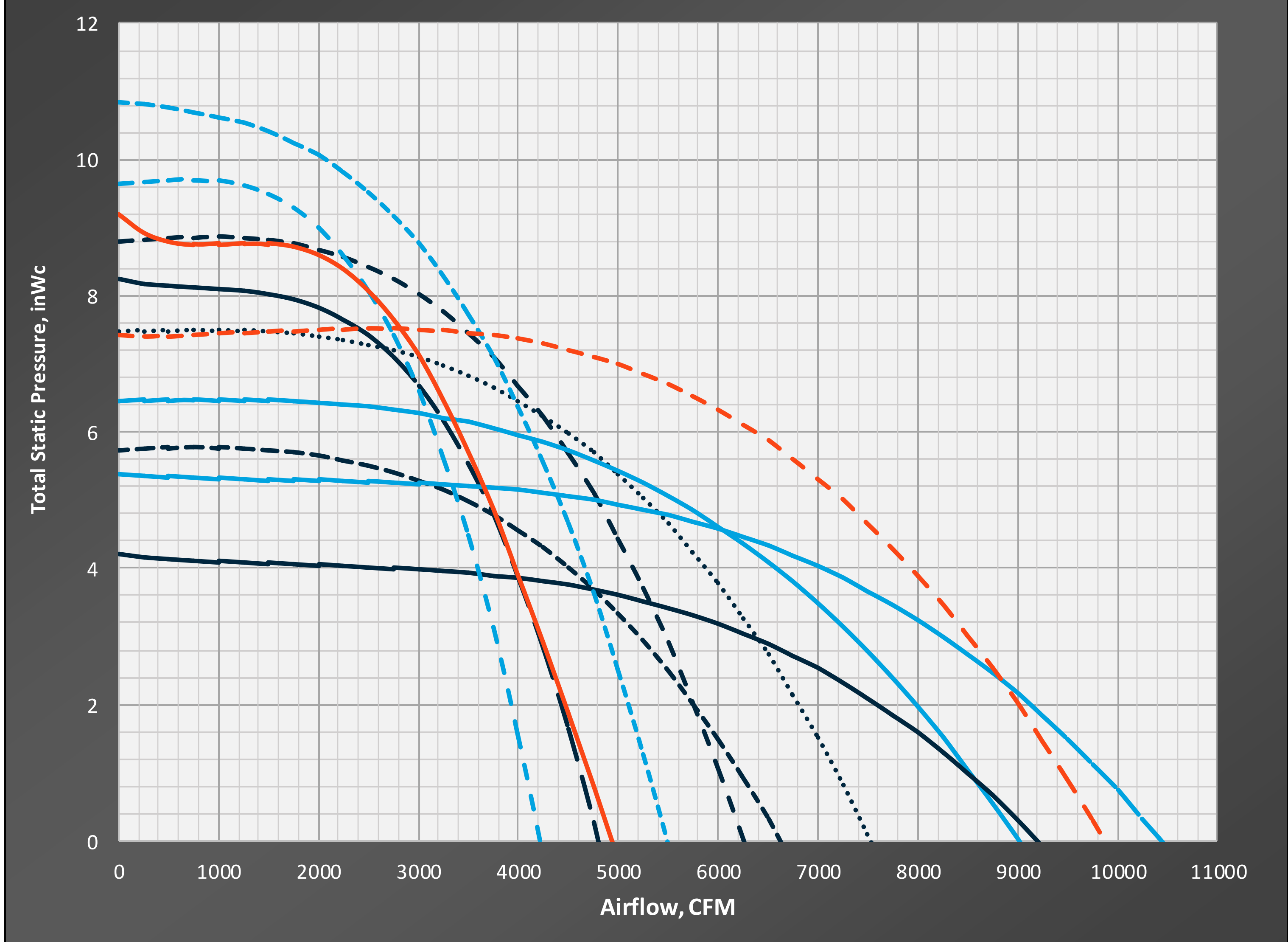
CFM + Static Pressure Fan Capability

Rosenberg

- 1700523
- 1700526

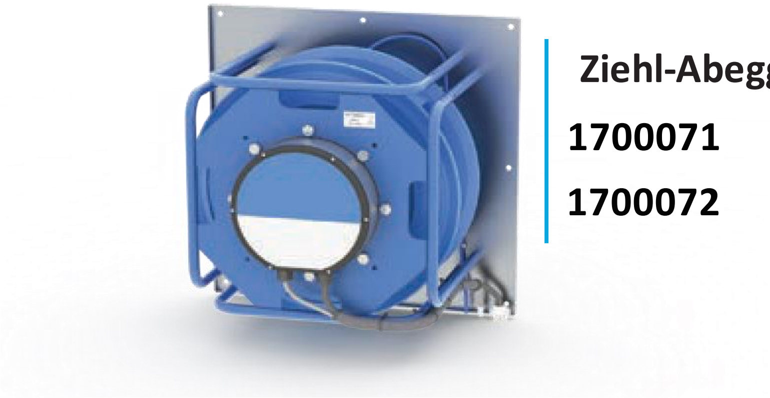
Ziehl-Abegg

- 1700054
- 1700069
- 1700076
- 1700077
- 1700078
- 1700079
- 1700081
- 1700082
- 1700083



