STANDARD

ANSI/AMCA Standard 214-21

Test Procedure for Calculating Fan Energy Index (FEI) for Commercial and Industrial Fans and Blowers

An American National Standard
Approved by ANSI on March 1, 2021

ANSI Accredited Standards Developer

Air Movement and Control Association International

AMCA Corporate Headquarters
30 W. University Drive, Arlington Heights, IL 60004-1893, USA
communications@amca.org ▪ Ph: +1-847-394-0150 ▪ www.amca.org

ANSI/AMCA Standard 214-21

Test Procedure for Calculating Fan Energy Index (FEI) for Commercial and Industrial Fans and Blowers

Air Movement and Control Association International
30 West University Drive
Arlington Heights, Illinois
60004

AMCA Publications

Authority ANSI/AMCA Standard 214 was adopted by the membership of the Air Movement and Control Association International Inc. on December 31, 2020. It was approved as an American National Standard on March 1, 2021.

Objections The Air Movement and Control Association (AMCA) International Inc. will consider and take action upon all written complaints regarding its standards, certification programs or interpretations thereof. For information on procedures for submitting and handling complaints, write to:

AMCA International Inc.
30 West University Drive
Arlington Heights, IL 60004-1893
U.S.A.

European AMCA
Avenue de Tervueren 188a
Postbox 4
1150 Brussels, Belgium

Asia AMCA Sdn Bhd
No. 7, Jalan SiLC 1/6,
Kawasan Perindustrian SiLC Nusajaya,
Mukim Jelutong, 79200 Nusajaya, Johor
Malaysia

Disclaimer AMCA uses its best efforts to produce publications for the benefit of the industry and the public in light of available information and accepted industry practices. However, AMCA does not guarantee, certify or assure the safety or performance of any products, components or systems tested, designed, installed or operated in accordance with AMCA publications or that any tests conducted under its publications will be non-hazardous or free from risk.

Foreword

(This foreword is not part of this standard. It is merely informative and does not contain requirements necessary for conformance to the standard. It has not been processed according to the ANSI requirements for a standard and may contain material that has not been subject to public review or a consensus process. Unresolved objectors on informative material are not offered the right to appeal at ANSI.)

The purpose of AMCA Standard 214, Test Procedure for Calculating Fan Energy Index (FEI) for Commercial and Industrial Fans and Blowers, is to aid federal and state rulemaking efforts to establish energy-efficiency standards for commercial and industrial fans and blowers, providing a consistent method of calculating FEI across the many different options or circumstances that exist in the fan market (fans sold without motors and drives, fans sold with unregulated motors or regulated motors, etc.).

An expressed difficulty in establishing an FEI-based fan regulation is having to work with four AMCA standards and publications: ANSI/AMCA Standard 207, Fan System Efficiency and Fan System Input Power Calculation; ANSI/AMCA Standard 208, Calculation of the Fan Energy Index; ANSI/AMCA Standard 210/ASHRAE Standard 51, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating); and AMCA Publication 211, Certified Ratings Program Product Rating Manual for Fan Air Performance. AMCA Standard 214 consolidates these documents.

AMCA Standard 214 primarily is for fans that are tested alone or with motors and drives; it does not apply to fans tested embedded inside of other equipment. AMCA Standard 214 covers most fan types and sizes.

For fans that already have been tested for rating using test procedures referenced in this document, no new testing is required for applying this standard. Fan manufacturers may be required to update their internal data-collection, calculation, and documentation systems to acquire the data necessary for the calculation of FEI.

AMCA Standard 214 covers only calculation of FEI and fan electrical power (FEP). It does not cover labeling, compliance filing, surveillance, and other regulatory processes.

Presenting FEI values to the market may also require fan manufacturers to modify fan-selection software and printed materials.

Calculations in AMCA Standard 214 may require fan manufacturers to collect additional information from prospective buyers, such as drive (transmission) configuration and expected motor selection.

Compliance with AMCA Standard 214 requires fan manufacturers to assemble product data not historically presented to the market, such as fan outlet area, fan total pressure, and fan category.

Review Committee

Mark Bublitz	Chair	The New York Blower Company
John Bade	Member	2050 Partners
Chaitanya Johar	Member	AAON
Adam Sterne	Member	Acme Engineering and Manufacturing Corp.
Chris Quinones	Member	AcoustiFLO, LLC
Christian Taber	Member	Big Ass Fans
Mark Gerken	Member	Cincinnati Fan
Chad Oldham	Member	Greenheck Fan Corporation
Aaron Saldanha	Member	Howden
Daniel Hernandez	Member	Johnson Controls Inc. / PennBarry
Bob Valbracht	Member	Loren Cook Company
Neal Boyd	Member	Northern Blower
Dan Delaney	Member	Regal Beloit
Ola Wettergren	Member	Systemair
Trinity Persful	Member	Twin City Fan Companies, Ltd.
Dustin Meredith	Member	Trane
William B Howarth	Member	Ventilation & Fan Consulting Service International
Aschenbach, Kai	Member	Ziehl-Abegg SE
Lee Buddrus	Non-Voting Member	Acme Engineering & Manufacturing Corp.
Anthony (Geoff) Sheard	Non-Voting Member	AGS Consulting, LLC
Abhishek Jain	Non-Voting Member	Air Flow Pvt Ltd
Joanna Mauer	Non-Voting Member	Appliance Standards Awareness Project
Fernando A. Ruiz Con., M.A., P.E.	Non-Voting Member	ARMEE
Franco Cincotti	Non-Voting Member	Comefri USA
Marcel Kamutzki	Non-Voting Member	Daltec Process Fans
Armin Hauer	Non-Voting Member	ebm-papst Inc.
Alejandro Galdamez	Non-Voting Member	California Energy Commission
Chad Worth	Non-Voting Member	Energy Solutions
Nathan Fetting	Non-Voting Member	Greenheck Fan Corporation

DongWon Park	Non-Voting Member	Gumsung Poong Ryuk Co,. Ltd
Sameh Ezzat	Non-Voting Member	Hammam Industries & Co.
Mohammad Sulaiman Hassan	Non-Voting Member	Italconsult Spa
Mark Lessans	Non-Voting Member	Johnson Controls
Sanaee Iyama	Non-Voting Member	Lawrence Berkeley National Laboratory
Keith Lins	Non-Voting Member	M. K. Plastics Corp.
Nigil Sudharjanan	Non-Voting Member	Maico Gulf
Tanmoy Kumar Choudhury	Non-Voting Member	Maico Gulf LLC (Dynair / Dynavent / Elicent)
Shekhar Maurya	Non-Voting Member	Nehmeh Corporation
Jim Gatto	Non-Voting Member	Robinson Fans Inc
Joshua Lynch	Non-Voting Member	S&P USA Ventilation Systems, LLC
Rad Ganesh	Non-Voting Member	Twin City Fan Companies, Ltd.
Luis Javier Diaz	Non-Voting Member	ZITRON SA
Joseph Brooks	AMCA Staff Liaison	AMCA International, Inc.

Contents

Test Procedure for Calculating Fan Energy Index (FEI) for Commercial and Industrial Fans and Blowers

1. Scope

This standard applies to fans where air is used as the test gas with the following exceptions:

- Ceiling fans
- Cross-flow fans
- Air Curtain Units

2. References (Normative)

The following referenced documents are required for the application of this document. For dated references only the edition cited applies. For undated references, the latest edition of the referenced document applies.

AHRI Standard 1210 (I-P/2019), Performance Rating of Variable Frequency Drives

ANSI/AMCA Standard 210-16/ASHRAE 51-16, Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating

ANSI/AMCA Standard 230-15, Laboratory Methods of Testing Air Circulating Fans for Rating and Certification

ANSI/AMCA Standard 250-12, Laboratory Methods of Testing Jet Tunnel Fans for Performance

ANSI/AMCA Standard 260-20, Laboratory Methods of Testing Induced Flow Fans for Rating

ANSI/AMCA Standard 99-2016, Standards Handbook

ANSI/ASHRAE Standard 222-2016, Standard Method of Test for Electrical Power Drive Systems

CAN/CSA C747-09, Energy efficiency test methods for small motors

CAN/CSA C838-13, Energy efficiency test methods for three-phase variable frequency drive systems

IEEE 112-2017, Standard Test Procedure for Polyphase Induction Motors and Generators

ISO 5801:2017, Fans – Performance testing using standardized airways

ISO 13350:2015, Fans – Performance testing of jet fans

10 CFR 431.25, Energy conservation standards and effective dates

3. Definitions

3.1 Absolute pressure
The pressure if the datum pressure is absolute zero. It is always positive.

3.2 Axial impeller
An impeller (propeller) with a number of blades extending radially from a central hub in which airflow through the impeller is axial in direction; that is, airflow enters and exits the impeller parallel to the shaft axis with a fan flow angle less than or equal to 20 degrees. Blades can be either single thickness or airfoil shaped.

3.3 Axial PRV
A powered roof ventilator (PRV) with an axial impeller that either supplies or exhausts air to a building. Inlets and outlets typically are not ducted.

3.4 Axial inline fan
A fan with an axial impeller and a cylindrical housing with or without turning vanes.

3.5 Axial panel fan
An axial fan, without cylindrical housing, that is mounted on a panel, orifice plate or ring.

3.6 Barometric pressure
The absolute pressure exerted by the atmosphere.

3.7 Base tests
The laboratory test or tests used in concert with rating development procedures to determine the performance of each model in a product line.

3.8 Direct drive
A form of transmission where the impeller is mounted directly on a motor without the use of belts or couplings. Impeller speed is identical to motor speed.

3.9 Centrifugal housed fan
A fan with a centrifugal or mixed flow impeller in which airflow exits into a housing that is generally scroll-shaped to direct the air through a single fan outlet. A centrifugal housed fan does not include a radial impeller.

3.9a Centrifugal impeller
An impeller with a number of blades extending between a back plate and shroud in which airflow enters axially through one or two inlets and exits radially at the impeller periphery. The airflow exits either into open space or into a housing with a fan flow angle greater than or equal to 70 degrees. Impellers can be classified as single inlet or double inlet. Blades can be tilted backward or forward with respect to the direction of impeller rotation. Impellers with backward tilted blades can be airfoil shaped (AF), backward curved single thickness (BC), backward inclined single thickness flat (BI) or radial tipped (RT). Impellers with forward tilted blades are known as forward curved (FC).

3.10 Centrifugal inline fan
A fan with a centrifugal or mixed-flow impeller in which airflow enters axially at the fan inlet and the housing redirects radial airflow from the impeller to exit the fan in an axial direction.

3.11 Centrifugal power roof ventilator exhaust (PRV-E) fan
A PRV with a centrifugal or mixed-flow impeller that exhausts air from a building. It is typically mounted on a roof or a wall.

3.12 Centrifugal power roof ventilator supply (PRV-S) fan
A PRV with a centrifugal or mixed-flow impeller that supplies air to a building. It is typically mounted on a roof or a wall.

3.13 Centrifugal unhoused fan
A fan with a centrifugal or mixed-flow impeller in which airflow enters through a panel and discharges into free space. Inlets and outlets are not ducted. This fan type also includes fans designed for use in fan arrays that have partition walls separating the fan from other fans in the array.

3.14 Ceiling fan
A nonportable device that is suspended from a ceiling or overhead structure for circulating air via the rotation of fan blades as defined in 10 CFR 430.2.

3.15 Circulating fan
A fan that is not a ceiling fan that is used to move air within a space but has no provision for connection to ducting or separation of the fan inlet from its outlet. The fan is designed to be used for the general circulation of air.

3.16 Compressibility coefficient
The ratio of the mean airflow rate through the fan to the airflow rate at fan air density; the ratio of the fan total pressure that would be developed with an incompressible fluid to the fan total pressure that is developed with a compressible fluid. The compressibility coefficient is a thermodynamic factor that must be applied to determine fan total efficiency from fan airflow rate, fan total pressure and fan input power. The coefficient is derived in ANSI/AMCA Standard 210-16, Annex D, or ISO 5801, Section 15.1.9.3.

3.17 Default motor efficiency
A default efficiency assigned to the motor at its operating point if either the specific motor is not identified or the efficiency of the motor used is unknown. The assumed motor efficiency is representative of a premium-efficiency (IE3), three-phase, four-pole, general purpose squirrel-cage induction motor.

3.18 Drive
Components used to power a fan, including a driver, may include a motor controller and/or transmission.

3.19 Driven fan
A fan equipped with a driver.

3.20 Driver
A machine, such as a motor, used to provide mechanical power to the impeller, either directly or through a transmission.

3.21 Dual-use fan
A fan with two operating modes to serve long-term ventilation purposes as well as short-time emergency duty at higher speed for fire or smoke extraction.

3.22 Duty point
A single airflow, pressure point and fan air density within the fan's operating range.

3.23 Dynamic (velocity) pressure
The portion of air pressure that exists by virtue of the rate of motion of the air.

3.24 Erosion-resistant fan
A fan designed with features intended to reduce erosion by particles or liquids passing through the fan, thereby extending its useful life. Such features may include wear plates, deflector vanes and/or thick coatings of erosion-resistant material, which will reduce the fan's efficiency.

3.25 Fan
A rotary-bladed machine used to convert electrical or mechanical power to air power, with an energy output limited to 25 kJ/kg of air. It consists of an impeller, shaft and bearings and/or driver to support the impeller as well as a structure or housing. A fan may include a transmission, driver and/or motor controller.

3.25.1 Bare shaft fan
A fan offered in commerce without a drive.

3.25.2 Driven fan
A fan equipped with a driver and, if included, transmission and motor controller.

3.25.3 Standalone fan
A fan in at least a minimum testable configuration. This includes any driver, transmission or motor controller if included in the rated fan. It also includes any appurtenances included in the rated fan, and it excludes the impact of any surrounding equipment whose purpose exceeds or is different than that of the fan.

3.25.4 Embedded Fan
A fan that is part of a manufactured assembly where the assembly includes functions other than air movement.

3.26 Fan air density
The density of the air corresponding to the total pressure and the stagnation (total) temperature of the air at the fan inlet.

3.27 Fan airflow rate
The volumetric airflow rate at fan air density.

3.28 Fan array
Multiple fans in parallel and in a single enclosure between two plenum sections in an air- distribution system, where a plenum means is a compartment or chamber that forms a part of the air- distribution system, and that is not used for occupancy or storage

3.29 Fan dynamic (velocity) pressure
A pressure calculated from the average air velocity and fan air density at the fan outlet.

3.30 Fan electrical power (FEP)
The electrical power required to operate a fan, including any motor controllers, at a given duty point.

- FEP_{ref} is the reference FEP used to calculate the FEI at a given fan duty point.

- FEP_{act} is the actual FEP at the same given fan duty point as FEP_{ref}.

3.31 Fan energy index (FEI)
A ratio of the electrical input power of a reference fan to the electrical input power as described in Section 4.

3.32 Fan flow angle
The angle of the centerline of the air-conducting surface of a fan blade measured at the midpoint of its trailing edge with the centerline of the rotation axis in a plane through the rotation axis and the midpoint of the trailing edge.

3.33 Fan inlet and outlet boundaries
The interfaces between a fan and the remainder of the air system; the respective planes perpendicular to an airstream entering or leaving a fan.

3.34 Fan input boundary
The point at which power input to the fan is measured. If fan shaft power is reported, it is the interface between a fan and its drive. If fan electrical power is reported, it is the interface between drive and the mains.

3.35 Fan shaft power
The mechanical input power to the shaft that is connected directly to the impeller.

3.36 Fan output power
The power delivered to air by the fan; it is proportional to the product of the fan airflow rate, the fan total pressure and the compressibility coefficient.

3.37 Fan performance ratings
Quantities used to describe aerodynamic performance of a fan at one or more duty points. Fan performance ratings can include any of the following:

- Airflow
- Fan static pressure
- Fan total pressure
- Fan velocity pressure
- Fan air density
- Fan thrust
- Fan shaft power
- Fan static efficiency
- Fan total efficiency

- Fan electrical power, actual (FEP_{act})
- Driven fan static efficiency
- Driven fan total efficiency
- FEI

3.38 Fan speed
The rotational speed of the impeller. If the fan has more than one impeller, fan rotational speed is the rotational speed of each impeller.

3.39 Fan series
A group of fan models that are geometrically similar per the requirements of Annex K.

3.40 Fan static efficiency
The fan total efficiency multiplied by the ratio of fan static pressure to fan total pressure.

3.41 Fan static pressure
The difference between the fan total pressure and the fan dynamic (velocity) pressure. Therefore, it is the difference between static pressure at the fan outlet and total pressure at the fan inlet.

3.42 Fan total efficiency
The ratio of fan output power to fan shaft power.

3.43 Fan total pressure
The difference between the total pressure at the fan outlet and the total pressure at the fan inlet.

3.44 Flexible coupling
A form of transmission utilizing a coupling to transmit torque from one shaft to another in a coaxial configuration where the two shafts are at the same speed. A flexible coupling allows for minor shaft misalignment.

3.45 Housing
Any fan component(s) that direct airflow into or away from the impeller and/or provide protection for the internal components. A housing may serve as a fan's structure.

3.46 Impeller
A fan's rotary bladed aerodynamic component that transfers mechanical energy to the airstream.

3.47 Induced-flow fan
A type of laboratory exhaust fan with a nozzle and windband; the fan's outlet airflow is greater than the inlet airflow due to induced airflow. All airflow entering the inlet exits through the nozzle. Airflow exiting the windband includes the nozzle airflow as well as the induced airflow.

3.48 Inlet area
The area in contact with the fan's inlet.

3.49 Inlet bell
A gradual transition of a duct, ring or cone located at a fan's inlet, which decreases in cross-sectional area with the airflow direction.

3.50 Inline mixed-flow fan
A fan with a mixed-flow impeller in which airflow enters axially at the fan inlet, and the housing redirects radial airflow from the impeller to exit the fan in an axial direction.

3.51 Jet fan
A fan designed and marketed specifically to produce a high-velocity air jet in a space to increase its air momentum. Jet fans are rated using thrust. Inlets and outlets are not ducted but may include acoustic silencers.

3.52 Laboratory exhaust fan
A fan designed and marketed specifically for exhausting contaminated air vertically away from a building using a high-velocity discharge.

3.53 Minimum testable configuration
A fan having at least an impeller; shaft and bearings and/or driver to support the impeller; and its structure or its housing.

3.54 Mixed-flow fan
A fan with a fan flow angle greater than 20 degrees and less than 70 degrees.

3.55 Mixed-flow impeller
An impeller featuring construction characteristics between those of an axial and centrifugal impeller. A mixed-flow impeller has a fan flow angle greater than 20 degrees and less than 70 degrees. Airflow enters axially through a single inlet and exits with combined axial and radial directions at a mean diameter greater than the inlet.

3.56 Motor controller
Any device connected between the motor and the electric supply that can be used to control the motor's speed.

3.57 Outlet area
The area in contact with the fan's outlet.

3.58 Power roof/wall ventilator (PRV)
A fan with an internal driver and a housing to prevent precipitation from entering a building. It has a base designed to fit over a roof or wall opening, usually by means of a roof curb.

3.59 Radial-housed fan
A fan with a radial impeller in which airflow exits into a housing that is generally scroll-shaped to direct air through a single fan outlet. Inlets and outlets can be ducted optionally.

3.60 Radial impeller
A form of centrifugal impeller with several blades extending radially from a central hub. Airflow enters axially through a single inlet and exits radially at the impeller periphery into a housing with impeller blades; the blades are positioned so their outward direction is perpendicular within 25 degrees to the axis of rotation. Impellers can have a back plate and/or shroud.

3.61 Polyphase regulated motor
A three-phase motor regulated under 10 CFR 431.25.

3.62 Series calculated fan
The fan models for which performance data was calculated based on a series tested fan from the same fan series using fan laws per the requirements of Annex E.

3.63 Series tested fan
The fan model tested in a laboratory to provide performance data for a fan series.

3.64 Stagnation (total) temperature
The temperature that exists by virtue of the internal and kinetic energy of the air. If the air is at rest, the stagnation (total) temperature will equal the static temperature.

3.65 Standard air
Air with a standard density of 1.2 kg/m^3 (0.075 lbm/ft^3).

3.66 Static pressure
The portion of air pressure that exists by virtue of the state of the air. If expressed as a gauge pressure, it may be positive or negative.

3.67 Static temperature
The temperature that exists by virtue of the internal energy of the air. If a portion of the internal energy is converted into kinetic energy, the static temperature is decreased accordingly.

3.68 Structure
Any fan component(s) necessary to support the shaft, bearings and/or driver.

3.69 Synchronous belt drive
A form of transmission utilizing drive belts that have a substantially rectangular cross section containing teeth that engage with corresponding teeth on the sheaves (pulleys), resulting in no-slip power transmission. The belts are sometimes called timing or toothed belts.

3.70 Total pressure
The air pressure that exists by virtue of the state of the air and the rate of motion of the air. It is the algebraic sum of velocity pressure and static pressure at a point. If air is at rest, its total pressure will equal the static pressure.

3.71 Transmission
Any component that transfers energy from a driver to an impeller.

3.72 V-belt drive
A form of transmission utilizing drive belts that have a substantially trapezoidal cross section and sheaves (pulleys) with smooth contact surfaces.

3.73 Windband
A generally cylindrical fan component that surrounds and mounts above the outlet of an upblast fan, protecting the fan outlet from crosswinds. In the case of an induced-flow fan, the windband also allows for the induction of ambient air and mixing with exhaust air prior to leaving the windband.

4. Calculation of the FEI for a Single Duty Point

The FEI is defined as the ratio of the reference fan electrical power to the actual fan electrical power, where each of these are calculated at the same duty point.

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

Where:
FEI_t is the FEI value calculated using total pressure as a pressure basis per Table 7.1
FEI_s is the FEI value calculated using static pressure as a pressure basis, per Table 7.1
FEP_{ref} is the reference fan electrical power, kW (see Section 5)
FEP_{act} is the actual fan electrical power, kW (see Section 6)

5. Reference Fan Electrical Power (*FEP_ref*)

The reference fan concept is used to normalize the FEI calculation to a consistent power level independent of fan type and fan drive components. The reference fan electrical power is a function of airflow, fan air density and fan air pressure.

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

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

Where:
FEP_{ref} is reference fan electrical power
$H_{i,ref}$ is reference fan shaft power determined in accordance with Section 5.1.
$\eta_{(trans,ref)}$ is reference transmission efficiency determined in accordance with Section 5.2.
$\eta_{(mtr,ref)}$ is reference motor efficiency determined in accordance with Section 5.3.

5.1 Reference fan shaft power ($H_{i,ref}$)

The reference fan shaft power, $H_{i,ref}$, is calculated on either a fan total pressure basis or a fan static pressure basis. See Section 7 for a complete description and a list of fan types as well as the FEI pressure basis.

5.1.1 Fan total pressure basis

For fans using a fan total pressure basis, the reference fan shaft power at a given duty point is calculated according to the following equation:

$$H_{i,ref} = \frac{(Q + Q_0)\left(P_t + P_0 \times \frac{\rho}{\rho_{std}}\right)}{1000 \times \eta_o} \quad \text{[SI]}$$

$$H_{i,ref} = \frac{(Q + Q_0)\left(P_t + P_0 \times \frac{\rho}{\rho_{std}}\right)}{6343.3 \times \eta_o} \quad \text{[I-P]}$$

Where:
$H_{i,ref}$ is reference fan shaft power in kW (SI) or hp (I-P)
Q is fan airflow rate in m^3/s (SI) or cfm (I-P)
P_t is fan total pressure at density ρ in Pa (SI) or in. wg (I-P)
ρ is fan air density at duty point in kg/m^3 (SI) or lbm/ft^3 (I-P)
ρ_{std} is standard air density, 1.2 kg/m^3 (0.075 lbm/ft^3)
Q_0 = 0.118 m^3/s (SI) or 250 cfm (I-P)
P_0 = 100 Pa (SI) or 0.40 in. wg (I-P)
η_0 = 66% (0.66)

5.1.2 Fan static pressure basis

For fans using a fan static pressure basis, the reference fan shaft power at a given duty point is calculated according to the following equation:

$$H_{i,ref} = \frac{(Q + Q_0)\left(P_s + P_0 \times \frac{\rho}{\rho_{std}}\right)}{1000 \times \eta_o} \quad \text{[SI]}$$

$$H_{i,ref} = \frac{(Q + Q_0)\left(P_s + P_0 \times \frac{\rho}{\rho_{std}}\right)}{6343.3 \times \eta_o} \quad \text{[I-P]}$$

Where:
$H_{i,ref}$ is reference fan shaft power in kW (SI) or hp (I-P)
Q is fan airflow rate in m^3/s (SI) or cfm (I-P)
P_s is fan static pressure at fan air density ρ in Pa (SI) or in. wg (I-P)
ρ is fan air density at duty point in kg/m^3 (SI) or lbm/ft^3 (I-P)
ρ_{std} is standard air density, 1.2 kg/m^3 (0.075 lbm/ft^3) (I-P)
Q_0 = 0.118 m^3/s (SI) or 250 cfm (I-P)

P_0 = 100 Pa (SI) or 0.40 in. wg (I-P)
η_0 = 60% (0.60)

5.2 Reference fan transmission efficiency
The reference fan transmission efficiency is calculated using the following equations:

$$\eta_{\mathrm{trans,ref}} = 0.96\left(\frac{H_{i,ref}}{H_{i,ref} + 1.64}\right)^{.05} \qquad \text{[SI]}$$

$$\eta_{\mathrm{trans,ref}} = 0.96\left(\frac{\mathrm{H_{i,ref}}}{\mathrm{H_{i,ref}} + 2.2}\right)^{.05} \qquad \text{[I-P]}$$

Where:
$H_{i,\mathrm{ref}}$ is reference fan shaft power in kW (SI) or hp (I-P)
$H_{trans,ref}$ is reference fan transmission efficiency (dimensionless)

5.3 Reference fan motor efficiency
Reference fan motor output power:

$$H_{t,ref} = \frac{H_{i,ref}}{\eta_{\mathrm{trans,ref}}}$$

Where:
$H_{i,ref}$ is reference fan shaft power in kW (SI) or hp (I-P)
$H_{trans,ref}$ is reference fan transmission efficiency (dimensionless)
$H_{t,ref}$ is reference fan motor output power in kW (SI) or hp (I-P)

The reference fan motor efficiency is calculated according to the following equation using the coefficients *A*–*E* in Table 5.1:

$$\eta_{mtr,ref} = \mathrm{A}\cdot\left[\log_{10}\left(H_{t,ref}\right)\right]^4 + \mathrm{B}\cdot\left[\log_{10}\left(H_{t,ref}\right)\right]^3 + \mathrm{C}\cdot\left[\log_{10}\left(H_{t,ref}\right)\right]^2 + \mathrm{D}\cdot\left[\log_{10} H_{t,ref}\right] + \mathrm{E} \qquad \text{[SI]}$$

$$\eta_{mtr,ref} = \mathrm{A}\cdot\left[\log_{10}\left(H_{t,ref}\times 0.7457\right)\right]^4 + \mathrm{B}\cdot\left[\log_{10}\left(H_{t,ref}\times 0.7457\right)\right]^3 + \mathrm{C}\cdot\left[\log_{10}\left(H_{t,ref}\times 0.7457\right)\right]^2 + \mathrm{D}\cdot\left[\log_{10} H_{t,ref}\times 0.7457\right] + \mathrm{E} \qquad \text{[I-P]}$$

Where:
$H_{t,ref}$ is reference fan motor output power in kW (SI) or hp (I-P)
$\eta_{mtr,ref}$ is reference fan motor efficiency (dimensionless)

Table 5.1 — Constants Used to Calculate Reference Fan Motor Efficiency

	$H_{t,ref}$<185 kW (<250 BHP)	$H_{t,ref}$≥185 kW (≥250 BHP)
A	-0.003812	0
B	0.025834	0
C	-0.072577	0
D	0.125559	0
E	0.850274	0.962

6. Determination of Actual Fan Electrical Input Power (FEP_{act})

FEP_{act} is determined using one of the following methods listed in Table 6.1.

Table 6.1 — Selection of Sections to be Used for Calculating FEP_{act}

Driver	Motor Controller	Transmission	Fan Shaft Power Known?	Must be Tested at Duty Point	Section
Electric motor	Yes or No	Any	No	Yes	6.1
Electric motor	Yes or No	Any	No	No	6.2
Regulated polyphase motor	Variable Frequency Drive (VFD) or None	Direct drive, V-belt drive, flexible coupling or synchronous belt drive	Yes	No	6.4
Electric motor	Yes or No	Direct drive, V-belt drive, flexible coupling or synchronous belt drive	Yes	No	6.5
None Supplied	None Supplied	None Supplied	Yes	No	6.3
Non-electric	N/A	N/A	Yes	No	6.3

6.1 Wire-to-air testing at the required duty point
The FEP_{act} of the driven fan is determined at the duty point using one of the methods described in Section 7.

6.2 Calculated ratings based on wire-to-air testing
The FEP_{act} of the driven fan is calculated at the duty point as described in Section 8.2.3 and Annex G.

6.3 Bare Shaft Fans
This section covers the determination of the actual fan electrical power of a fan (FEP_{act}) at each fan duty point i based on fan shaft power ($H_{i,act}$) measurement combined with default motor and transmission efficiency values. It applies only to bare shaft fans and fans sold with a driver other than an electric motor.

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

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

Where:

FEP_{act}	is actual fan electrical power (kW or hp)
$H_{i,act}$	is actual fan shaft power, (kW or hp), determined per Section 7 or Section 8
$\eta_{trans,def}$	is default transmission efficiency, calculated per the requirements of Section 6.3.1
$\eta_{mtr,def}$	is default motor efficiency, calculated per the requirements of Section 6.3.3

6.3.1 Calculation of FEP_{act} for bare shaft fans where the motor, transmission and motor controller are unknown
For bare shaft fans that can only have a direct-drive transmission:

$$\eta_{trans,def} = 1$$

For all other bare shaft fans and fans with drivers other than motors:

$$\eta_{trans,def} = 0.96\left(\frac{H_{i,act}}{H_{i,act}+1.64}\right)^{.05} \quad \text{[SI]}$$

$$\eta_{trans,def} = 0.96\left(\frac{H_{i,act}}{H_{i,act}+2.2}\right)^{.05} \quad \text{[I-P]}$$

Where:
$\eta_{trans,def}$ is default transmission efficiency,
$H_{i,act}$ is actual fan shaft power (kW or hp)

Fan shaft power is determined at the duty point using one of the methods described in Section 7 or rated at the duty point using one of the methods described in Section 8.2.1.

6.3.2 Default motor output power

The default power output of the motor.

$$H_{m,def} = \frac{H_{i,act}}{\eta_{trans,def}}$$

Where:
$H_{m,def}$ is default motor output power at the duty point (kW or hp)
$H_{i,act}$ is actual fan shaft power (kW or hp)
$\eta_{trans,def}$ is default transmission efficiency calculated from Section 6.3.1

6.3.3 Default motor efficiency

The default motor efficiency is calculated using the following equation. Constants A, B, C, D and E are found in Table 6.2:

$$\eta_{mtr,def} = \mathrm{A}\cdot\left[\log_{10}\left(H_{m,def}\right)\right]^4 + \mathrm{B}\cdot\left[\log_{10}\left(H_{m,def}\right)\right]^3 + \mathrm{C}\cdot\left[\log_{10}\left(H_{m,def}\right)\right]^2 + \mathrm{D}\cdot\left[\log_{10}\left(H_{m,def}\right)\right] + \mathrm{E} \quad \text{[SI]}$$

$$\eta_{mtr,def} = \mathrm{A}\cdot\left[\log_{10}\left(H_{m,def}\cdot 0.7457\right)\right]^4 + \mathrm{B}\cdot\left[\log_{10}\left(H_{m,def}\cdot 0.7457\right)\right]^3 + \mathrm{C}\cdot\left[\log_{10}\left(H_{m,def}\cdot 0.7457\right)\right]^2 + \mathrm{D}\cdot\left[\log_{10}\left(H_{m,def}\cdot 0.7457\right)\right] + \mathrm{E} \quad \text{[I-P]}$$

Where:
$\eta_{mtr,def}$ is default motor efficiency
$H_{m,def}$ is default motor output power calculated at the duty point per Section 6.3.2

Table 6.2 — Default Motor Efficiency Coefficients

	60 Hz, IE3	
Applicability Examples	**U.S., Canada, Mexico**	
	$H_{m,def}$ <185 kW ($H_{m,def}$ <250 BHP)	$H_{m,def}$ ≥185 kW ($H_{m,def}$ ≥250 BHP)
A	-0.003812	0
B	0.025834	0
C	-0.072577	0
D	0.125559	0
E	0.850274	0.962

6.4 Fans with Polyphase Regulated Motors
The calculation of FEP_{act} is permitted for driven fans meeting the requirements shown in Section 6.4.1.

6.4.1 Requirements for driven fan components
The calculation method can be used only if all requirements in this subsection are met for the fan, transmission, motor and VFD (if included)

6.4.1.1 Requirements for the fan
The fan shaft power is determined at the duty point using one of the methods described in Section 7 or rated at the duty point using one of the methods described in Section 8.2.1.

6.4.1.2 Requirements for the transmission
The transmission must be V-belt drive, synchronous belt drive, flexible coupling or direct drive.

6.4.1.3 Requirements for the motor
The motor must be a polyphase regulated motor.

6.4.1.4 Requirements for the VFD, if included
The VFD must meet the following requirements:

- Be pulse-width modulated
- Output voltage cannot exceed the voltage listed on the motor nameplate
- Output frequency cannot exceed 120 Hz at the duty point
- Be programmed for variable torque using a constant V/Hz ratio for operating points under 60 Hz or another method that yields the same or higher efficiency

6.4.2 Calculation of FEP_{act}
FEP_{act} is calculated using the equations in this section and the tables in Annexes A through D. The values of fan shaft power $H_{i,act}$, measured in accordance with Section 6.4.1.1, must be used to calculate FEP_{act} as follows:

For driven fans where no VFD is included, the equation is:

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

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

Where:
FEP_{act} is actual fan electrical power (kW)
$H_{i,act}$ is actual fan shaft power, determined per Section 6.4.1.1 (kW or hp)
$\eta_{trans,\ act}$ is actual transmission efficiency, calculated per the requirements of Section 6.4.2.1
$\eta_{mtr,act}$ is actual motor efficiency, calculated per the requirements of Section 6.4.2.4

For driven fans where a VFD is included, the equation is:

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

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

Where:
FEP_{act} is actual fan electrical power (kW)
$H_{i,act}$ is actual fan shaft power, determined per Section 6.4.1.1 (kW or hp)
$\eta_{trans,act}$ is actual transmission efficiency, calculated per the requirements of Section 6.4.2.1
$\eta_{mtr-ctl,act}$ is actual combined motor/VFD efficiency, calculated per the requirements of Section 6.4.2.4

6.4.2.1 Calculation of transmission efficiency ($\eta_{trans,act}$)
Transmission efficiency must be calculated using the appropriate equation for the type of transmission included with the fan.

6.4.2.1.1 V-belt drive

$$\eta_{trans,act} = 0.96\left(\frac{H_{i,act}}{H_{i,act}+1.64}\right)^{.05} \quad \text{[SI]}$$

$$\eta_{trans,act} = 0.96\left(\frac{H_{i,act}}{H_{i,act}+2.2}\right)^{.05} \quad \text{[I-P]}$$

Where:
$\eta_{trans,act}$ is actual transmission efficiency
$H_{i,act}$ is actual fan shaft power (kW or hp)

6.4.2.1.2 Synchronous belt drive
SI:
$H_{i,act} \leq 1.00$ kW, $\eta_{trans,act} = 0.94$
1.00 kW < $H_{i,act} \leq 5.00$ kW, $\eta_{trans,act} = 0.01 \cdot H_{i,act} + 0.93$
$H_{i,act} > 5.00$ kW, $\eta_{trans,act} = 0.98$

I-P:
$H_{i,act} \leq 1.34$ hp, $\eta_{trans,act} = 0.94$
1.34 hp < $H_{i,act} \leq 6.70$ hp, $\eta_{trans,act} = 0.007456 \cdot H_{i,act} + 0.93$
$H_{i,act} > 6.70$ hp, $\eta_{trans,act} = 0.98$

Where:
$\eta_{trans,act}$ is actual transmission efficiency
$H_{i,act}$ is actual fan shaft power (kW or hp)

6.4.2.1.3 Flexible coupling
$\eta_{trans,act} = 0.98$

6.4.2.1.4 Direct drive
$\eta_{trans,act} = 1$

6.4.2.2 Calculation of actual motor output power
The actual motor output power at the duty point is calculated using this equation:

$$H_{m,act} = \frac{H_{i,act}}{\eta_{trans,act}}$$

Where:
$H_{m,act}$ is actual motor output power, at the duty point (kW or hp)
$H_{i,act}$ is actual fan shaft power, (kW or hp)
$\eta_{trans,act}$ is actual transmission efficiency, calculated from Section 6.4.2.1

6.4.2.3 Motor efficiency if no VFD is included
The calculation method for motor efficiency if the driven fan does not include a VFD.

$$\eta_{mtr,act} = \eta_r\left(\frac{aL_m}{b+L_m} + cL_m^2\right)$$

Where:
$\eta_{mtr,act}$ is actual motor efficiency
η_r is polyphase regulated motor nominal full-load efficiency per Section 6.4.2.3.1
a, b, c are constant values per Section 6.4.2.3.2
L_m is motor load ratio calculated per Section 6.4.2.3.3

6.4.2.3.1 Nominal full-load efficiency table lookup
For polyphase regulated motors, the minimum- required nominal full-load efficiency is found in Annex A.

If the motor nameplate output power value is not shown in the table, follow these instructions:

1. (1) A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers.
2.
3. (2) A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers.
4.
5. (3) A shaft power rating in kilowatt shall be directly converted from kilowatts to horsepower using the formula 1 kilowatt = (1/0.746) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with paragraph (1) or (2) of this section, whichever applies.

6.4.2.3.2 Motor constants without VFD
The values for *a* and *b* are found in Annex D. Constant *c* is calculated with this equation:

$$c = 1 - \frac{a}{b+1}$$

6.4.2.3.3 Motor load ratio
This is the ratio of the load on the motor to the motor nameplate output power calculated with the following equation:

$$L_m = \frac{H_{m,act}}{H_{mo}} \quad [0 < L_m < 1.5]$$

Where:
L_m is motor load ratio
$H_{m,act}$ is motor output power (kW or hp) in accordance with Section 6.4.2.2
H_{mo} is motor nameplate output power (kW or hp) in accordance with Section 6.4.2.3.1

6.4.2.4 Combined motor-VFD efficiency
This is the calculation method for the efficiency of a motor-VFD combination if the driven fan includes a VFD. The general equation is:

$$\eta_{mtr-ctl,act} = \eta_{mtr'act} \times \eta_{VFD}$$

Where:
$\eta_{mtr-ctl,act}$ is combined Motor-VFD efficiency, actual
$\eta_{mtr'act}$ is motor efficiency if used in combination with a VFD
η_{VFD} is VFD efficiency at the required motor electrical power input

6.4.2.4.1 Motor efficiency if used in combination with a VFD
How to calculate the efficiency of the motor if it is combined with a VFD.

$$\eta_{mtr',act} = \eta_r \left(\frac{gL_m}{h + L_m} + iL_m^2 \right)$$

Where:
$\eta_{mtr',act}$ is actual motor efficiency if used in combination with a VFD
η_r is nominal full load efficiency per Section 6.4.2.4.1.1
g, h, i are constant values per Section 6.4.2.4.1.2
L_m is motor load ratio calculated per Section 6.4.2.4.1.3

6.4.2.4.1.1 Nominal full-load efficiency table lookup
For polyphase regulated motors, nominal full-load efficiency is obtained from Annex A. It is based on the motor enclosure (open or enclosed), the number of poles and the motor nameplate output power (H_{mo}).

If the motor nameplate output power value is not shown in the table, the following instructions shall be used:

(1) A horsepower at or above the midpoint between the two consecutive horsepowers shall be rounded up to the higher of the two horsepowers.

(2) A horsepower below the midpoint between the two consecutive horsepowers shall be rounded down to the lower of the two horsepowers.

(3) A shaft power rating in kilowatt shall be directly converted from kilowatts to horsepower using the formula 1 kilowatt = (1/0.746) horsepower. The conversion should be calculated to three significant decimal places, and the resulting horsepower shall be rounded in accordance with paragraph (1) or (2) of this section, whichever applies.

6.4.2.4.1.2 Motor constants if combined with VFD
The values for g and h are found in Annex B. Table B.1 shall be used for motors rated in horsepower. Table B.2 shall be used for motors rated in kilowatts.

$$i = 1 - \frac{g}{h+1}$$

Where:
g, h, i are constants used in Section 6.4.2.4.1

6.4.2.4.1.3 Motor load ratio
The ratio of the load on the motor to the motor nameplate output power is calculated using the following equation:

$$L_m = \frac{H_{m,act}}{H_{mo}}$$

Where:
L_m is motor load ratio
$H_{m,act}$ is motor output power (kW or hp)
H_{mo} is motor nameplate output power (kW or hp)

6.4.2.4.2 VFD efficiency at the required motor electrical power input
The method for calculating VFD efficiency for a given power output. A single VFD may operate one or many motors.

$$\eta_{VFD} = \frac{\mathrm{d}L_c}{\mathrm{e} + L_c} + \mathrm{f}L_c$$

Where:
η_{VFD} is VFD efficiency at the required motor electrical power input
d, e, f are constants determined per Section 6.4.2.4.2.1
L_c is VFD load ratio determined per Section 6.4.2.4.2.2

6.4.2.4.2.1 VFD constants
Look up the values for constants d, e and f using Table C.1 for horsepower or Table C.2 for kilowatts based on the rated output power of the VFD (H_{co}). If that value is not shown in the table, use the next highest value.

6.4.2.4.2.2 VFD load ratio
The equation in this section only applies in the case of a unique or several identical motor(s) connected to the same VFD. If $H_{m,act}$ is equal across each motor, the VFD load ratio shall be calculated using the following equation:

$$L_c = \frac{N \cdot H_{m,act}}{\eta_{mtr',act} \cdot H_{co}}$$

Where:

L_c	is VFD load ratio
N	is quantity of motors controlled by the VFD
$H_{m,act}$	is motor output power (kW or hp), calculated per Section 6.4.2.2
$\eta_{mtr',act}$	is motor efficiency if used in combination with a VFD calculated per Section 6.4.2.4.1
H_{co}	is rated power output of the VFD (kW or hp)

6.5 Fans with Power Drive Systems
This section describes the calculation of FEP_{act} for a fan with a motor and without motor controller or with a combined motor and motor controller with known efficiency at the duty point.

6.5.1 Requirements for driven fan components
The calculation method can only be used if all the requirements for the fan, transmission, motor and motor controller, if included, in Section 6.5.1 are met.

6.5.1.1 Requirements for the fan
The fan shaft power is determined at the duty point using one of the methods described in Section 7 or rated at the duty point using one of the methods described in Section 8.2.1.

6.5.1.2 Requirements for the transmission
The transmission must be V-belt drive, synchronous belt drive, flexible coupling or direct drive.

6.5.1.3 Requirements for the motor without motor controller or combined motor and motor controller
The efficiency of the motor without motor controller or combined motor and controller at the duty point has been determined per the requirements in Annex F.

6.5.2 Calculation of FEP_{act}

6.5.2.1 Motor output power
The actual motor output power at the duty point is calculated using this equation:

$$H_{m,act} = \frac{H_{i,act}}{\eta_{trans,act}}$$

Where:

$H_{m,act}$	is actual motor output power, at the duty point (kW or hp)
$H_{i,act}$	is actual fan shaft power, determined per Section 7-Testing or 8-Rating Development, subsection 8.2.1 (kW or hp)
$\eta_{trans,act}$	is actual transmission efficiency, calculated using the equation in Section 6.4.2.1

6.5.2.2 Motor without motor controller

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

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

Where:

FEP_{act}	is actual fan electrical power (kW)
$H_{i,act}$	is actual fan shaft power, determined per Section 7-Testing or 8-Rating Development subsection 8.2.1 (kW or hp)
$\eta_{trans,act}$	is actual transmission efficiency, calculated using the equation in subsection 6.4.2.1
η_{motor}	is motor-only efficiency calculated per Annex F, based on the motor output power equation in Section 6.5.2.1

6.5.2.3 Combined motor and motor controller

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

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

Where:

FEP_{act}	is actual fan electrical power (kW or hp)
$H_{i,act}$	is actual fan shaft power, determined per Section 7 or Section 8.2.1 (kW or hp)
$\eta_{trans,act}$	is actual transmission efficiency, calculated per the requirements of Section 6.4.2.1
$\eta_{motor+control}$	is the combined motor and motor controller efficiency calculated per Annex F, based on the motor output power from Section 6.5.2.1

7. Testing

All base tests will be accomplished via one of the approved laboratory methods of test for the applicable fan type. The approved laboratory methods of test procedures are listed below. The methods of test and installation categories are listed in Table 7.1.