200-240V

CFM + Static Pressure Fan Capability



Ziehl-Abegg

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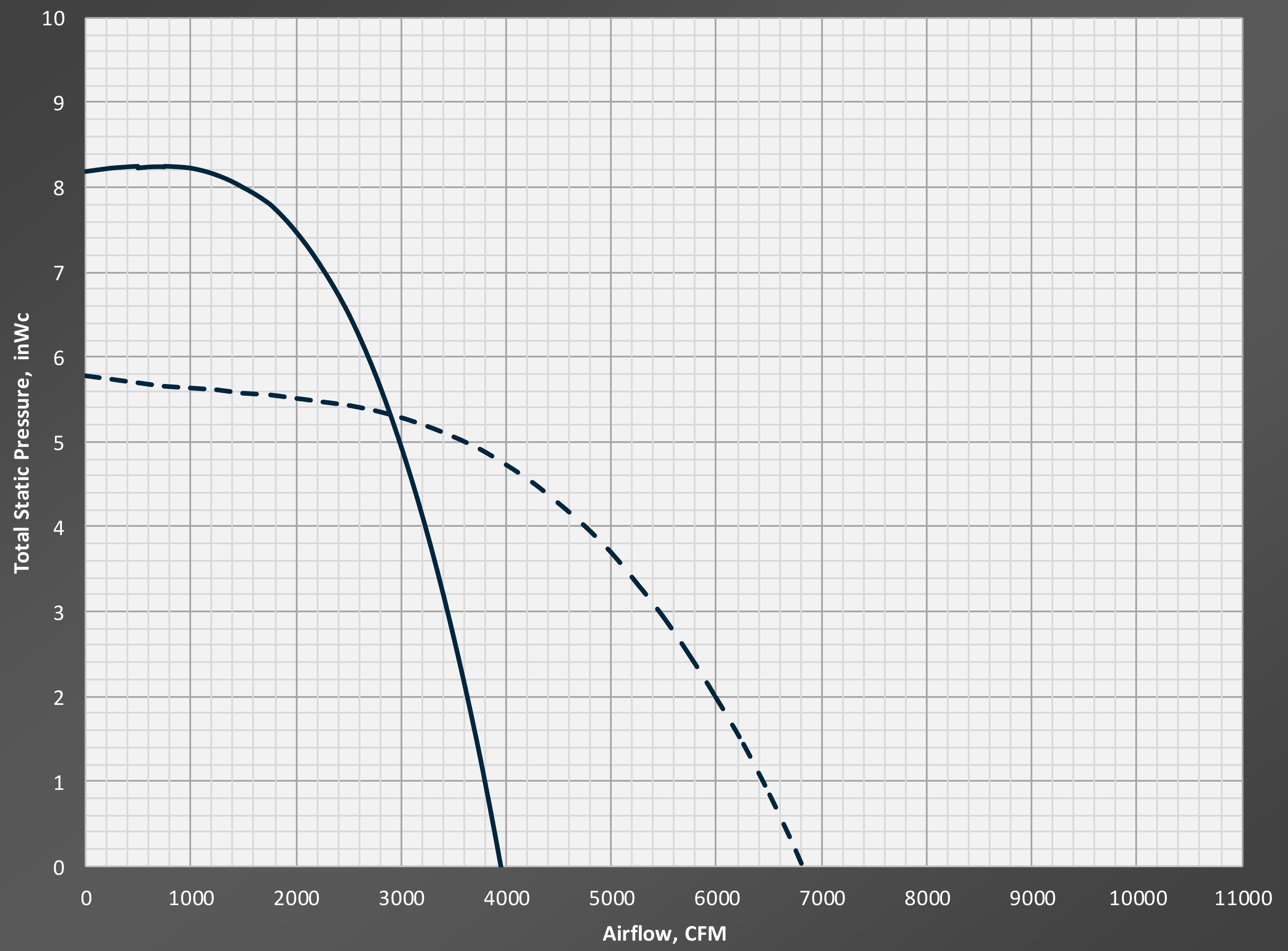

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