- ANSI/AMCA Standard 210
- ANSI/AMCA Standard 230
- ANSI/AMCA Standard 250
- ANSI/AMCA Standard 260
- ISO 5801

Table 7.1 — Fan Types, Test Configurations and FEI Pressure Basis

		Required		Optional[3]	
Fan Type	**Test Standard**[1]	**Test Configuration** (See Figure 7.1)	**FEI Pressure Basis**	**Test Configuration** (See Figure 7.1)	**FEI Pressure Basis**
Centrifugal housed[2]	AMCA 210	B or D	Total	A or C	Static
Radial housed	AMCA 210	B or D	Total	A or C	Static
Centrifugal inline	AMCA 210	B or D	Total	A or C	Static
Centrifugal unhoused	AMCA 210	A	Static	N/A	N/A
Centrifugal PRV exhaust	AMCA 210	A or C	Static	N/A	N/A
Centrifugal PRV supply	AMCA 210	B	Total	A	Static
Axial inline	AMCA 210	D	Total	C	Static
Axial panel	AMCA 210	A	Static	N/A	N/A
Axial PRV	AMCA 210	A or C	Static	N/A	N/A
Laboratory exhaust, excluding induced flow	AMCA 210	A or C	Total	N/A	N/A
Laboratory exhaust induced flow	AMCA 260	A or C	Total	N/A	N/A
Jet fan	AMCA 250	E	Total	N/A	N/A
Circulating	AMCA 230	E	Total	N/A	N/A

Notes:

1. ANSI/AMCA Standard 210 can be substituted with ISO 5801 and ANSI/AMCA Standard 250 can be substituted with ISO 13350, if ISO is used instead of AMCA standards.
2. In this table, the centrifugal housed fan type does not include centrifugal inline fans.
3. All fans shall be tested using the configuration in the “required” column. As some markets may also require an FEI value tested to an alternate configuration, tests using the configuration in the “Optional” column may be performed at the manufacturer’s discretion. FEI for that configuration may be published in addition to the FEI derived from the required tests.

7.1 Test configurations

The test configuration distinguishes the arrangement of ducting to the inlet and outlet of the fan during the test. (See Figure 7.1.) These configurations are consistent with the test requirements of ANSI/AMCA Standard 210, ANSI/AMCA Standard 230, ANSI/AMCA Standard 250, ANSI/AMCA Standard 260, ISO 5801 and ISO 13350, although not all configurations are found in each standard.

Additional test configuration requirements are found in Table 7.2.

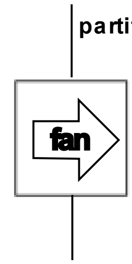
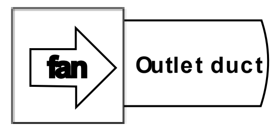
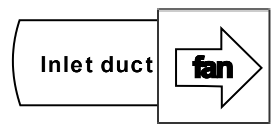
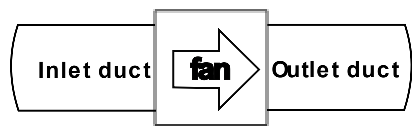
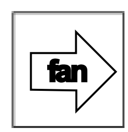
Test Configuration	Duct Configuration	
A	Free inlet, free outlet with partition	
B	Free inlet, ducted outlet	
C	Ducted inlet, free outlet	
D	Ducted inlet, ducted outlet	
E	Free inlet, free outlet without partition	

Figure 7.1 – Test configurations

Table 7.2 — Test Configuration Requirements

Test Standard	Test Configuration	Inlet Duct[1]	Outlet Duct[2]
AMCA 210 AMCA 260	A	No[3]	No
AMCA 210	B	No[3]	Yes
AMCA 210 AMCA 260	C	Yes	No
AMCA 210	D	Yes	Yes
AMCA 230 AMCA 250	E	No	No

Notes:

1. An inlet bell or an inlet bell and one equivalent duct diameter conforming to ANSI/AMCA Standard 210, Section 5.2.3.2, or ISO 5801, Section 8.3, shall be used to simulate an inlet duct.
2. An outlet duct or a short outlet duct between two and three equivalent diameters long conforming to ANSI/AMCA Standard 210, Section 5.2.3.1, or ISO 5801, Section 8.5, shall be used.
3. A test using test configuration A with an inlet bell is equivalent to test configuration C and a test using test configuration B with an inlet bell is equivalent to test configuration D.

Required test configurations and pressure basis for the various fan types are found in Table 7.1.

7.2 Setup selection

For fans tested using ANSI/AMCA Standard 210 or ISO 5801, Table 7.3 shall be used as a guide to the selection of an appropriate setup. In addition, axial inline fans with no turning vanes (e.g., tube axial fans) must be tested using Figure 13, 15 or 16.

Table 7.3 — Test Setup Selection

	Test Configuration			
Setup Figure	A	B	C	D
7A, 7B, 8A, 8B, 9A, 9B, 9C, 10A, 10B, 10C		NS		NS[1]
11, 12, 13, 14, 15	Y[2]	Y[3]	Y[1,4]	Y[1,3]
16			Y	Y[3]

NS = Not suitable for fans with significant swirl
Y = Suitable for all fan types

Notes:
1. A simulated inlet duct may be used.
2. An auxiliary inlet bell or outlet duct may not be used.
3. An outlet duct or a short outlet duct between two and three equivalent diameters long conforming to ANSI/AMCA Standard 210, Section 5.2.3.1 or ISO 5801, Section 8.5 shall be used.
4. No outlet duct may be used.

Boundaries used for testing are defined in Table 7.4, shown in Figure 7.2 and further specified in Section 7.13.

Table 7.4 — Fan Input Boundary

Case	Motor Control	Motor	Transmission	Fan	Fan Input Boundary	Boundary Output	Quantity Measured
1	X	X	X	X	Mains	Motor controller	W_{cmti}
2		X	X	X	Mains	Motor	W_{mti}
3		X		X	Mains	Motor	W_{mi}
4	X	X		X	Mains	Motor controller	W_{cmi}
5			X	X	Dynamometer or calibrated motor	Transmission	H_{ti}
6				X	Dynamometer or calibrated motor	Fan shaft	H_i

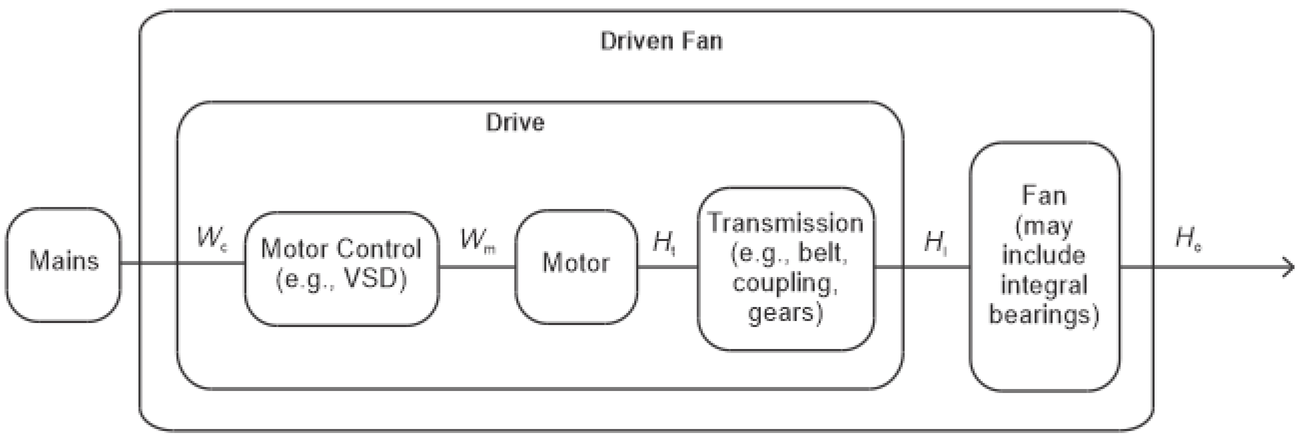


Figure 7.2 – Input Power boundary

7.3 Appurtenances

7.3.1 Appurtenances that improve performance

Appurtenances that improve the performance of the fan, including but not limited to inlet bells, diffusers, stators, or guide vanes shall not be mounted unless the appurtenance is always supplied with the fan when distributed in commerce.

7.3.2 Appurtenances that reduce performance

Appurtenances that reduce the performance include, but are not limited to, safety guards, dampers, filters, or weather hoods. If the appurtenance is always supplied with the fan when distributed in commerce, then it shall be tested with the fan. If the appurtenance is not always supplied with the fan when distributed in commerce, it shall not be tested with the fan.

7.4 Run-in requirements

All fans shall be run-in for not less than fifteen minutes prior to the commencement of data collection.

7.5 Airstream restrictions

If a fan is designed with motors, sheaves, bearings and shafts in the airstream, they shall be in place during the test. Dummy or simulated components shall be used if the fan shaft power is measured using a dynamometer.

7.6 Roof curb installations

PRVs designed to be installed on roof curbs shall be tested on a simulated curb conforming to the minimum recommended curb height and the interior dimensions shown in the manufacturer's catalog. In the absence of recommendations, the curb height shall not exceed 150 mm (6 in.) and the interior dimensions shall be at least 100 mm (4 in.) less than the interior dimensions of the curb cap for units with impeller diameters up to and including 750 mm (30 in.) and at least 200 mm (8 in.) less than the curb cap for units with impeller diameters greater than 750 mm (30 in.).

7.7 Simulated roofs

All PRVs with hoods that direct air downward toward the roof shall be tested with a simulated roof that is flat and normal to the PRV axis. The simulated roof shall extend beyond the maximum overhang of the hood, a distance of one-half of the impeller diameter in all directions. However, one side of the hood may be blocked by the floor or a wall of the test setup.

7.8 Electrical power requirements

For fan electrical power measurement, the fan shall be operated at 60 Hz unless that frequency conflicts with nameplate values. The voltage during the test shall match the highest allowable value that corresponds with the relevant nameplate.

7.9 Stability

Any performance measurement at a bistable operating point - airflow rates at which two different pressures can be measured - shall be based on the measurements providing the lowest pressure.

7.10 Dual-use fans

For the purposes of calculating FEI, dual-use fans shall be tested in their long-term, non-emergency ventilation mode.

7.11 Erosion-resistant fans

Erosion-resistant fans shall be tested prior to being modified for erosion resistance.

7.12 Bare shaft fans sold with a transmission only

Bare shaft fans that are sold with a transmission only shall be tested and rated as a bare shaft fan without the transmission.

7.13 For fans tested using ANSI/AMCA Standard 210, ISO 5801, or ANSI/AMCA Standard 260

7.13.1 If using the methods described in Section 6.1. or 6.2:

For fans with a motor but without a motor controller tested using ANSI/AMCA Standard 210, ISO 5801 or AMCA 260:

- Testing must be performed based on fan input boundary Case 2 (for fans with a transmission) or Case 3 (for fans without a transmission) of Table 7.5 and in accordance with Sections 4, 5, 6 and 7 of ANSI/AMCA Standard 210, with additions as noted below and in Section 7.
- The measured electrical input power W_{mti} (for Case 2) or W_{mi} (for Case 3) is FEP_{act}.
- If needed, duty points between laboratory tested points (determinations), are obtained by fitting a cubic polynomial based on the four closest determinations.

For fans with a motor and motor controller tested using ANSI/AMCA Standard 210, ISO 5801, or AMCA 260:

- Testing must be performed based on the fan input boundary Case 1 (for fans with transmission) or Case 4 (for fans without transmission) of Table 7.4 and in accordance with Sections 4, 5, 6 and 7 of ANSI/AMCA Standard 210, with additions as noted below and in Section 7.
- For fans that are not tested at all fan speeds at which the fan may be operated when distributed in commerce, the interpolation method in Annex G shall be used.

- Testing can be performed with or without the use of the conversion formulae in Annex G.
    - If the conversion formulae in Annex G are not used, the fan must be tested at each of the speeds of rotation for which results are generated.
    - If the conversion formulae in Annex G are used, the fan must be tested at the speeds specified in Section 8.2.3.
- The measured electrical input power W_{cmti} (for Case 1) or W_{cmi} (for Case 4) is FEP_{act}.
- If needed, duty points between laboratory tested points (determinations), are obtained by fitting a cubic polynomial based on the four closest determinations.

7.13.2 If using the methods described in Section 6.3, 6.4 or 6.5:
The fan shaft power ($H_{i,act}$) must be measured based on the fan input boundary Case 6 of Table 7.4 and in accordance with ANSI/AMCA Standard 210 or ANSI/AMCA Standard 260 as well as the additions noted in this "Testing" section and below.

Testing can be performed with or without the use of the calculation methods in Annex E to determine fan performance ratings at different fan operating speeds.

- If the calculation methods in Annex E are applied, the fan must be tested at least at one speed for which results are generated.
- If the calculation methods in Annex E are not applied, the fan must be tested at each of the fan speeds at which results are generated.

The values of fan shaft power $H_{i,act}$, at each fan determination i, measured in accordance as described above, must be used to calculate fan input electrical power (FEP_{act}) per Section 6.3, 6.4 or 6.5. If needed, duty points between laboratory tested points (determinations), are obtained by fitting a cubic polynomial based on the four closest determinations.

8. Rating Development

The performance ratings of a fan or a series of similar fans are developed from tests conducted in accordance with the laboratory methods as required in Section 7 using the test configurations as required in Table 7.1. The manufacturer is responsible for determining the product sizes to be tested as well as the number of tests that meet the test procedure requirements and the number of tests that must be performed to provide the data necessary for the development of fan performance ratings.

8.1 Laboratory measurement only
Each unique fan model and size is tested individually at all speeds at which it is to be placed in the market. In this method, the laboratory test is performed according to Section 7. If needed, duty points between laboratory tested points are obtained by curve fitting a cubic polynomial based on the four closest determinations.

8.2 Calculation methods

8.2.1 Fan laws and other calculation methods for shaft-to-air testing
The calculation methods defined in Annex E may be used to determine fan performance ratings from laboratory tests of fans at other speeds and/or sizes or to interpolate between two tests. Annex K specifies similarity requirements for calculating other sizes. Note that the calculation methods in Annex E strictly apply to fan shaft power, not to fan electrical power, because drive component efficiencies change with load. Therefore, this section only applies to fans tested per Case 6 of Table 7.4.

8.2.2 Separate fan and motor tests
The ratings of fan electrical power based on tests or calculations of fan shaft power combined with separate wire-to-shaft tests of a motor or motor and motor controller shall use the methods described in Annex F.

8.2.3 Calculation to other speeds and densities for wire-to-air testing
The ratings of fan electrical power based on tests or calculations of electrical input power is described in Annex G.

8.3 Appurtenances

As illustrated in Figure 8.1, the reduced performance of a fan with appurtenances (the curve labeled *2*) can be published and matched against system pressures to make proper fan selections. The process of fan selection includes determining the fan speed and/or blade pitch needed to achieve the required system pressure (P_{req}) at the required airflow (Q_{req}) (point B in Figure 8.1). Once the required fan speed and/or blade pitch are determined, the FEI is determined from the fan performance of the fan without appurtenances (the curve labeled *1* in Figure 8.1) at the same airflow, fan speed and blade pitch (point A in Figure 8.1).

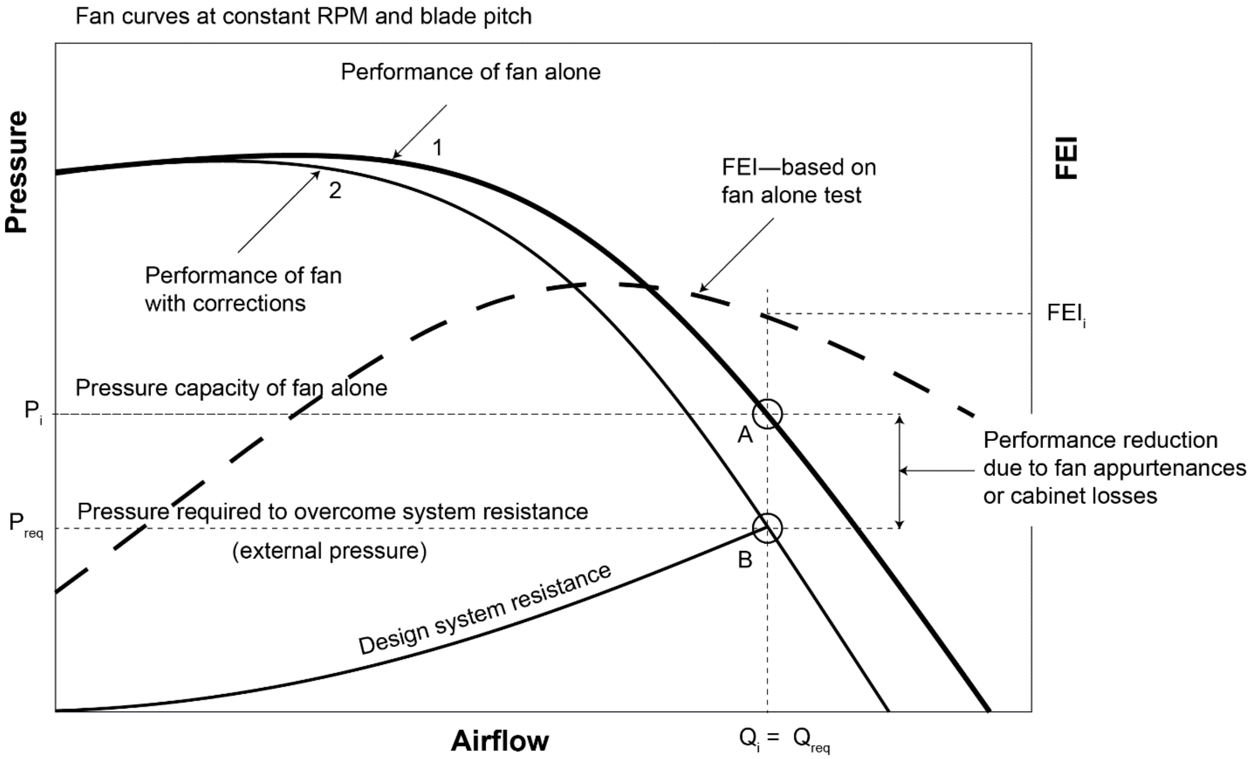


Figure 8.1 — Fan Curves at Constant Revolutions Per Minute and Blade Pitch

Annex A
Polyphase Regulated Motor Efficiencies (Normative)

Table A.1 — EPCA Nominal Full-Load Efficiency (60 Hz motors)

Motor Horsepower/ Standard Kilowatt Equivalent	Nominal Full-Load Efficiency (%)							
	2 Pole		4 Pole		6 Pole		8 Pole	
	Enclosed	Open	Enclosed	Open	Enclosed	Open	Enclosed	Open
1/0.75	77.0	77.0	85.5	85.5	82.5	82.5	75.5	75.5
1.5/1.1	84.0	84.0	86.5	86.5	87.5	86.5	78.5	77.0
2/1.5	85.5	85.5	86.5	86.5	88.5	87.5	84.0	86.5
3/2.2	86.5	85.5	89.5	89.5	89.5	88.5	85.5	87.5
5/3.7	88.5	86.5	89.5	89.5	89.5	89.5	86.5	88.5
7.5/5.5	89.5	88.5	91.7	91.0	91.0	90.2	86.5	89.5
10/7.5	90.2	89.5	91.7	91.7	91.0	91.7	89.5	90.2
15/11	91.0	90.2	92.4	93.0	91.7	91.7	89.5	90.2
20/15	91.0	91.0	93.0	93.0	91.7	92.4	90.2	91.0
25/18.5	91.7	91.7	93.6	93.6	93.0	93.0	90.2	91.0
30/22	91.7	91.7	93.6	94.1	93.0	93.6	91.7	91.7
40/30	92.4	92.4	94.1	94.1	94.1	94.1	91.7	91.7
50/37	93.0	93.0	94.5	94.5	94.1	94.1	92.4	92.4
60/45	93.6	93.6	95.0	95.0	94.5	94.5	92.4	93.0
75/55	93.6	93.6	95.4	95.0	94.5	94.5	93.6	94.1
100/75	94.1	93.6	95.4	95.4	95.0	95.0	93.6	94.1
125/90	95.0	94.1	95.4	95.4	95.0	95.0	94.1	94.1
150/110	95.0	94.1	95.8	95.8	95.8	95.4	94.1	94.1
200/150	95.4	95.0	96.2	95.8	95.8	95.4	94.5	94.1
250/186	95.8	95.0	96.2	95.8	95.8	95.8	95.0	95.0
300/224	95.8	95.4	96.2	95.8	95.8	95.8		
350/261	95.8	95.4	96.2	95.8	95.8	95.8		
400/298	95.8	95.8	96.2	95.8				
450/336	95.8	96.2	96.2	96.2				
500/373	95.8	96.2	96.2	96.2				

Annex B
Motor Constants if Used With VFD (Normative)

Table B.1 — Polyphase Induction Motor Performance Constants (Horsepower-Rated Motors With VFD)

Horsepower	2 Pole		4 Pole		6 and 8 Pole	
	g	*h*	*g*	*h*	*g*	*h*
1	1.02906	0.01701	1.03744	0.03337	1.09059	0.06457
1.5	1.02998	0.01610	1.03812	0.03120	1.08484	0.05903
2	1.03090	0.01520	1.03880	0.02902	1.07910	0.05349
3	1.03273	0.01338	1.04016	0.02467	1.06760	0.04240
5	1.03641	0.00975	1.04288	0.01596	1.04461	0.02024
7.5	1.03489	0.00892	1.04077	0.01446	1.04243	0.01798
10	1.03338	0.00808	1.03866	0.01296	1.04025	0.01572
15	1.03035	0.00641	1.03443	0.00996	1.03588	0.01121
20	1.02732	0.00474	1.03021	0.00696	1.03152	0.00670
25	1.02654	0.00476	1.02882	0.00642	1.02977	0.00622
30	1.02575	0.00478	1.02742	0.00588	1.02803	0.00575
40	1.02418	0.00481	1.02464	0.00479	1.02454	0.00480
50	1.02261	0.00485	1.02185	0.00370	1.02106	0.00384
60	1.02226	0.00449	1.02100	0.00350	1.02057	0.00399
75	1.02174	0.00395	1.01972	0.00320	1.01985	0.00420
100	1.02087	0.00306	1.01758	0.00269	1.01864	0.00455
125	1.01997	0.00299	1.01725	0.00286	1.01956	0.00459
150	1.01907	0.00293	1.01692	0.00303	1.02047	0.00462
200	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
250	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
300	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
350	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
400	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
450	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
500	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468

Table B.2 — Polyphase Induction Motor Performance Constants (Kilowatt-Rated Motors With VFD)

Kilowatts	2 Pole		4 Pole		6 and 8 Pole	
	g	*h*	*g*	*h*	*g*	*h*
1	1.02968	0.01639	1.03791	0.03189	1.08668	0.06080
1.1	1.02993	0.01615	1.03809	0.03131	1.08514	0.05931
1.5	1.03092	0.01518	1.03882	0.02897	1.07897	0.05337
2.2	1.03264	0.01347	1.04009	0.02489	1.06819	0.04297
3	1.03461	0.01153	1.04155	0.02022	1.05586	0.03108
3.7	1.03633	0.00982	1.04283	0.01614	1.04507	0.02068
4	1.03619	0.00963	1.04257	0.01575	1.04430	0.01991
5.5	1.03497	0.00896	1.04088	0.01454	1.04254	0.01810
7.5	1.03335	0.00806	1.03861	0.01293	1.04020	0.01568
11	1.03050	0.00650	1.03465	0.01012	1.03610	0.01144
15	1.02731	0.00474	1.03018	0.00695	1.03148	0.00669
18.5	1.02657	0.00476	1.02887	0.00644	1.02984	0.00624
22	1.02583	0.00477	1.02756	0.00593	1.02821	0.00580
30	1.02414	0.00481	1.02458	0.00477	1.02447	0.00478
37	1.02267	0.00485	1.02196	0.00375	1.02120	0.00388
45	1.02225	0.00448	1.02097	0.00349	1.02056	0.00399
55	1.02178	0.00400	1.01983	0.00322	1.01991	0.00418
75	1.02085	0.00305	1.01758	0.00269	1.01866	0.00455
90	1.02013	0.00300	1.01731	0.00283	1.01940	0.00458
110	1.01916	0.00294	1.01695	0.00301	1.02038	0.00461
132	1.01810	0.00286	1.01656	0.00321	1.02146	0.00465
150	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
160	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
185	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
200	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
220	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
250	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
300	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
330	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468
375	1.01727	0.00280	1.01626	0.00336	1.02230	0.00468

Annex C
VFD Performance Constants (Normative)

Table C.1 — VFD Performance Constants (Horsepower Capacity)

Horsepower	*d*	*e*	*f*
1	0.98030	0.04000	-0.01310
1.5	0.97995	0.03855	-0.01180
2	0.97960	0.03710	-0.01050
3	0.97890	0.03420	-0.00790
5	0.97750	0.02840	-0.00270
7.5	0.97810	0.02530	-0.00040
10	0.97870	0.02220	0.00190
15	0.98185	0.01985	0.00070
20	0.98500	0.01750	-0.00050
25	0.98620	0.01650	-0.00320
30	0.98740	0.01550	-0.00590
40	0.98765	0.01695	-0.00380
50	0.98790	0.01840	-0.00170
60	0.97190	0.01450	0.01180
75	0.99190	0.01790	-0.00130
100	0.98240	0.01260	0.00140
125	0.98293	0.01190	-0.00010
150	0.98345	0.01120	-0.00160
200	0.98450	0.00980	-0.00460
250	0.98450	0.00980	-0.00460
300	0.98450	0.00980	-0.00460
350	0.98450	0.00980	-0.00460
400	0.98450	0.00980	-0.00460
450	0.98450	0.00980	-0.00460
500	0.98450	0.00980	-0.00460

Table C.2 — VFD Performance Constants (Kilowatt Capacity)

Kilowatts	*d*	*e*	*f*
1	0.98006	0.03901	-0.01221
1.1	0.97997	0.03862	-0.01187
1.5	0.97959	0.03707	-0.01047
2.2	0.97894	0.03435	-0.00803
3	0.97818	0.03124	-0.00524
3.7	0.97753	0.02852	-0.00280
4	0.97759	0.02795	-0.00237
5.5	0.97807	0.02546	-0.00052
7.5	0.97873	0.02217	0.00189
11	0.98169	0.01997	0.00076
15	0.98503	0.01748	-0.00056
18.5	0.98615	0.01654	-0.00309
22	0.98728	0.01560	-0.00562
30	0.98766	0.01698	-0.00375
37	0.98789	0.01834	-0.00178
45	0.97233	0.01457	0.01152
55	0.99020	0.01761	-0.00019
75	0.98241	0.01258	0.00137
90	0.98283	0.01202	0.00016
110	0.98340	0.01127	-0.00145
132	0.98402	0.01045	-0.00322
150	0.98450	0.00980	-0.00460
160	0.98450	0.00980	-0.00460
185	0.98450	0.00980	-0.00460
200	0.98450	0.00980	-0.00460
220	0.98450	0.00980	-0.00460
250	0.98450	0.00980	-0.00460
300	0.98450	0.00980	-0.00460
330	0.98450	0.00980	-0.00460
375	0.98450	0.00980	-0.00460

Annex D
Motor Performance Constants (Normative)

Table D.1 — Polyphase Induction Motor Performance Constants (Horsepower-Rated Motors)

Horsepower	2 Pole		4 Pole		6 and 8 Pole	
	a	***b***	***a***	***b***	***a***	***b***
1	1.13460	0.08674	1.12541	0.09132	1.16873	0.11466
1.5	1.12932	0.08114	1.12067	0.08492	1.15895	0.10606
2	1.12405	0.07555	1.11592	0.07851	1.14917	0.09747
3	1.11350	0.06436	1.10643	0.06571	1.12962	0.08027
5	1.09241	0.04197	1.08745	0.04009	1.09051	0.04588
7.5	1.08883	0.03990	1.08340	0.03745	1.08579	0.04217
10	1.08526	0.03783	1.07936	0.03481	1.08107	0.03846
15	1.07811	0.03368	1.07127	0.02953	1.07163	0.03104
20	1.07096	0.02953	1.06318	0.02425	1.06218	0.02362
25	1.06949	0.02923	1.06033	0.02291	1.05966	0.02257
30	1.06802	0.02892	1.05749	0.02157	1.05713	0.02152
40	1.06508	0.02831	1.05180	0.01889	1.05208	0.01942
50	1.06214	0.02769	1.04612	0.01621	1.04703	0.01732
60	1.05946	0.02585	1.04436	0.01556	1.04553	0.01691
75	1.05544	0.02309	1.04172	0.01459	1.04328	0.01631
100	1.04874	0.01849	1.03732	0.01298	1.03954	0.01530
125	1.04713	0.01813	1.03731	0.01332	1.03948	0.01463
150	1.04553	0.01778	1.03729	0.01365	1.03942	0.01396
200	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
250	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
300	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
350	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
400	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
450	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
500	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262

Table D.2 — Polyphase Induction Motor Performance Constants (Kilowatt-rated Motors)

	2 Pole		4 Pole		6 and 8 Pole	
Kilowatts	***a***	***b***	***a***	***b***	***a***	***b***
1	1.13101	0.08293	1.12218	0.08696	1.16207	0.10881
1.1	1.12959	0.08143	1.12091	0.08524	1.15945	0.10650
1.5	1.12394	0.07543	1.11582	0.07837	1.14896	0.09728
2.2	1.11404	0.06493	1.10691	0.06636	1.13061	0.08115
3	1.10273	0.05292	1.09674	0.05263	1.10964	0.06271
3.7	1.09283	0.04242	1.08783	0.04061	1.09129	0.04657
4	1.09189	0.04167	1.08686	0.03971	1.08982	0.04534
5.5	1.08902	0.04000	1.08361	0.03759	1.08603	0.04236
7.5	1.08518	0.03778	1.07927	0.03476	1.08097	0.03838
11	1.07848	0.03389	1.07168	0.02980	1.07211	0.03142
15	1.07093	0.02952	1.06311	0.02422	1.06213	0.02360
18.5	1.06955	0.02924	1.06045	0.02296	1.05976	0.02261
22	1.06817	0.02895	1.05778	0.02171	1.05739	0.02163
30	1.06502	0.02829	1.05168	0.01883	1.05197	0.01937
37	1.06226	0.02772	1.04635	0.01631	1.04723	0.01740
45	1.05937	0.02579	1.04430	0.01554	1.04548	0.01690
55	1.05578	0.02333	1.04194	0.01468	1.04347	0.01636
75	1.04871	0.01848	1.03732	0.01299	1.03954	0.01528
90	1.04741	0.01820	1.03731	0.01326	1.03949	0.01474
110	1.04569	0.01782	1.03729	0.01362	1.03943	0.01403
132	1.04380	0.01740	1.03728	0.01401	1.03936	0.01323
150	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
160	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
185	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
200	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
220	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
250	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262
300	1.04231	0.01707	1.03726	0.01432	1.03931	0.01262

Annex E
Calculation Methods for Fans Tested Shaft-to-Air (Normative)

Annex E covers all calculation methods used for fans tested per Case 6 of Table 7.4. The results are to be used for the FEP_{act} calculations found in Sections 6.3, 6.4 and 6.5. This annex includes three sections, each used to calculate fan performance ratings in terms of airflow (Q), total pressure (P_t), velocity pressure (P_v), static pressure (P_s) and fan shaft power ($H_{i,act}$). Section E.1 covers the traditional fan laws that are used to calculate ratings at higher speeds and larger diameters than tested. Section E.2 includes a modification of the traditional fan laws used to interpolate fan ratings between two tested speeds. Section E.3 covers general interpolation between two fan tests in which a single geometric feature is varied.

The calculations in Sections E.1, E.2 and E.3 are presented as separate and unique calculation methods. However, the separate methods can be combined.

E.1 Fan laws

E.1.1 Requirements for the use of fan laws

E.1.1.1 Tested data
Calculations shall be based on tested fan performance measured via a test executed per the requirements of Section 7. Fan performance curves used to derive intermediate values for a given speed are determined per Section 8.1.

E.1.1.2 Minimum tested fan speed for same model
For calculating fan performance data of the same model fan, the maximum fan speed as defined in Annex H must be greater than or equal to the minimum tested fan speed.

E.1.1.3 Minimum diameter for series calculated fan
A series of fans for which fan performance is calculated must have a greater diameter than the series tested fan.

E.1.1.4 Minimum fan speed for larger diameter fans in a fan series
For calculating fan performance data of a series calculated fan, the calculated series fan tip speed must be greater than or equal to the tested fan tip speed.

$$N \geq \frac{D_{test}}{D} \cdot N_{test}$$

Where:

N is fan speed of the series calculated fan (rpm)
D_{test} is diameter of the series tested fan (m or ft)
D is diameter of the series calculated fan (m or ft)
N_{test} is fan speed of the series tested fan (rpm)

E.1.2 Calculation of airflow
Airflow shall be calculated using the following equation:

$$Q = Q_{test}\left[\frac{D}{D_{test}}\right]^3\left[\frac{N}{N_{test}}\right]\left[\frac{K_{p,test}}{K_p}\right]$$

Where:
Q is calculated airflow (m³/s or cfm)
Q_{test} is tested airflow (m³/s or cfm)
D is diameter of the series calculated fan (m or ft)
D_{test} is diameter of the series tested fan (m or ft)
N is fan speed of the series calculated fan (rpm)
N_{test} is fan speed of the series tested fan (rpm)
$K_{p,test}$ is compressibility coefficient, series tested fan, calculated as shown in Section E.1.5
K_p is compressibility coefficient, series calculated fan, calculated as shown in Section E.1.5

E.1.3 Calculating fan total, velocity and static pressure

Fan total, velocity and static pressure are calculated using the following equations:

$$P_t = P_{t,test}\left[\frac{D}{D_{test}}\right]^2\left[\frac{N}{N_{test}}\right]^2\left[\frac{K_{p,test}}{K_p}\right]\left[\frac{\rho}{\rho_{test}}\right]$$

$$P_v = P_{v,test}\left[\frac{D}{D_{test}}\right]^2\left[\frac{N}{N_{test}}\right]^2\left[\frac{\rho}{\rho_{test}}\right]$$

$$P_s = P_t - P_v$$

Where:
P_t is calculated fan total pressure (Pa or in. wg)
$P_{t,test}$ is test fan total pressure (Pa or in. wg)
P_v is calculated fan velocity pressure (Pa or in. wg)
$P_{v,test}$ is test fan velocity pressure (Pa or in. wg)
P_s is calculated fan static pressure (Pa or in. wg)
$P_{s,test}$ is test fan static pressure (Pa or in. wg)
D is diameter of the series calculated fan (m or ft)
D_{test} is diameter of the series tested fan (m or ft)
N is fan speed of the series calculated fan (rpm)
N_{test} is fan speed of the series tested fan (rpm)
$K_{p,test}$ is compressibility coefficient, series tested fan, calculated as shown in Section E.1.5
K_p is compressibility coefficient, series calculated fan, calculated as shown in Section E.1.5
ρ is fan air density at the calculated duty point (kg/m³ or lbm/ft³)
ρ_{test} is fan air density at the tested duty point (kg/m³ or lbm/ft³)

E.1.4 Calculation of fan shaft power

Fan shaft power shall be calculated using the following equation:

$$H_{i,act} = H_{i,test}\left[\frac{D}{D_{test}}\right]^5\left[\frac{N}{N_{test}}\right]^3\left[\frac{K_{p,test}}{K_p}\right]\left[\frac{\rho}{\rho_{test}}\right]$$

Where:
$H_{i,act}$ is fan shaft power used to calculate FEP_{act} (kW or hp)
$H_{i,test}$ is tested fan shaft power (kW or hp)
D is diameter of the series calculated fan (m or ft)
D_{test} is diameter of the series tested fan (m or ft)
N is fan speed of the series calculated fan (rpm)
N_{test} is speed of the series tested fan (rpm)
$K_{p,test}$ is compressibility coefficient, series tested fan, calculated as shown in Section E.1.5
K_p is compressibility coefficient, series calculated fan, calculated as shown in Section E.1.5
ρ is fan air density at the calculated duty point (kg/m³ or lbm/ft³)
ρ_{test} is fan air density at the tested duty point (kg/m³ or lbm/ft³)

E.1.5 Calculation of compressibility coefficient

Manufacturers shall be permitted to assume the compressibility ratio is equal to 1 if the fan total pressure is less than 2,500 Pa (10 in. wg) at any fan air density.

K_p and K_{ptest} are determined from:

$$K_{ptest} = \left[\frac{\ln(1 + x_{test})}{x_{test}}\right]\left[\frac{z_{test}}{\ln(1 + z_{test})}\right]$$

$$x_{test} = \left(\frac{P_{ttest}}{P_{t1test}+p_{btest}}\right) \text{ [SI]}$$

$$x_{test} = \left(\frac{P_{ttest}}{P_{t1test}+13.595p_{btest}}\right) \text{ [IP]}$$

$$z_{test} = \left[\frac{\gamma_{test}-1}{\gamma_{test}}\right]\left[\frac{H_{test}}{Q_{test}(P_{t1test}+p_{btest})}\right] \text{ [SI]}$$

$$z_{test} = \left[\frac{\gamma_{test}-1}{\gamma_{test}}\right]\left[\frac{6343.3H_{test}}{Q_{test}(P_{t1test}+13.595p_{btest})}\right] \text{ [IP]}$$

$$\frac{z_{test}}{z} = \left[\frac{P_{t1}+p_b}{P_{t1test}+p_{btest}}\right]\left[\frac{\rho_{test}}{\rho}\right]\left[\frac{N_{test}}{N}\right]^2\left[\frac{D_{test}}{D}\right]^2\left(\frac{\gamma}{\gamma-1}\right)\left(\frac{\gamma_{test}-1}{\gamma_{test}}\right) \text{ [SI]}$$

$$\frac{z_{test}}{z} = \left[\frac{P_{t1}+13.595p_b}{P_{t1test}+13.595p_{btest}}\right]\left[\frac{\rho_{test}}{\rho}\right]\left[\frac{N_{test}}{N}\right]^2\left[\frac{D_{test}}{D}\right]^2\left(\frac{\gamma}{\gamma-1}\right)\left(\frac{\gamma_{test}-1}{\gamma_{test}}\right) \text{ [IP]}$$

$$z = \frac{z_{test}}{\left(\frac{z_{test}}{z}\right)}$$

$$x = e^{\left\{\ln(1+x_{test})*\left[\frac{\ln(1+z)}{\ln(1+z_{test})}\right]*\left(\frac{\gamma_{test}-1}{\gamma_{test}}\right)*\left(\frac{\gamma}{\gamma-1}\right)\right\}} - 1$$

$$\frac{K_{p,test}}{K_p} = \left(\frac{z_{test}}{z}\right)\left(\frac{x}{x_{test}}\right)\left(\frac{\gamma_{test}}{\gamma_{test}-1}\right)\left(\frac{\gamma-1}{\gamma}\right)$$

Where:

K_{ptest} is compressibility coefficient (dimensionless)
K_p is compressibility coefficient, calculated (dimensionless)
x_{test} is coefficient of convenience
z, z_{test} is coefficient of convenience
P_{t1test} is total pressure at fan inlet (Pa or in. wg)
P_{t1} is total pressure at fan inlet, calculated (Pa or in. wg)
p_{btest} is barometer pressure (Pa or in. Hg)
γ_{test} is ratio of specific heats
γ is ratio of specific heats, calculated

E.2 Interpolating between tested speeds

This section describes the interpolation used to develop ratings for a fan speed between two adjacent tested speeds. The method also applies to ratings for a series calculated fan when the required fan speed is between two fan speeds with ratings calculated per Section E.1. At fan speeds higher than the highest tested speed, the fan laws described in Section E.1 shall be applied.

E.2.1 Range of application
The interpolation method may only be applied between two tested speeds.

$$N_{low} < N < N_{high}$$

Where:
N_{low} is fan speed of the lower speed test (rpm)
N is interpolated fan speed under evaluation (rpm)
N_{high} is fan speed of the higher speed test (rpm)

E.2.2 Interpolation along a system curve
All interpolated points must be on the same system curve and meet the requirements of one of the following equations.

If airflows are equal to zero (shutoff point of fan curve): $Q_{low} = Q = Q_{high} = 0$

If pressures are equal to zero (free air point of fan curve): $P_{low} = P = P_{high} = 0$

If airflows and pressures are greater than zero: $\frac{P_{low}}{\rho_{std} Q_{low}^2} = \frac{P}{\rho Q^2} = \frac{P_{high}}{\rho_{std} Q_{high}^2}$

Where:
P_{low} is total or static pressure from the fan curve derived from the lower speed test (Pa or in. wg)
ρ_{std} is density of standard air (1.2 kg/m^3 or 0.075 lbm/ft^3)
Q_{low} is airflow from the fan curve derived from the lower speed test (m^3/s or cfm)
P is interpolated total or static pressure at interpolated fan air density, ρ (Pa or in. wg)
ρ is interpolated fan air density under evaluation (kg/m^3 or lbm/ft^3)
Q is interpolated airflow (m^3/s or cfm)
P_{high} is total or static pressure from the fan curve derived from the higher speed test (Pa or in. wg)
Q_{high} is airflow from the fan curve derived from the higher speed test of the series tested fan (m^3/s or cfm)

E.2.3 Interpolation of airflow
Airflow shall be calculated using this equation:

$$Q = Q_{low} + \left(\frac{N - N_{low}}{N_{high} - N_{low}}\right)(Q_{high} - Q_{low})$$

Where:
Q is interpolated airflow (m^3/s or cfm)
Q_{low} is airflow from the fan curve derived from the lower speed test (m^3/s or cfm)
N is interpolated fan speed under evaluation (rpm)
N_{low} is fan speed from the lower speed test (rpm)
N_{high} is fan speed from the higher speed test (rpm)
Q_{high} is airflow from the fan curve derived from the higher speed test (m^3/s or cfm)

E.2.4 Interpolation of total and static pressure
At airflows greater than zero, total and static pressure shall be calculated using this equation:

$$P = P_{low} \times \left(\frac{Q}{Q_{low}}\right)^2 \left(\frac{\rho}{\rho_{std}}\right)$$

Where:
P is interpolated total or static pressure at interpolated fan air density, ρ (Pa or in. wg)
P_{low} is total or static pressure from the fan curve derived from the lower speed test (Pa or in. wg)

Q is interpolated fan airflow calculated in Section E.2.3 (m^3/s or cfm)
Q_{low} is fan airflow from the fan curve derived from the lower speed test (m^3/s or cfm)
ρ is interpolated fan air density under evaluation (kg/m^3 or lbm/ft^3)
ρ_{std} is density of standard air (1.2 kg/m^3 or 0.075 lbm/ft^3)

At airflows equal to zero (the shutoff point of the fan curve), fan total and static pressure shall be calculated using this equation:

$$P = \left\{P_{low}\left(\frac{N}{N_{low}}\right)^2 + \left(\frac{N - N_{low}}{N_{high} - N_{low}}\right)\left[P_{high}\left(\frac{N}{N_{high}}\right)^2 - P_{low}\left(\frac{N}{N_{low}}\right)^2\right]\right\}\left(\frac{\rho}{\rho_{std}}\right)$$

Where:
P is Interpolated total or static pressure at interpolated fan air density, ρ (Pa or in. wg)
P_{low} is Total or static pressure from the fan curve derived from the lower speed test (Pa or in. wg)
P_{high} is Total or static pressure from the fan curve derived from the higher speed test (Pa or in. wg)
N is Interpolated fan speed under evaluation (rpm)
N_{low} is Fan speed from the lower speed test (rpm)
N_{high} is Fan speed from the higher speed test (rpm)
ρ is Interpolated fan air density under evaluation (kg/m^3 or lbm/ft^3)
ρ_{std} is Density of standard air (1.2 kg/m^3 or 0.075 lbm/ft^3)

E.2.5 Interpolation of fan shaft power

E.2.5.1 Interpolation if both airflow and static pressure are greater than zero

If airflow (*Q*) and fan static pressure (P_s) are both greater than zero, fan shaft power shall be interpolated using this equation:

$$H_{i,act} = H_{i,low} + \left(\frac{QP - Q_{low}P_{low}}{Q_{high}P_{high} - Q_{low}P_{low}}\right)\left(H_{i,high} - H_{i,low}\right)$$

Where:
$H_{i,act}$ is interpolated fan shaft power to be used to calculate FEP_{act} (kW or hp)
$H_{i,low}$ is fan shaft power from the fan curve derived from the lower speed test (kW or hp)
Q is interpolated airflow calculated in Section E.2.3 (m^3/s or cfm)
P is interpolated total or static pressure calculated in Section E.2.4 (Pa or in. wg)
Note: This pressure may be at a density other than standard air density.
Q_{low} is airflow from the fan curve derived from the lower speed test (m^3/s or cfm)
P_{low} is total or static pressure from the lower speed test (Pa or in. wg)
Q_{high} is airflow from the higher speed test (m^3/s or cfm)
P_{high} is total or static pressure from the higher speed test (Pa or in. wg)
$H_{i,high}$ is fFan shaft power from the fan curve derived from the higher speed test (kW or hp)

E.2.5.2 Interpolation if pressure is equal to zero

If fan static pressure (P_s) is equal to zero, fan shaft power shall be interpolated using this equation:

$$H_{i,act} = H_{i,low} + \left(\frac{\rho Q^3 - \rho_{std}Q_{low}^3}{\rho_{std}Q_{high}^3 - \rho_{std}Q_{low}^3}\right)\left(H_{i,high} - H_{i,low}\right)$$

Where:
$H_{i,act}$ is interpolated fan shaft power to be used to calculate FEP_{act} (kW or hp)
$H_{i,low}$ is fan shaft power from the fan curve derived from the lower speed test (kW or hp)
ρ is interpolated fan air density under evaluation (kg/m^3 or lbm/ft^3)
Q is interpolated airflow calculated in Section E.2.3 (m^3/s or cfm)
ρ_{std} is density of standard air (1.2 kg/m^3 or 0.075 lbm/ft^3)
Q_{low} is airflow from the fan curve derived from the lower speed test (m^3/s or cfm)

Q_{high} is airflow from the higher speed test (m^3/s or cfm)
$H_{i,high}$ is fan shaft power from the fan curve derived from the higher speed test (kW or hp)

E.2.5.3 Interpolation if airflow is equal to zero
If airflow (*Q*) is equal to zero, fan shaft power shall be interpolated using this equation:

$$H_{i,act} = H_{i,low} + \left[\frac{P^{1.5}\left(\frac{\rho_{std}}{\rho}\right)^{0.5} - P_{low}^{1.5}}{P_{high}^{1.5} - P_{low}^{1.5}}\right]\left(H_{i,high} - H_{i,low}\right)$$

Where:
$H_{i,act}$ is interpolated fan shaft power to be used to calculate FEP_{act} (kW or hp)
$H_{i,low}$ is fan shaft power from the fan curve derived from the lower speed test (kW or hp)
ρ is interpolated fan air density under evaluation (kg/m^3 or lbm/ft^3)
P is interpolated total or static pressure calculated in Section E.2.4 (Pa or in. wg)
ρ_{std} is density of standard air (1.2 kg/m^3 or 0.075 lbm/ft^3)
P_{low} is total or static pressure from the fan curve derived from the lower speed test (Pa or in. wg)
P_{high} is total or static pressure from the fan curve derived from the higher speed test (Pa or in. wg)
$H_{i,high}$ is fan shaft power from the fan curve derived from the higher speed test (kW or hp)

E.3 General interpolation between tested fans
This section describes the method of interpolation used to develop ratings for a fan where a single geometric feature is varied. Examples include changes in axial fan blade pitch, centrifugal fan blade width and the distance from an impeller to a separating panel on fans for fan arrays. A change in fan impeller diameter is not considered a single geometric feature; changes to fan impeller diameter are covered in Section E.1.

E.3.1 Range of application
The interpolation method may only be applied between two fan tests at the same tested fan speed. The dimension for the calculated fan must be between the dimension for the two tested fans.

E.3.2 Interpolation between corresponding points of a fan curve
All interpolation must be between corresponding points of a fan curve. This is accomplished by dividing each tested fan curve into an equal number of equally spaced pressure increments from the minimum to the maximum pressure tested. Alternatively, the tested fan curve can be divided into an equal number of equally spaced airflow increments. See Section 8.1 for interpolation between test determinations. For fans with an unstable region on their fan curve, only the stable region is divided into equal increments. Interpolation then is conducted between successive points on the two fan curves. An example of pitch interpolation is shown in Figure E.1.

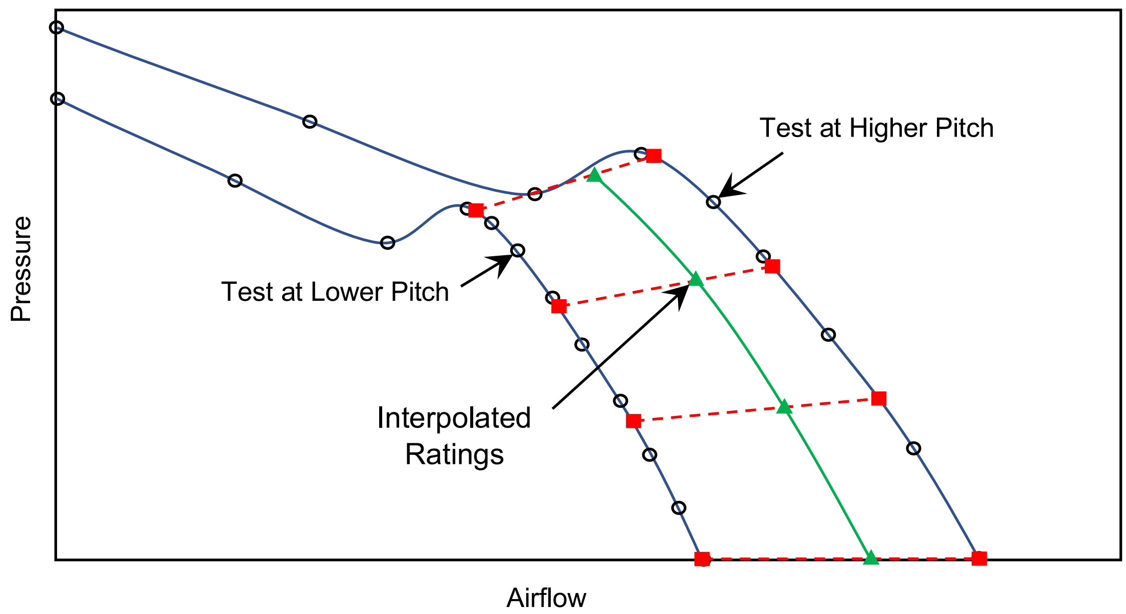


Figure E.1 — Example of Blade Pitch Interpolation

E.3.3 Interpolation of airflow

Airflow shall be calculated using this equation:

$$Q = Q_{low} + \left(\frac{X - X_{low}}{X_{high} - X_{low}}\right)\left(Q_{high} - Q_{low}\right)$$

Where:

Q is interpolated airflow (m^3/s or cfm)
Q_{low} is airflow from the test at X_{low} (m^3/s or cfm)
X is value of the variable under evaluation (consistent units)
X_{low} is value of the variable for the first fan test (consistent units)
X_{high} is value of the variable for the second fan test (consistent units)
Q_{high} is airflow from the test at X_{high} (m^3/s or cfm)

E.3.4 Interpolation of total and static pressure

Total and static pressure shall be interpolated using this equation:

$$P = P_{low} + \left(\frac{X - X_{low}}{X_{high} - X_{low}}\right)\left(P_{high} - P_{low}\right)$$

Where:

P is interpolated fan total or static pressure (Pa or in. wg)
P_{low} is fan total or static pressure from the test at X_{low} (Pa or in. wg)
X is value of the variable under evaluation (consistent units)
X_{low} is value of the variable for the first fan test (consistent units)
X_{high} is value of the variable for the second fan test (consistent units)
P_{high} is fan total or static pressure from the test at X_{high} (Pa or in. wg)

E.3.5 Interpolation of fan shaft power

E.3.5.1 Interpolation if both airflow and static pressure are greater than zero

If airflow (Q) and fan static pressure (P_s) are both greater than zero, fan shaft power shall be calculated using this equation:

$$H_{i,act} = H_{i,low} + \left(\frac{QP - Q_{low}P_{low}}{Q_{high}P_{high} - Q_{low}P_{low}}\right)\left(H_{i,high} - H_{i,low}\right)$$

Where:

$H_{i,act}$ is interpolated fan shaft power (kW or hp)
$H_{i,low}$ is fan shaft power from the test at X_{low} (kW or hp)
Q is interpolated airflow calculated in Section E.3.3 (m^3/s or cfm)
P is interpolated fan total or static pressure calculated in Section E.3.4 (Pa or in. wg)
Q_{low} is airflow from the test at X_{low} (m^3/s or cfm)
P_{low} is fan total or static pressure from the test at X_{low} (Pa or in. wg)
Q_{high} is airflow from the test at X_{high} (m^3/s or cfm)
P_{high} is fan total or static pressure from the test at X_{high} (Pa or in. wg)
$H_{i,high}$ is fan shaft power from the test at X_{high} (kW or hp)

E.3.5.2 Interpolation if pressure is equal to zero

If fan static pressure (P_s) is equal to zero, fan shaft power shall be calculated using this equation:

$$H_{i,act} = H_{i,low} + \left(\frac{\rho Q^3 - \rho_{std}Q_{low}^3}{\rho_{std}Q_{high}^3 - \rho_{std}Q_{low}^3}\right)\left(H_{i,high} - H_{i,low}\right)$$

Where:

$H_{i,act}$ is interpolated fan shaft power (kW or hp)
$H_{i,low}$ is fan shaft power from the test at X_{low} (kW or hp)
ρ is interpolated fan air density under evaluation (kg/m^3 or lbm/ft^3)
Q is interpolated airflow calculated in Section E.3.3 (m^3/s or cfm)
ρ_{std} is density of standard air (1.2 kg/m^3 or 0.075 lbm/ft^3)
Q_{low} is airflow from the test at X_{low} (m^3/s or cfm)
Q_{high} is airflow from the test at X_{high} (m^3/s or cfm)
$H_{i,high}$ is fan shaft power from the test at X_{high} (kW or hp)

E.3.5.3 Interpolation if airflow is equal to zero

If airflow (Q) is equal to zero, fan shaft power shall be calculated using this equation:

$$H_{i,act} = H_{i,low} + \left[\frac{P^{1.5}\left(\frac{\rho_{std}}{\rho}\right)^{0.5} - P_{low}^{1.5}}{P_{high}^{1.5} - P_{low}^{1.5}}\right]\left(H_{i,high} - H_{i,low}\right)$$

Where:

$H_{i,act}$ is interpolated fan shaft power (kW or hp)
$H_{i,low}$ is fan shaft power from the test at X_{low} (kW or hp)
ρ is interpolated fan air density under evaluation (kg/m^3 or lbm/ft^3)
ρ_{std} is density of standard air (1.2 kg/m^3 or 0.075 lbm/ft^3)
P is interpolated total or static pressure calculated in Section E.3.4 (Pa or in. wg)
P_{low} is fan total or static pressure from the test at X_{low} (Pa or in. wg)
P_{high} is fan total or static pressure from the test at X_{high} (Pa or in. wg)
$H_{i,high}$ is fan shaft power from the test at X_{high} (kW or hp)

Annex F

Electrical Power With a Separately Tested Motor or Combined Motor and Controller (Normative)

F.1 General

This annex covers ratings of fan electrical power based on separate tests of shaft-to-air fan input power and a wire-to-shaft efficiency of either a motor or a motor and motor controller.

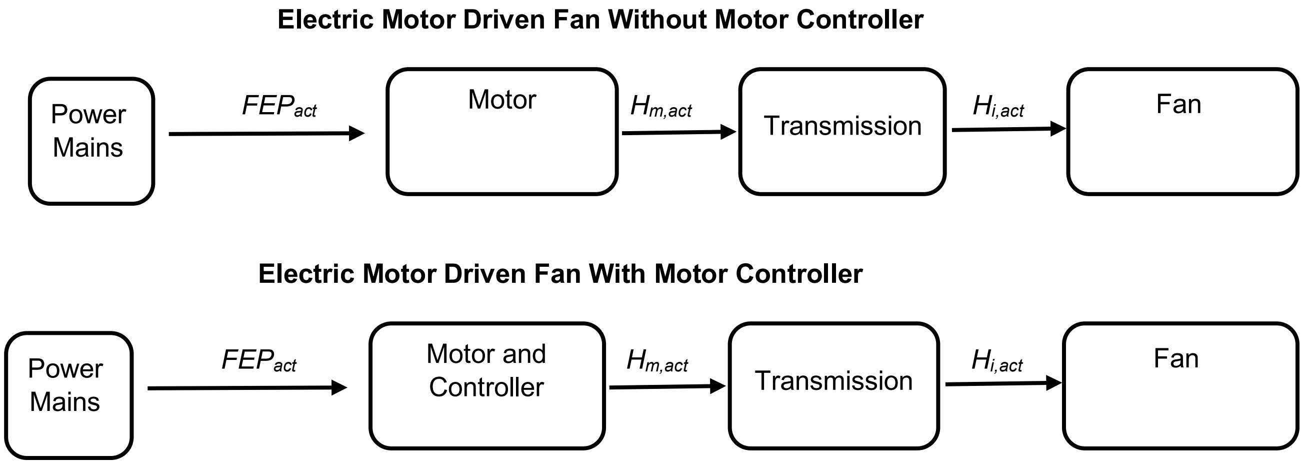


Figure F.1 — Electric Motor Driven Fans

To combine separate fan and drive component tests to determine fan electrical power, the fan input power, $H_{i,act}$, is divided by the drive component efficiencies as shown in Figure F.1 corresponding to the required fan speed and shaft power. The corresponding equations for FEP_{act} are found in Section 6.5. Note that these are not nameplate or nominal efficiencies; they are efficiencies corresponding to the required speed and load (the term “load” is used to refer to either power or torque).

F.2 Motor and motor with controller testing

Various motor and motor controller test standards exist, but none for the specific purpose of mapping the wire-to-shaft efficiency at all speeds and loads. Permissible test methods include portions of the following test standards, including their individual scope limits:

- ANSI/ASHRAE Standard 222
- CAN/CSA C838
- CAN/CSA C747
- IEEE 112-2017

The test standard selected shall be applicable to the equipment being tested and followed except that a) only the efficiency test of the motor without motor controller or combined motor and motor controller need be run, and b) speed and loads used for drive component testing shall be as defined in Section F.5.

F.3 Test conditions

Motors and controllers, if included, shall be tested at the name plate voltage over the range of speeds and loads in which the fans are to be rated (see Section F.5). Test conditions and equipment must be as specified in the test standard used. The temperature and operation of the motor(s) and controller(s) shall be stable for each tested operating point. If the motor includes a motor controller, the input power is measured at the input to the controller.

F.3.1 Highest voltage

For any motor without motor controller or combined motor and motor controller that is rated to operate at multiple nameplate voltages, the test shall be conducted at the highest nameplate voltage. If the motor without motor controller or combined motor and motor controller can be operated on either single-phase or polyphase electricity, it shall be tested with single-phase electricity.

F.4 Test report

The test report shall include:

- Description of equipment tested, including manufacturer and model number
- Nameplate voltage, frequency and power
- Controller parameters used for the test include mode (variable or constant torque), carrier frequency, maximum frequency, maximum output voltage, V/f ratio and a descriptor, title or name of the output algorithm.
- Ambient air conditions as required by the applied test standard from Section F.2.
- Measurements and calculated data, resulting in a map of the input power (kW) vs. speed and load; the map may include efficiency for each tested point

F.5 Speed and load points

Speed and load points must cover the entire range to be rated. Determination points need not be restricted by motor nameplate ratings in speed or load; however, test data cannot be extrapolated beyond these measured determination points. Intermediate data between tested points shall be based on a simple linear interpolation or a polynomial curve fit. In no case shall the results from the curve fit result in efficiencies exceeding the nearest test values. If efficiency vs. load is within 5% of the average of all test speeds, the average efficiency vs. load can be used for the entire speed range.

Informative note: For example, if the efficiency vs. load data includes the values 91.5, 90, 88, 87 and 86, the average would be 88.5. A 5% range would include any values between 92.9 and 84.1, so this example would be allowed to use 88.5 for the entire range.

Table F.1 — Example of determination points

		Speed (Percent Rated)				
		25%	50%	75%	100%	125%
Torque (Percent Rated)	125%				X	
	100%			X	X	X
	75%		X	X	X	X
	50%	X	X	X	X	X
	25%	X	X	X	X	X

Table F.2 — Example of test results

(Efficiency Values)		Speed (Percent Rated)				
		25%	50%	75%	100%	125%
Torque (Percent Rated)	125%				88%	
	100%			91%	90%	88%
	75%		86%	89%	88%	86%
	50%	79%	83%	85%	85%	83%
	25%	70%	79%	81%	81%	79%

:

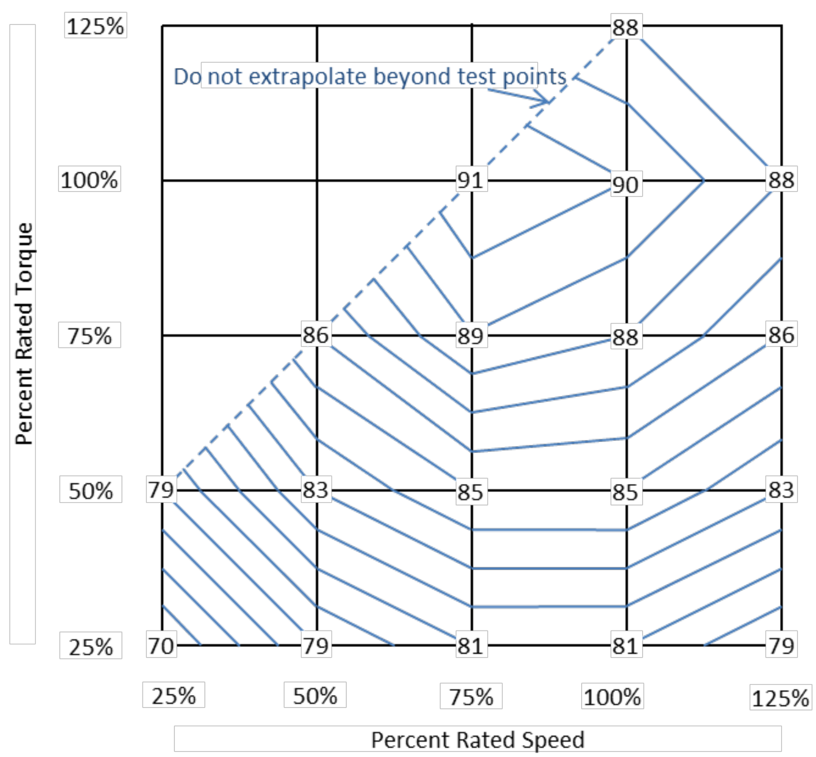


Figure F.2 — Example of interpolation (efficiency vs. torque and speed)

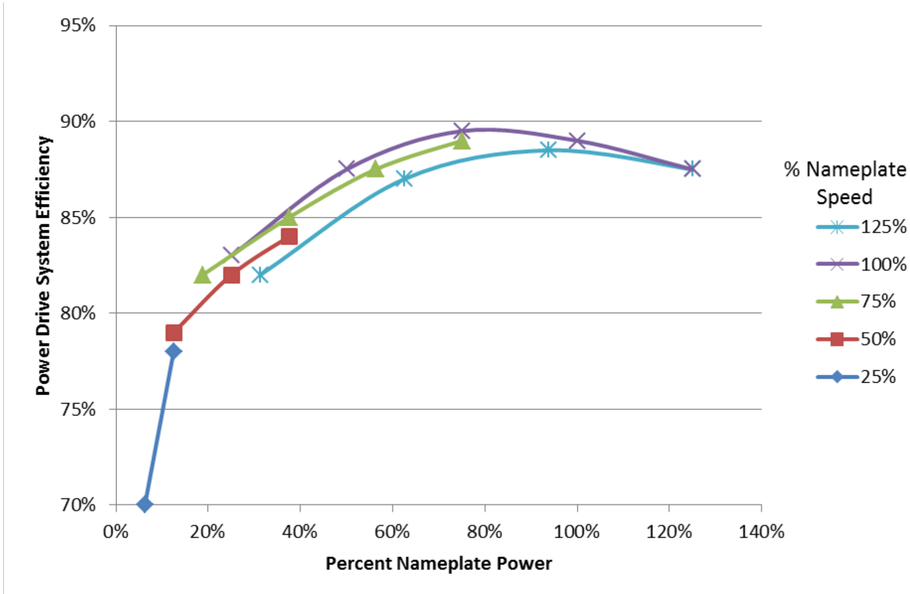


Figure F.3 — Example of curve fit (efficiency vs. power and speed)

Annex G
Wire-to-Air Measurement – Calculation to Other Speeds and Densities (Normative)

This annex defines a method to interpolate between wire-to-air tests at multiple speeds to obtain fan ratings at an intermediate speed or different density. This standardized interpolation provides the fan pressure, airflow and fan electrical power given the fan performance ratings at two tested fan speeds: one speed greater and one speed less than the desired speed. The results from the calculations in this annex are to be used for the FEP_{act} determination in Section 6.2.

G.1 Requirements for the use of these calculations in Annex G

G.1.1 Tested data

Calculations shall be based on tests performed per the requirements of Section 7. – Testing, excluding the requirements of Section 7.8 – Electrical Power Requirements. Intermediate values along the tested fan curves shall be determined per Section 8.1 – Laboratory Measurement Only. Tested fan performance for this annex already have already been corrected to standard air density.

G.2 Interpolating between tested fan speeds

This section describes the method of interpolation to develop ratings for a fan tested at two or more speeds. The method only applies to fan curves of two adjacent speeds. If three or more speeds are tested, a separate interpolation must be completed between each fan curve. Data from Annex G calculations shall not be used to extrapolate to values greater than tested efficiencies.

In these methods of interpolation, W_i is the measured fan electrical power and is equal to W_{mti} (see Case 2 from Table 7.4), W_{mi} (see Case 3 from Table 7.4), W_{cmti} (see Case 1 from Table 7.4) or W_{cmi} (see Case 4 from Table 7.4).

G.2.1 Range of application

The interpolation method may only be applied to speeds between two tested speeds.

$$N_{low} < N < N_{high}$$

Where:

N is interpolated fan speed (rpm)

N_{low} is fan speed of the lower speed test (rpm)

N_{high} is fan speed of the higher speed test (rpm)

G.2.2 Interpolation along a system curve

All interpolated determination points must be on the same system curve and meet the requirements of one of the following equations:

If airflows are equal to zero (shutoff point of fan curve): $Q_{low} = Q = Q_{high} = 0$

If pressures are equal to zero (free air point of fan curve): $P_{low} = P = P_{high} = 0$

If airflows and pressures are greater than zero:

$$\frac{P_{low}}{\rho_{std} Q_{low}^2} = \frac{P}{\rho Q^2} = \frac{P_{high}}{\rho_{std} Q_{high}^2}$$

Where:
Q is interpolated airflow (m^3/s or cfm)
Q_{low} is airflow from the lower speed test (m^3/s or cfm)
Q_{high} is Airflow from the higher speed test (m^3/s or cfm)
P is interpolated total or static pressure at interpolated fan air density, ρ (Pa or in. wg)
P_{low} is pressure from the lower speed test (Pa or in. wg)
P_{high} is pressure from the higher speed test (Pa or in. wg)
ρ is interpolated fan air density (kg/m^3 or lbm/ft^3)
ρ_{std} is density of standard air (1.2 kg/m^3 or 0.075 lbm/ft^3)

G.2.3 Interpolation of airflow
Airflow shall be calculated using this equation:

$$Q = Q_{low} + \left(\frac{N - N_{low}}{N_{high} - N_{low}}\right)(Q_{high} - Q_{low})$$

Where:
Q is interpolated airflow (m^3/s or cfm)
Q_{low} is airflow from the fan curve derived from the lower speed test (m^3/s or cfm)
Q_{high} is airflow from the fan curve derived from the higher speed test (m^3/s or cfm)
N is interpolated fan speed (rpm)
N_{low} is fan speed from the lower speed test (rpm)
N_{high} is fan speed from the higher speed test (rpm)

G.2.4 Interpolation of total and static pressure
At airflows greater than zero, total and static pressure shall be calculated using this equation:

$$P = P_{low}\left(\frac{Q}{Q_{low}}\right)^2\left(\frac{\rho}{\rho_{std}}\right)$$

Where:
Q is interpolated fan airflow calculated in G.2.3 (m^3/s or cfm)
Q_{low} is fan airflow from the lower speed test (m^3/s or cfm)
P is interpolated total or static pressure at interpolated fan air density, ρ (Pa or in. wg)
P_{low} is pressure from the lower speed test (Pa or in. wg)
ρ is interpolated fan air density (kg/m^3 or lbm/ft^3)
ρ_{std} is density of standard air (1.2 kg/m^3 or 0.075 lbm/ft^3)

At airflows equal to zero (the shutoff point of the fan curve), fan total and static pressure shall be calculated using this equation:

$$P = \left\{P_{low}\left(\frac{N}{N_{low}}\right)^2 + \left(\frac{N - N_{low}}{N_{high} - N_{low}}\right)\left[P_{high}\left(\frac{N}{N_{high}}\right)^2 - P_{low}\left(\frac{N}{N_{low}}\right)^2\right]\right\}\left(\frac{\rho}{\rho_{std}}\right)$$

Where:
P is interpolated total or static pressure at interpolated fan air density, ρ (Pa or in. wg)
P_{low} is total or static pressure from the fan curve derived from the lower speed test (Pa or in. wg)
P_{high} is total or static pressure from the fan curve derived from the higher speed test (Pa or in. wg)
N is interpolated fan speed under evaluation (rpm)
N_{low} is fan speed from the lower speed test (rpm)
N_{high} is fan speed from the higher speed test (rpm)
ρ is interpolated fan air density under evaluation (kg/m^3 or lbm/ft^3)
ρ_{std} is density of standard air (1.2 kg/m^3 or 0.075 lbm/ft^3)

G.2.5 Interpolation of fan electrical power

G.2.5.1 Interpolation if both airflow and static pressure are greater than zero

If airflow (Q) and fan static pressure (P_s) are both greater than zero, fan shaft power shall be interpolated using this equation:

$$FEP_{act} = W_{i,low} + \left(\frac{QP - Q_{low}P_{low}}{Q_{high}P_{high} - Q_{low}P_{low}}\right)\left(W_{i,high} - W_{i,low}\right)$$

Where:

FEP_{act} is interpolated fan electrical power (kW)
Q is interpolated airflow calculated in Section G.2.3 (m^3/s or cfm)
Q_{low} is airflow from the lower speed test (m^3/s or cfm)
Q_{high} is airflow from the higher speed test (m^3/s or cfm)
P is interpolated total or static pressure calculated in Section G.2.4 (Pa or in. wg)
P_{low} is total or static pressure from the lower speed test (Pa or in. wg)
P_{high} is total or static pressure from the higher speed test (Pa or in. wg)
$W_{i,low}$ is fan electrical power from the lower speed test (kW)
$W_{i,high}$ is fan electrical power from higher speed test (kW)

G.2.5.2 Interpolation if pressure is equal to zero

If fan static pressure (P_s) is equal to zero, fan electrical power shall be interpolated using this equation:

$$FEP_{act} = W_{i,low} + \left(\frac{\rho Q^3 - \rho_{std}Q_{low}^3}{\rho_{std}Q_{high}^3 - \rho_{std}Q_{low}^3}\right)\left(W_{i,high} - W_{i,low}\right)$$

Where:

FEP_{act} is interpolated fan electrical power (kW)
Q is interpolated airflow calculated in Section G.2.3 (m^3/s or cfm)
Q_{low} is airflow from the lower speed test (m^3/s or cfm)
Q_{high} is airflow from the higher speed test (m^3/s or cfm)
ρ is fan air density (kg/m^3 or lbm/ft^3)
ρ_{std} is density of standard air (1.2 kg/m^3 or 0.075 lbm/ft^3)
$W_{i,low}$ is fan electrical power from the lower speed test (kW)
$W_{i,high}$ is fan electrical power from the higher speed test (kW)

G.2.5.3 Interpolation if airflow is equal to zero

If airflow (Q) is equal to zero, fan electrical power shall be interpolated using this equation:

$$FEP_{act} = W_{i,low} + \left[\frac{P^{1.5}\left(\frac{\rho_{std}}{\rho}\right)^{0.5} - P_{low}^{1.5}}{P_{high}^{1.5} - P_{low}^{1.5}}\right]\left(W_{i,high} - W_{i,low}\right)$$

Where:

FEP_{act} is interpolated fan electrical power (kW)
P is interpolated total or static pressure calculated in Section G.2.4 (Pa or in. wg)
P_{low} is total or static pressure from the lower speed test (Pa or in. wg)

P_{high} is total or static pressure from the higher speed test (Pa or in. wg)
ρ is fan air density (kg/m^3 or lbm/ft^3)
ρ_{std} is density of standard air (1.2 kg/m^3 or 0.075 lbm/ft^3)
$W_{i,low}$ is fan electrical power from the lower speed test (kW)
$W_{i,high}$ is fan electrical power from the higher speed test (kW)

G.2.6 Check on the wire-to-air efficiency at the new speed and density

The equations in Section G.2.5 may result in electrical input power outside the bounds of W_{low} and W_{high}. The resulting efficiency can be lower than the efficiency at the lower and higher speed tests, however, the resulting efficiency shall not exceed that of each of the tests. If this happens, the efficiency is capped at the higher of the two test results.

$$FEP_{act} \geq \frac{QP}{\eta_{max}}$$

$$FEP_{act} \geq \frac{QP}{8507 \times \eta_{max}}$$

And:

$$\eta_{max} \text{ is the maximum of } \frac{Q_{low}P_{low}}{W_{low}} \text{ and } \frac{Q_{high}P_{high}}{W_{high}}$$

$$\eta_{max} \text{ is the maximum of } \frac{Q_{low}P_{low}}{8507 \times W_{low}} \text{ and } \frac{Q_{high}P_{high}}{8507 \times W_{high}}$$

Where:
FEP_{act} is interpolated fan electrical power (kW)
η_{max} is maximum efficiency of the corresponding test point of either the lower or higher test speed (dimensionless)
Q is interpolated airflow calculated in Section G.2.3 (m^3/s or cfm)
Q_{low} is airflow from the lower speed test (m^3/s or cfm)
Q_{high} is airflow from the higher speed test (m^3/s or cfm)
P is interpolated total or static pressure calculated in Section G.2.4 (Pa or in. wg)
P_{low} is total or static pressure from the lower speed test (Pa or in. wg)
P_{high} is total or static pressure from the higher speed test (Pa or in. wg)
$W_{i,low}$ is fan electrical power from the lower speed test (kW)
$W_{i,high}$ is fan electrical power from the higher speed test (kW)

Annex H
Required Reported Values (Normative)

H.1 General

H.1.1 Purpose
Annex H defines the three values that shall be used to report the upper boundaries of performance for which the fan meets or exceeds a required minimum FEI as defined in Section H.2.1 (Figures H.1–H.5).

H.2 Definitions

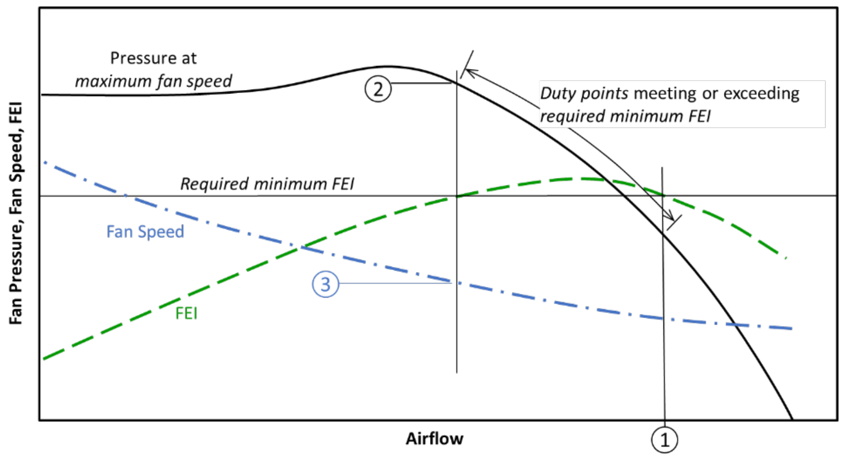
H.2.1 Reported values
Values submitted to a regulatory body.

H.2.2 Required minimum FEI
The minimum value established for FEI in a regulation that references this standard.

H.2.3 Maximum airflow
The maximum reported value for airflow in cubic feet per minute at standard air density that meets or exceeds the required minimum FEI for at least one duty point. Maximum airflow is represented as Point 1 in Figures H.1-H.4.

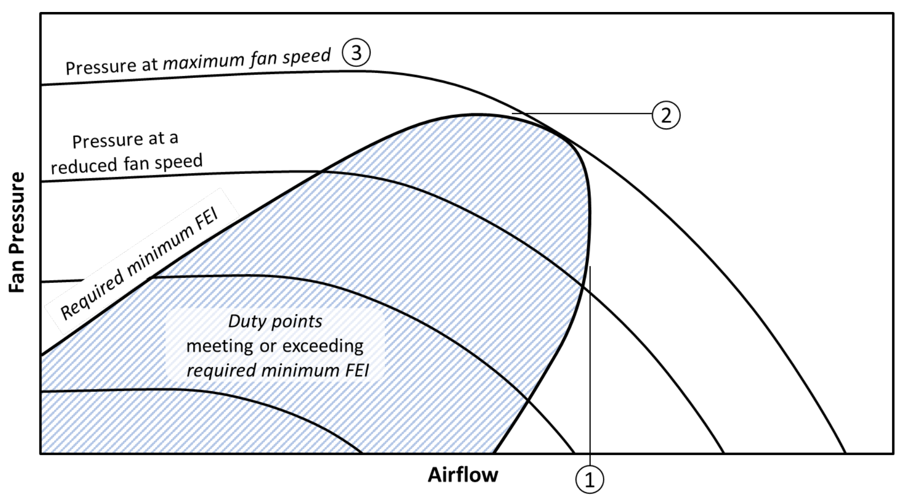
H.2.4 Maximum pressure
The maximum reported value for fan pressure in inches water gauge at standard air density that meets or exceeds the required minimum FEI for at least one duty point. Maximum pressure is represented as Point 2 in Figures H.1-H.4.

H.2.5 Maximum fan speed
The maximum reported value for fan speed in revolutions per minute that meets or exceeds the required minimum FEI for at least one duty point. Maximum fan speed is represented as Point 3 in Figures H.1-H.4.



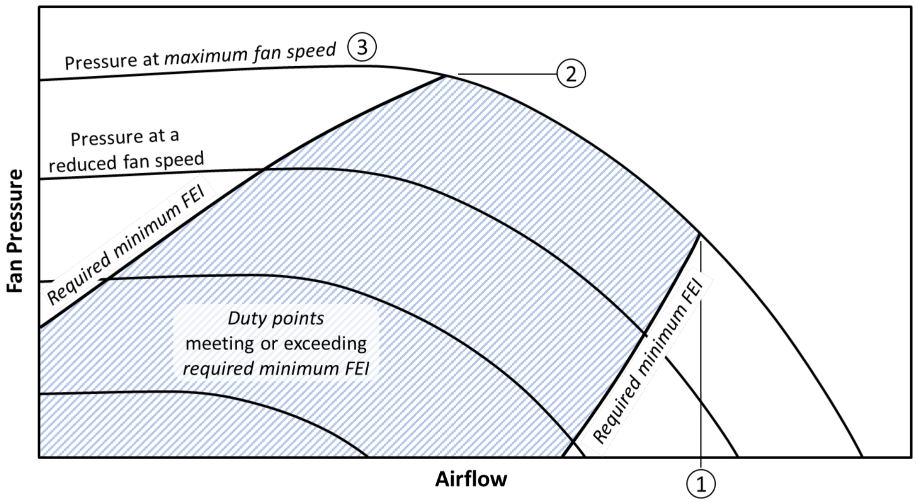
Definition of points	
1 -	Maximum airflow
2 -	Maximum pressure
3 -	Maximum fan speed
Note: These three points meet or exceed required minimum FEI	

Figure H.1 — Fans Offered for Sale Only at Discrete Speeds (example shown has significant variation of speed with load)



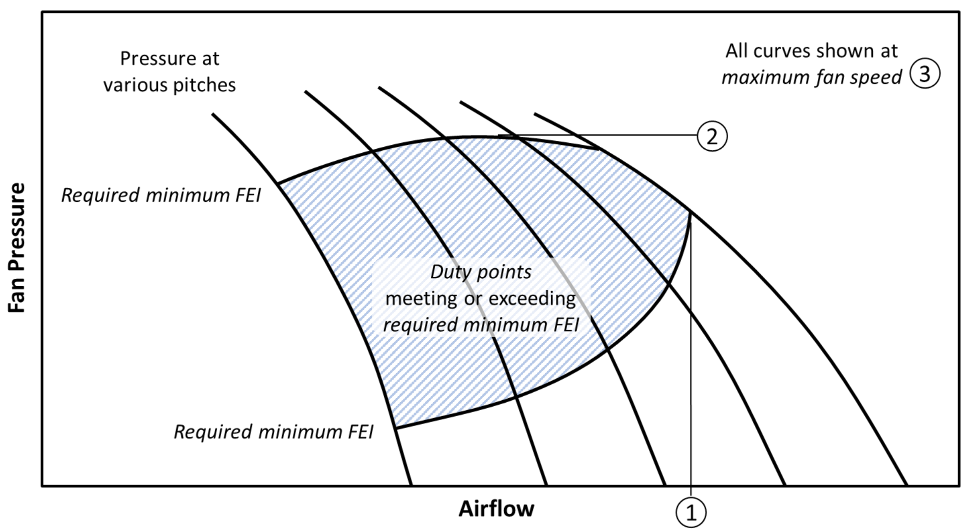
Definition of points	
1 -	Maximum airflow
2 -	Maximum pressure
3 -	Maximum fan speed
Note: These three points meet or exceed required minimum FEI	

Figure H.2 — Fans Offered for Sale Over a Continuous Range of Speeds Limited by Required Minimum FEI



Definition of points	
1 -	Maximum airflow
2 -	Maximum pressure
3 -	Maximum fan speed
Note: These three points meet or exceed required minimum FEI	

Figure H.3 — Fans Offered for Sale Over a Continuous Range of Speeds Limited by Reasons Other than the Required Minimum FEI (e.g., maximum structural speed)



Definition of points	
1 -	Maximum airflow
2 -	Maximum pressure
3 -	Maximum fan speed
Note: These three points meet or exceed required minimum FEI	

Figure H.4 — Fans Offered for Sale at Discrete Fan Speeds and a Continuous Range of Pitches

Annex I
Minimum Data Requirements for Published Ratings (Informative)

I.1 Minimum requirements for published ratings
At a minimum, Published Ratings shall consist of the following information found in Sections I.3 and I.4.

I.2 Definitions

I.2.1 Fan outlet velocity
Average velocity of air emerging from an outlet measured in the plane of the outlet.

I.2.2 Published rating
A statement of the assigned values of performance characteristics, at stated rating conditions, by which a unit may be chosen to fit its application. These values apply to all units of like nominal size and type produced by the same manufacturer. The term “published rating” includes the rating of all performance characteristics shown on the unit or published in specifications, advertising or other literature controlled by the manufacturer, at stated rating conditions.

I.3 General requirements
For each published duty point, the following must be included:

- FEP_{act} in kilowatts
- FEP_{act} method of determination
    - Section 6.1, Wire-to-air testing at the required duty point
    - Section 6.2, Calculated ratings based on wire-to-air testing
    - Section 6.3, Bare shaft fans
    - Section 6.4, Fans with polyphase regulated motors
    - Section 6.5, Fans with power drive systems
- FEI, rounded to the nearest hundredth
- Fan airflow in cubic feet per minute
- Fan air density
- For a fan using a FEI on a total pressure basis:
    - Fan total pressure in inches of water gauge or
    - Fan static pressure in inches of water gauge and one of the following:
        - Fan outlet velocity in feet per minute,
        - Fan outlet area in square feet or
        - Fan velocity pressure in inches of water gauge
- For a fan using a FEI on a static pressure basis:
    - Fan static pressure in inches of water gauge
- Fan speed in revolutions per minute
- Fan shaft input power in horsepower for fans tested in accordance with Section 6.3, 6.4 or 6.5

I.4 Required information based on the FEP_{act} method of determination
Sections I.4.1 through I.4.4 contain additional required specific information that apply to the individual methods of determination in Section 6 and are in addition to the requirements in Section I.2.

I.4.1 Required information for fans in which FEP_{act} is determined per Section 6.1 or 6.2

- Fan model number
- Transmission type

I.4.2 Required information for fans in which FEP_{act} is determined per Section 6.3

- Model number of the bare shaft fan
- Modeled transmission type, direct drive or V-belt drive, used in the calculation

I.4.3 Requirements for fans in which FEP_{act} is determined per Section 6.4

- Model number of the bare shaft fan
- For the polyphase regulated motor:
  - Nameplate output horsepower
  - Number of poles
  - Enclosure type (open or enclosed)
- Type of transmission modeled (V-belt, synchronous belt drive, flexible coupling or direct drive)
- Voltage and output capacity of the VFD, if included, that was modeled

I.4.4 Requirements for fans in which FEP_{act} is determined per Section 6.5

- Model number of the bare shaft fan
- Type of transmission modeled (V-belt, synchronous belt drive, flexible coupling or direct drive)
- Model number of the motor or motor and motor controller

Annex J
Other Data and Calculations to be Retained (Informative)

J.1 Purpose
This annex describes which test data and calculations used to determine reported values per the requirements of this standard should be retained by manufacturer.

J.2 General requirements

J.2.1 Laboratory test data
The results of all tests performed per the requirements of Section 7 that are used for the calculations described in Annex H shall be retained. The fan test report must include the test results, test data and descriptions of the tested fan, including accessories (as allowed in accordance with Section 7.3) and test instruments. Additionally, the test report must include:

- Base test and fan test configuration described in Table 7.1 and test setup figure per Table 7.3 used to establish the FEI and FEP_{act}
- Pressure, airflow and fan electrical or fan shaft input power for each determination
- Section used to establish the FEI and FEP_{act} as listed in Table 6.1
- For series calculated fans per Annex E, the performance test data from the series tested fan shall be maintained. In addition, the fan dimensional data necessary to verify geometric similarity in accordance with Annex K for both the series calculated fan and the series tested fan shall be maintained
- For fans with test results calculated using Section E.3, the performance test data of the two tests used as the basis for the interpolation must be maintained as well as the raw data and calculations used to perform the interpolation
- The setting of any geometric feature (see list in Section E.3) that impacts the test results must be documented (examples include changes in axial fan blade pitch, centrifugal fan blade width and the distance from an impeller to a separating panel on fans for fan arrays)

J.2.2 Maximum reported values
The manufacturer must be able to show, via direct testing or calculation, at least one duty point each for maximum airflow, maximum pressure and maximum fan speed:

- FEI calculated per Section 4
- FEP_{ref} calculated per Section 5
- FEP_{act} calculated per Section 6

J.3 Fans in which FEP_{act} is determined per Section 6.1
For each of the reported values listed in Annex H, at least one tested duty point shall demonstrate that the fan meets or exceeds the required minimum FEI.

J.4 Fans in which FEP_{act} is determined per Section 6.2
The calculated interpolations per Annex G used to determine FEP_{act} at the duty points used for Annex H shall be retained.

J.5 Fans in which FEP_{act} is determined per Sections 6.3 through 6.5

J.5.1 Fan shaft input power
The calculations performed per Annex E used to determine fan shaft input power at the duty point for the values for Annex H shall be retained.

J.5.2 Series fans

The Annex E calculations used to determine the performance of series calculated fans with test data from a series tested fan shall be retained.

J.5.3 Transmission, motor and controller efficiencies

The calculations performed per Section 6.3, 6.4 or 6.5 used to determine FEP_{act} for the values for Annex H shall be retained.

Annex K
Proportionality and Dimensional Requirements (Normative)

K.1 General requirements

K.1.1 Tolerance and precision

Absolute proportionality is not always required to maintain the validity of calculated performance using the fan laws. Exceptions to strict proportionality are listed below. Other than the following items listed, all design dimensions shall be proportional within ±1%.

- The dimensions of the following items may be greater than that derived from proportionality:
  - *P* Panel size
  - *T* Length to belt tube
  - *K* Orifice depth
  - *R* Orifice radius
  - *M* Height above roof
  - *I* Inside curb
  - *F* Discharge size or area
  - *Q* Shaft height above base
  - *S* Shaft diameter, if shaft extends through box
  - *V* Hood size
  - *X* Wind band diameter
- The number of blades, *N*, shall be equal for all proportional fans.
- The number of vanes, *NV*, shall be equal for all proportional fans.
- The belt tube dimension, *J*, may be less than that derived from proportionality or up to 7½% larger.
- The hood height above the roof, dimension *M*, may be greater than that derived from proportionality. The hood depth, dimension *N*, may be less than that derived from proportionality provided that the sum of the *N* and *M* dimensions is proportional or greater.

K.1.2 Illustrations

In the illustrations, the term "size" is understood to mean diameter, length or width as appropriate for the product being described.

A Diameter at Blade Tip
B Diameter at Blade Heel
W Blade Width at Discharge
D Minimum Diameter at Inlet Cone
N Number of Blades

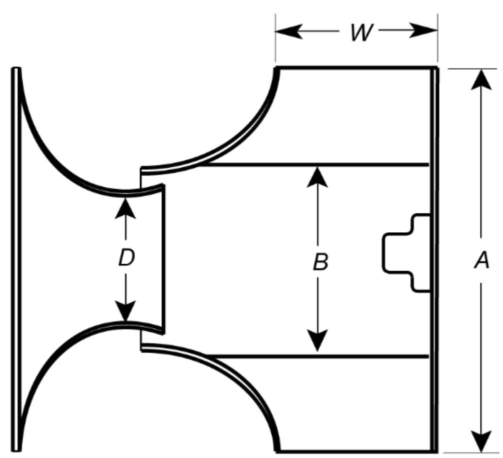


Figure K.1 — Backward Inclined Centrifugal Impeller

A	Diameter at Blade Tip
B	Diameter at Blade Heel
W	Blade Width at Discharge
D	Minimum Diameter at Inlet
N	Number of Blades

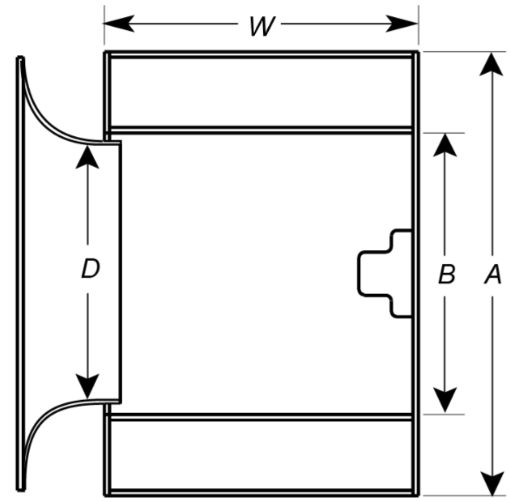


Figure K.2 — Forward Curved Centrifugal Impeller

A	Diameter at Blade Tip
B	Diameter at Blade Heel
W	Blade Width at Discharge
D	Inlet Diameter
N	Number of Blades

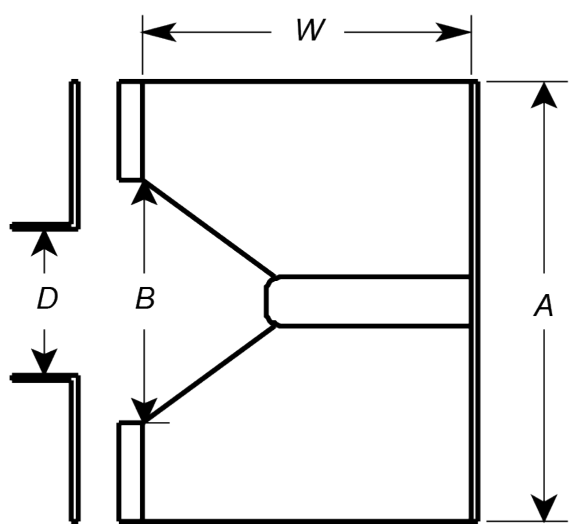


Figure K.3 — Radial Centrifugal Impeller

A	Major Diameter at Discharge
A_1	Minor Diameter at Discharge
B	Major Diameter at Blade Heel
W	Blade Width at Discharge
D	Minimum Diameter at Inlet Cone
N	Number of Blades

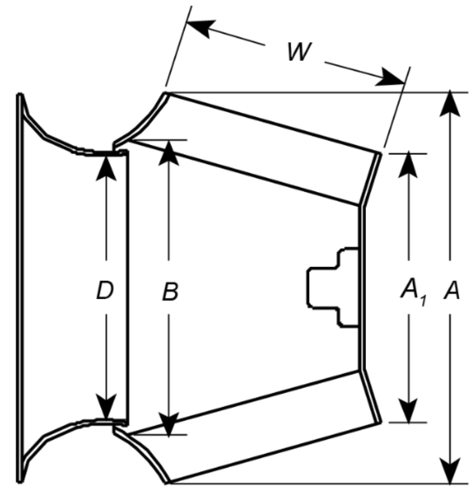


Figure K.4 — Mixed Flow Impeller

A	Diameter at Blade Tip
H	Hub Diameter
G	Blade Width at Discharge
α	Pitch Angle at Tip or at a Designated Radius
N	Number of Blades

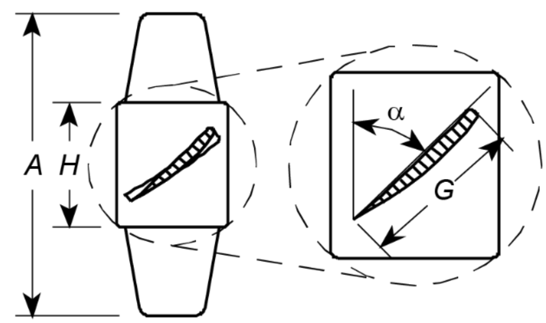


Figure K.5 — Vaneaxial Propeller

A	Diameter at Blade Tip
H	Hub Diameter
G	Blade Width at Tip
α	Pitch Angle at Tip or at a Designated Radius
N	Number of Blades

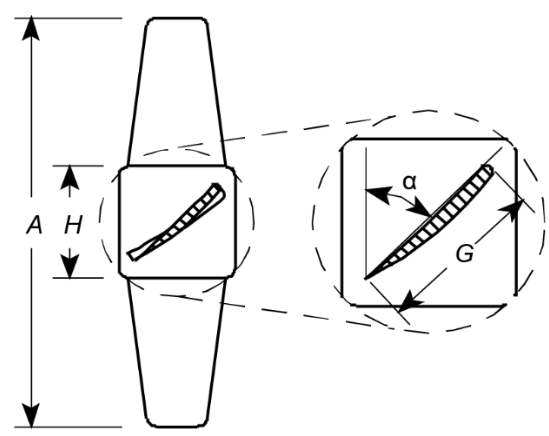


Figure K.6 — Tubeaxial Propeller

A Diameter
H Blade Root Diameter
G Blade Width at a Designated Radius
α Pitch Angle at a Designated Radius
N Number of Blades

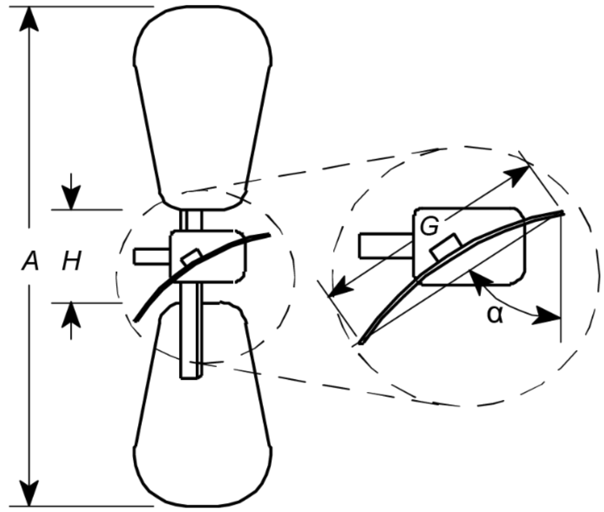
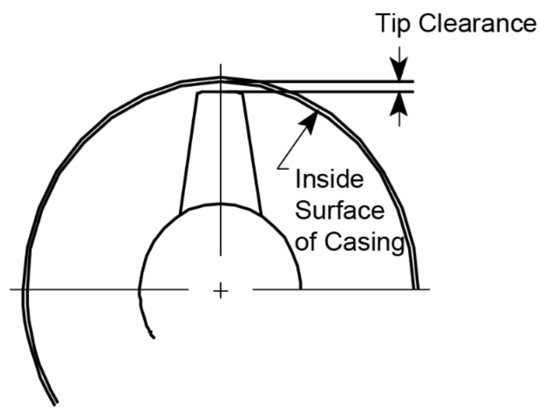


Figure K.7 — Fabricated Propeller

Design tip clearance is defined as the difference between the design radius of the impeller and the design internal radius of the fan casing. Measured tip clearance is defined as the average of the tip clearance measurement for all blades taken at eight locations (in 45-degree intervals) around the fan casing.



Note: This dimension is not required for proportionality.

Figure K.8 — Tip Clearance

A Width of Discharge
(or Evase, as Applicable)
B Height of Discharge
(or Evase, as Applicable)
C Point of Inlet Radius or Inlet Collar Diameter

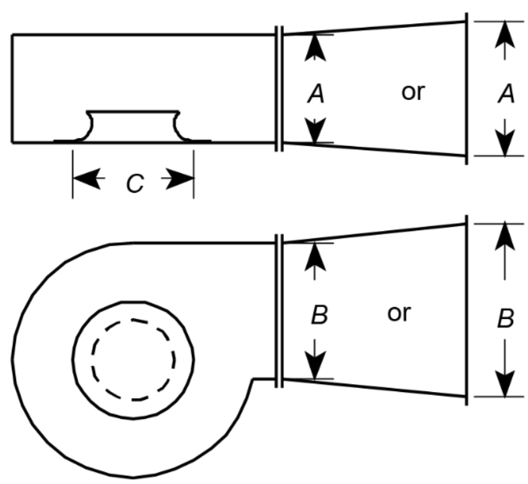


Figure K.9 — Centrifugal Fan Housing

S Shaft Diameter if Shaft Extends Through Box
A Inlet Height
B Inlet Width
L Inlet Box Length

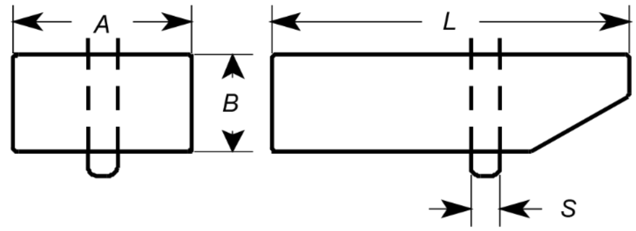


Figure K.10 — Inlet Box

Q Shaft Height Above Base
C Inlet Diameter at Tangent Point of Inlet Radius or Inlet Collar Diameter

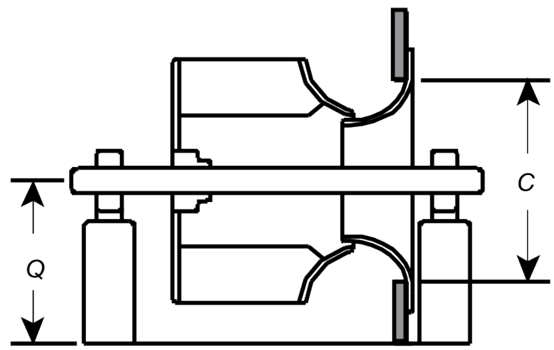


Figure K.11 — Arrangement 3 Plenum Fan

Q Shaft Height Above Base
C Inlet Diameter at Tangent Point of Inlet Radius or Inlet Collar Diameter

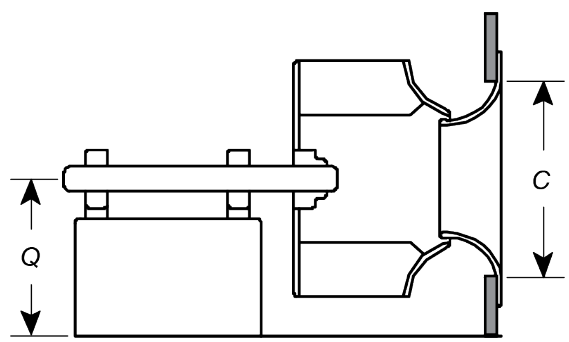


Figure K.12 — Arrangement 1 Plenum Fan

P Panel Size

C Inlet Diameter at Tangent Point of Inlet Radius or Inlet Collar Diameter

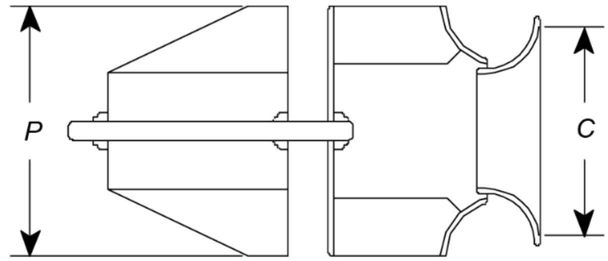
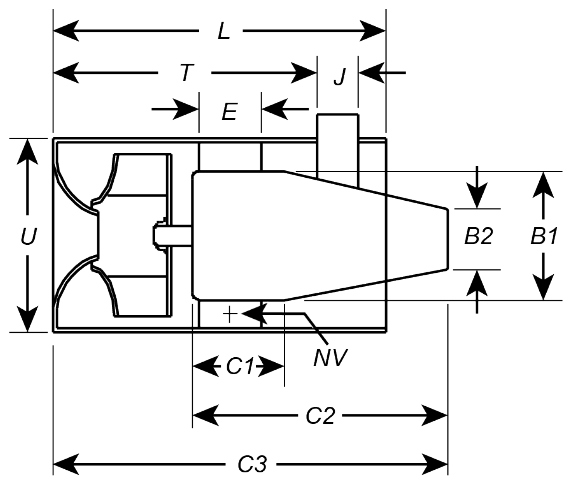


Figure K.13 — Plug Fan

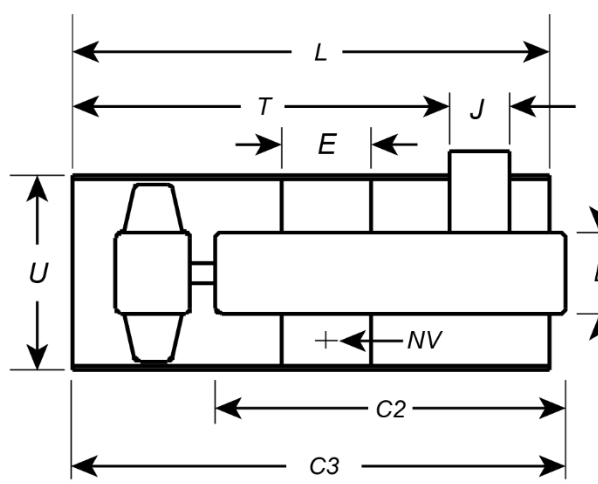
L Tube Length
T Length to Belt Tube
J Belt Tube Size
E Length of Vanes
U Drum Diameter or Square Size
B2 Interior Drum Size at Discharge
B1 Interior Drum Size
NV Number of Vanes
C1 Center Body Front Section
C2 Center Body Length
C3 Length to End of Center Body



Note: If *C3* is less than or equal to *L*, then *L* does not need to be proportional.

Figure K.14 — Inline Centrifugal Fan Belt Drive

L Tube Length
T Length to Belt Tube
J Belt Tube Size
E Length of Vanes
U Drum Diameter or Square Size
B Interior Drum Size at Discharge
NV Number of Vanes
C2 Center Body Length
C3 Length to End of Center Body



Note: If *C3* is less than or equal to *L*, then *L* does not need to be proportional.

Figure K.15 — Vaneaxial Fan Belt Drive

U Diameter - ID
B Inside Diameter of Vanes
E Length of Vanes
NV Number of Vanes

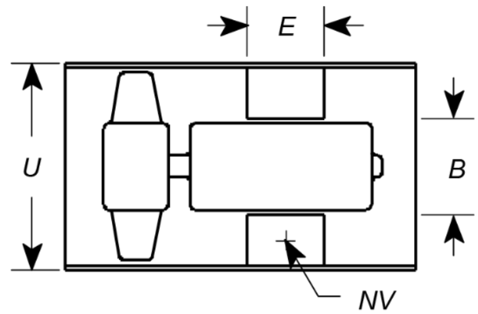


Figure K.16 — Vaneaxial Fan Direct Drive

U Diameter - ID
B Size of Drive Tube
T Length to Belt Tube
J Belt Tube Size

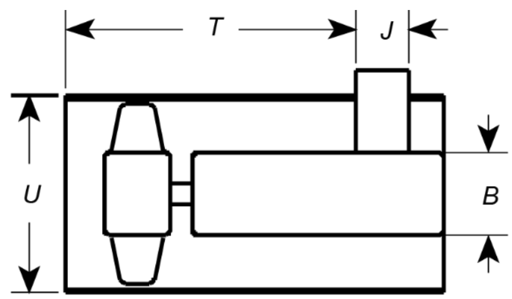


Figure K.17 — Tubeaxial Fan Belt Drive

U Diameter

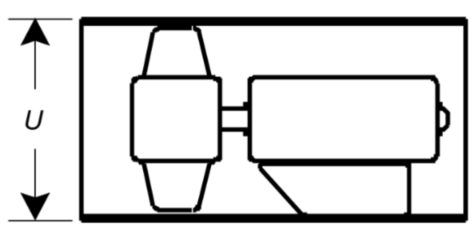


Figure K.18 — Tubeaxial Fan Direct Drive

O Orifice Diameter
K Orifice Depth
R Orifice Radius
P Panel or Ring Size

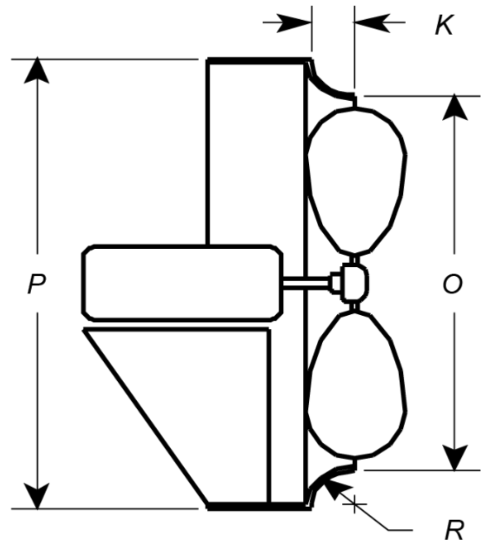


Figure K.19 — Propeller Fan

N Hood Height
V Hood Diameter
C Inlet Collar Diameter
I Recommended Inside Curb Dimension
M Minimum Height Above Roof
D_1 Inside Diameter of Discharge
D_2 Outside Diameter of Discharge

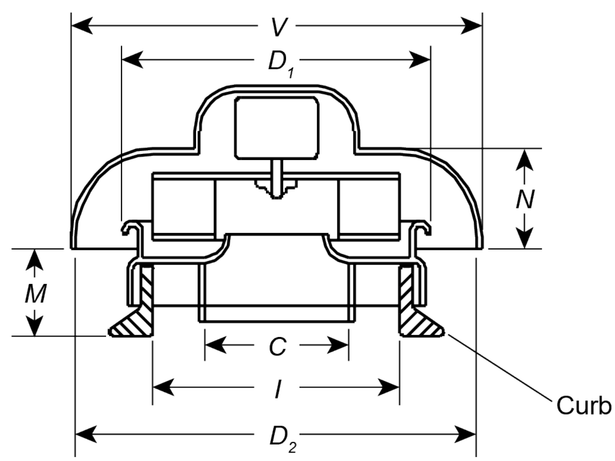


Figure K.20 — Centrifugal PRV Exhaust-Down Discharge

V	Hood Diameter
C	Inlet Collar Diameter
I	Recommended Inside Curb Dimension
D_1	Inside Diameter of Discharge
D_2	Outside Diameter of Discharge

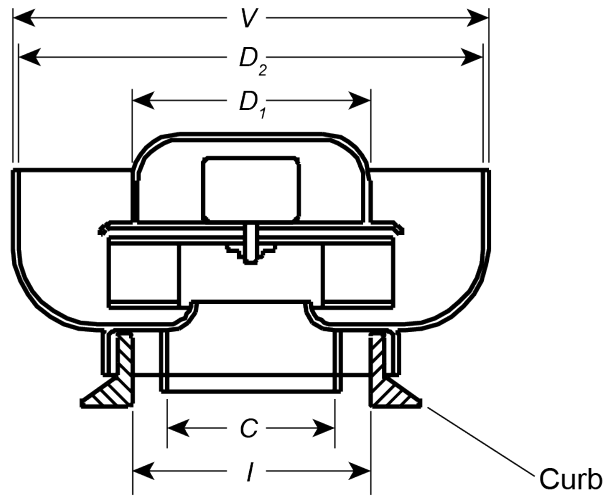


Figure K.21 — Centrifugal PRV Exhaust-Up Discharge

V	Hood Diameter
C	Inlet Collar Diameter
I	Recommended Inside Curb Dimension
M	Minimum Height Above Roof
O	Orifice Diameter
K	Orifice Depth
R	Orifice Radius
D_1	Inside Diameter of Discharge
D_2	Outside Diameter of Discharge

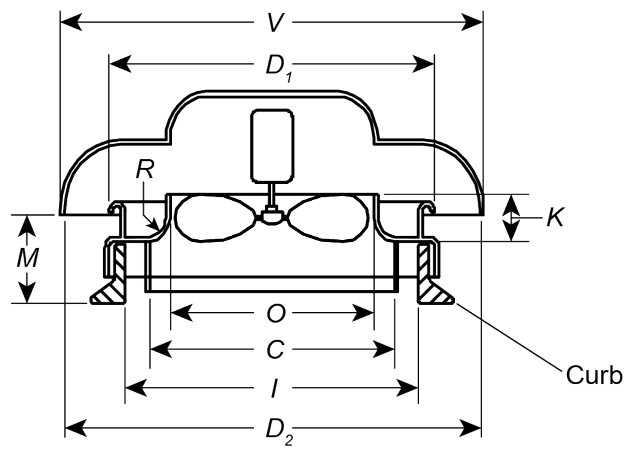


Figure K.22 — Axial PRV Supply or Exhaust

V	Hood Length
W	Hood Width
V_1	Body, Length Offset
W_1	Body, Width Offset
N	Hood Height
M	Height Above Base
Y	Body Size

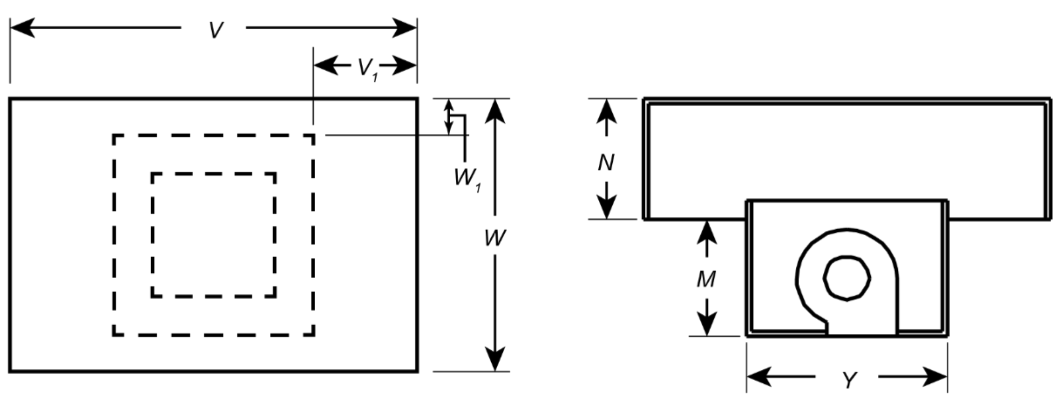


Figure K.23 — Centrifugal Supply PRV

X	Windband Diameter
C	Inlet Collar Size (If Provided)
O	Orifice Diameter
K	Orifice Depth
R	Orifice Radius
I	Recommended Inside Curb Dim.

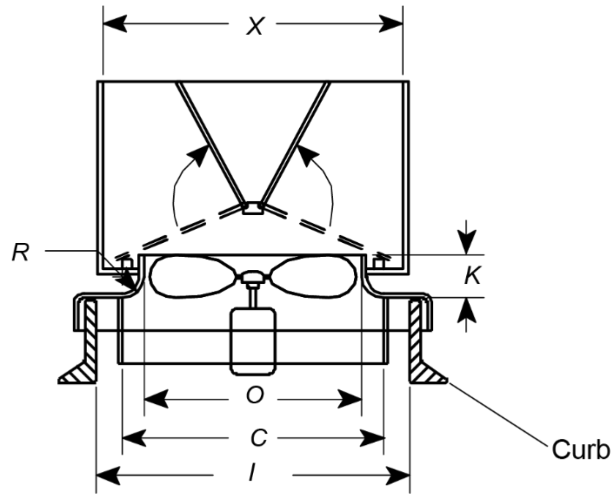


Figure K.24 — Axial Upblast PRV

C	Inlet Collar Size (If Provided)
X	Windband Diameter, Inside
I	Recommended Inside Curb Diameter

See Tubeaxial and Vaneaxial for Diameter Figures M.15 to M.18

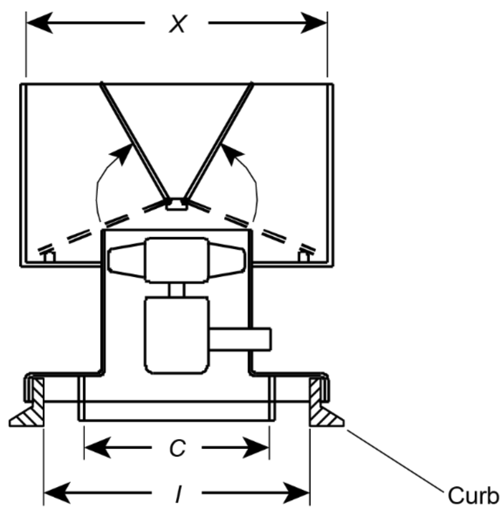


Figure K.25 — Axial Upblast PRV

V Hood Length
W Hood Width

N Hood Height
M Height Above Base
C Inlet Collar Size (If Provided)
I Recommended Inside Curb Dimension

See Tubeaxial Figures M.17 and M.18
for Required Fan Dimensions

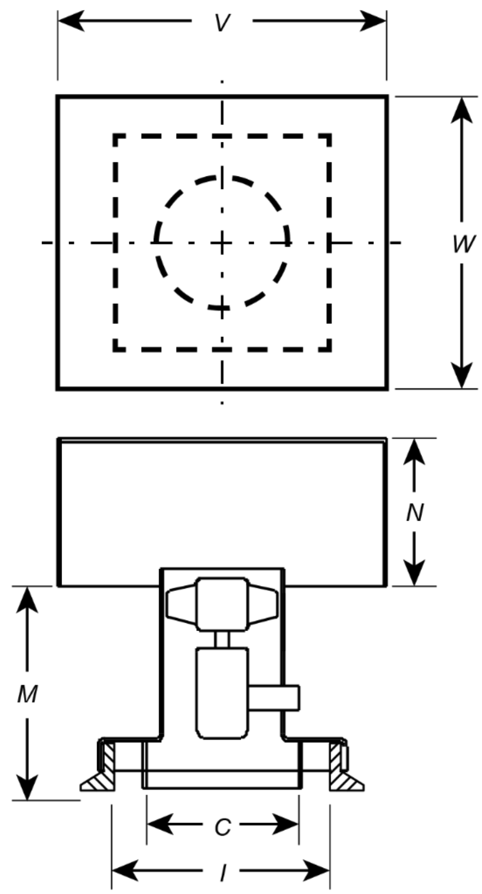


Figure K.26 — Axial Supply/Exhaust PRV

V	Hood Length
W	Hood Width
V_1	Body, Length Offset
W_1	Body, Width Offset
N	Hood Height
M	Height Above Base
R	Orifice Radius
K	Orifice Depth
O	Orifice Diameter
Y	Body Size

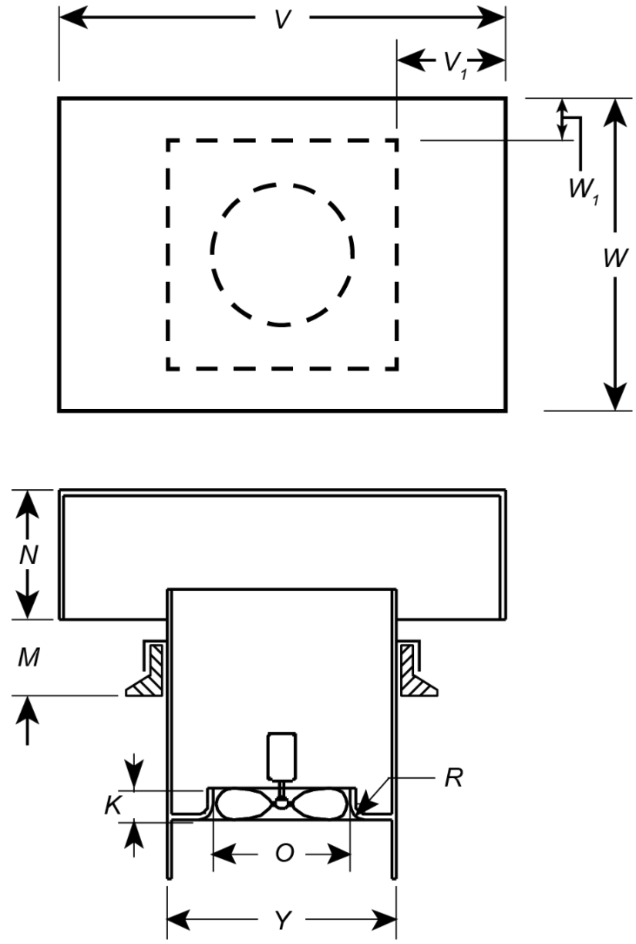


Figure K.27 — Combination PRV Exhaust-Supply-Circulate

Y	Body Size
K	Orifice Depth
O	Orifice Depth
R	Orifice Radius
X	Wind Band Diameter, Inside

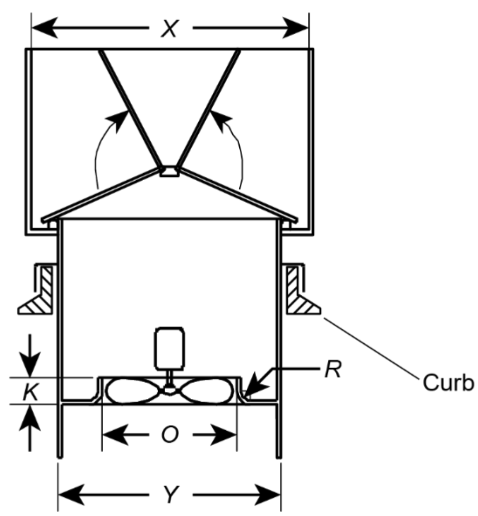
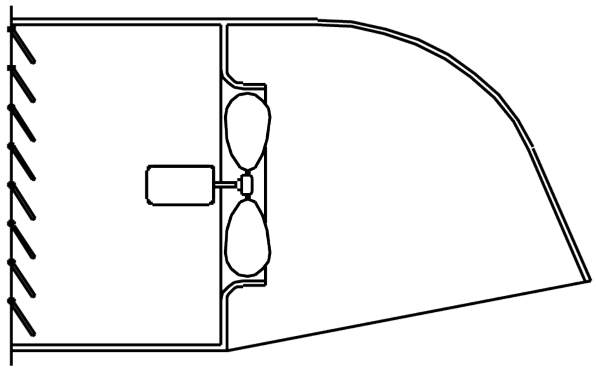


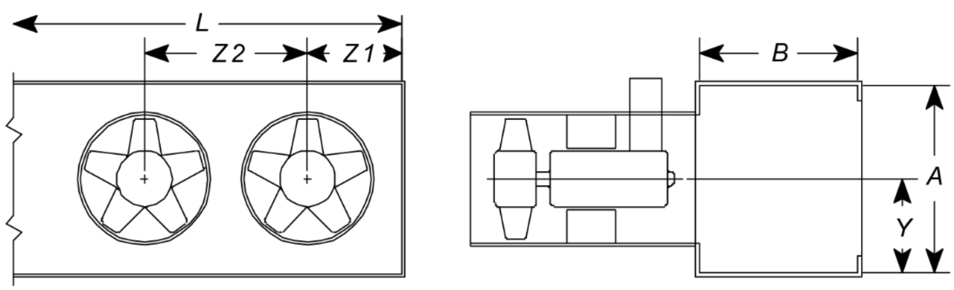
Figure K.28 — Combination PRV Exhaust/Circulate



See Figure M.19 for Dimensional Requirements for Propeller Fans
Provide All Dimensions Required to Define Inlet and/or Outlet Appurtenances

Figure K.29 — Agricultural Fans

L	Interior Width
Z1, Z2	Fan Spacing
A	Interior Height
B	Interior Depth
Y	Shaft Center Height



See Tubeaxial and Vaneaxial Figures M.15 to M.18 for Required Fan Dimensions

Figure K.30 — Vane/Tubeaxial Air Curtain

A	Interior Height
B	Interior Depth
L	Interior Width
V	Motor Spacing (where applicable)
W	Centrifugal Fan/Housing Width
X	Shaft Center Depth
Y	Shaft Center Heigfht
Z	Centrifugal Fan/Housing Spacing

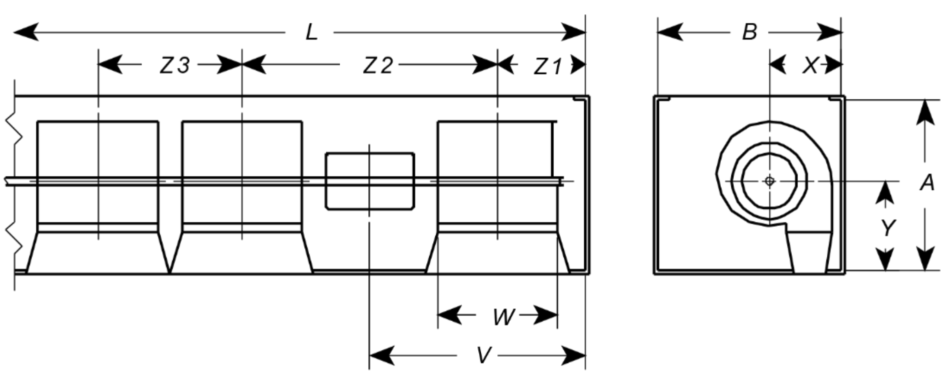


Figure K.31 — Centrifugal/Tangential Air Curtain

L	Interior Width
Z1, Z2	Axial Fan Spacing
W	Impeller Diameter at Blade Tip
A	Interior Height
B	Interior Depth
K	Orifice Depth
R	Orifice Radius
O	Min. Diameter of Inlet Cone
Y	Shaft Center height

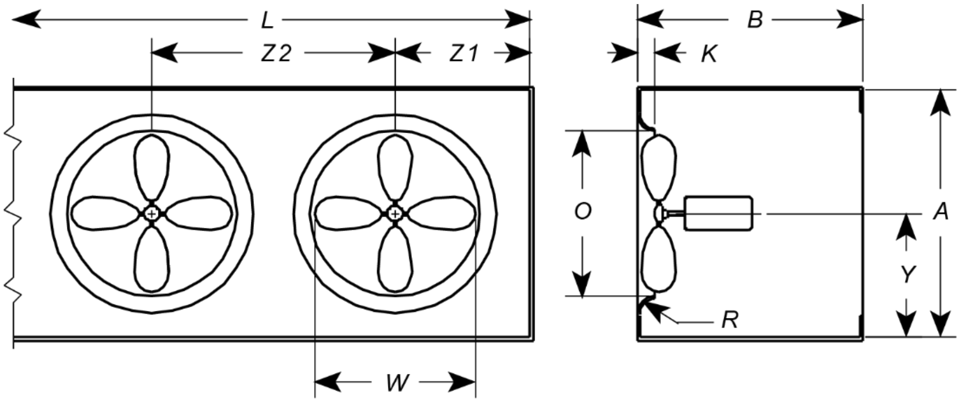


Figure K.32 — Axial Air Curtain

A	Housing Dimensions
B	Inlet Length
C	Outlet Length
K	Inlet Orifice Depth
O	Minimum Diameter of Inlet Orifice

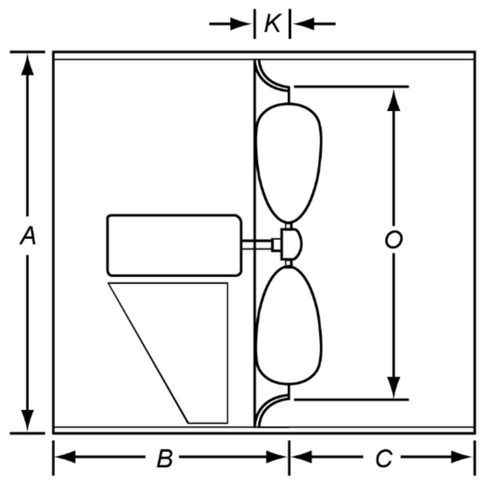


Figure K.33 — Circulating Fan

N1	Number of Rings
N2	Number of Radial Supports
T1	Ring Thickness
T2	Radial Support Thickness
S1	Ring Spacing

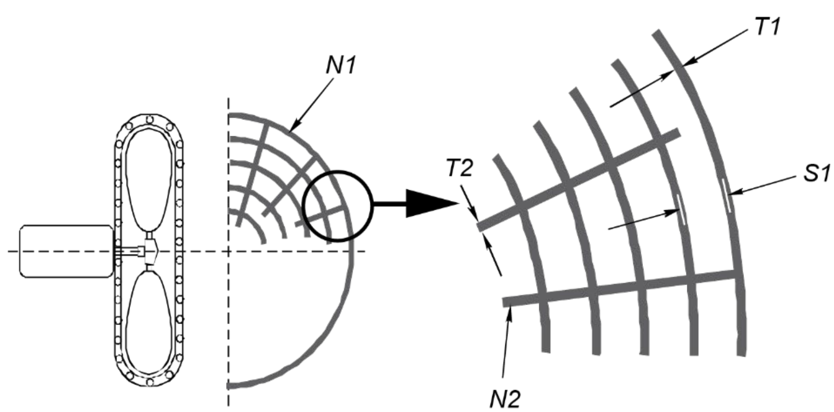
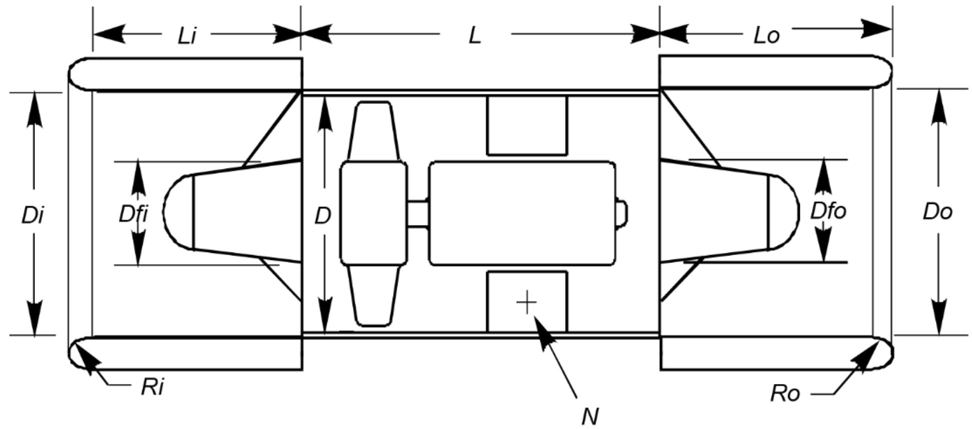


Figure K.34 — Circulating Fan Head with Guard

L	Fan Length
Li	Inlet Silencer Length
Lo	Outlet Silencer Length
D	Fan Diameter
Di	Inlet Silencer Diameter
Do	Outlet Silencer Diameter
Dfi	Inlet Fairing Diameter
Dfo	Outlet Fairing Diameter
Ri	Inlet Bell Radius
Ro	Outlet Bell Radius
N	Number of Vanes



Note: This figure is for reporting and is not used in a proportionality review.

Figure K.35 — Jet Fan

A	Nozzle Inlet Area After Blade Discharge
B	Nozzle Height
C	Nozzle Discharge Area
D	Windband Inlet Area
E	Windband Height
F	Windband Discharge Area
G	Overlap Between Nozzle and Windband

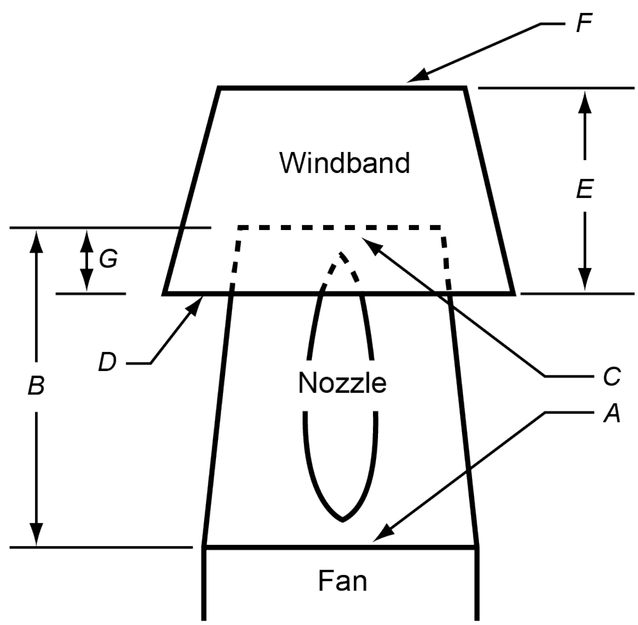


Figure K.36 — Induced Flow Fan Nozzle and Windband

A	Impeller Diameter
H	Hub Diameter
G	Blade Width at Tip
α	Pitch Angle at Tip or at a Designated Radius
N	Number of Blades

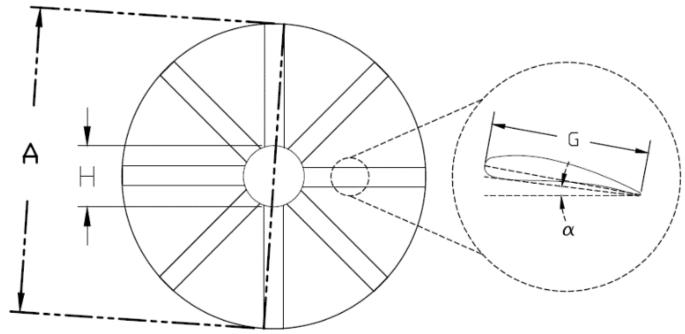


Figure K.37 — Ceiling Fan

RESOURCES

AMCA Membership Information
http://www.amca.org/member

AMCA International Headquarters and Laboratory
www.amca.org

AMCA White Papers
www.amca.org/whitepapers

Searchable CRP Database of AMCA Certified Products
www.amca.org/certified

VISIT THE AMCA STORE

AMCA provides its Publications and Standards through the AMCA Store. Any document selected will bring up options for a free or at-cost PDF, and, where applicable, at-cost print (hard copy), redline, multi-user license, and PDF + print options. To access member-only pricing and access your 50% discount, first log into amca.org/login or click on amca.org/login from within the AMCA website. For more information on AMCA Publications and Standards, visit www.amca.org/store.

Air Movement and Control Association International

AMCA Corporate Headquarters
30 W. University Drive, Arlington Heights, IL 60004-1893, USA
communications@amca.org ▪ Ph: +1-847-394-0150 ▪ www.amca.org

The Air Movement and Control Association International Inc. is a not-for-profit association of the world's manufacturers of air system equipment, such as fans, louvers, dampers, air curtains, airflow measurement stations, acoustic attenuators, and other air system components for the industrial and commercial markets.