

ANSI/AMCA Standard 99-10

Standards Handbook

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**AIR MOVEMENT AND CONTROL
ASSOCIATION INTERNATIONAL, INC.**

The International Authority on Air System Components



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ANSI/AMCA Standard 99-10

Standards Handbook



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0021 _ The Fan Laws

Fan impellers differ from one another in many respects, even among those of the same type. One characteristic that all share is that each individual impeller design can be uniquely related to the overall diameter of the impeller. Because of this unique relationship, all impellers that share the same geometric design but differ only in size are said to have similarity. Fan casings share in this unique relationship, with the casing being optimized with respect to an impeller design so that aerodynamic performance goals are achieved. A fan design, then, is a geometrically unique combination of fan impeller and fan casing. All sizes of fans produced according to this unique geometry have similarity based on their respective diameters. Similarity is useful in that it enables the prediction of aerodynamic performance: given the performance of a fan of a given diameter at a certain rotational speed and a certain air density, the performance of that same unique geometry at another impeller diameter, or rotational speed or air density can be determined.

Note that the variables that affect a fan's aerodynamic performance are: impeller diameter, rotational speed and air density. Since these variables are expressed as ratios, they are dimensionless and are independent of the system of units used, as long as the units are used consistently for each ratio.

The mathematical statements which describe the effects of these factors on aerodynamic performance for any known performance point are known collectively as the FAN LAWS.

Fan Laws For Compressible Flow

As with all laws, some similarity requirements must be met if the FAN LAWS are to be effective:

A. Design Geometry

Geometric similarity must exist between any two fan sizes; i.e., dimensions must be proportional and angularity must be constant for all essential air passages of the impeller and the casing.

B. Gas Density

As air moves through the fan, it is acted upon by the rotating impeller and there results a pressure rise. With a pressure rise, one would expect that the gas undergoes compression. Compression, in turn, means a change in gas density.

The compressibility coefficient, K_p , must be calculated for the condition. The supporting formulas for K_p originate in ANSI/AMCA Standard 210-07, Annex D.

C. Reynolds Number

Reynolds number is one of many descriptors of fan performance, and further information is available in most textbooks on fluid mechanics. For our purposes here, it is necessary to know that for a given fan design geometry, there are many possible Reynolds numbers, and that there is a threshold value on either side of which fluids behave differently. The similarity requirement here is that both sets of operating parameters result in Reynolds numbers such that the effect of any difference between them is negligible. The implied requirement is that both of the Reynolds numbers must be on the same side of the threshold value. For additional information on Reynolds number, see Handbook of Fan Engineering, latest edition.

D. Mach Number

Mach number relates to the velocity of a gas (air) as it passes into or through a fan. Similarity requires that the Mach numbers for the two sets of parameters must be reasonably close. Just as was the case with Reynolds number, there is a threshold value and a difference in performance on either side of the threshold. Since almost all fans operate well below the threshold value for Mach number, no procedure for determining the threshold value is given in this document.

Then for any given point on a fan performance curve, the relationship between a known performance point and desired performance point, c (converted), is given by the **Fan Laws**.

The Fan Laws

1st Law:

$$\left[\frac{Q_c}{Q} \right] = \left[\frac{D_c}{D} \right]^3 \left[\frac{N_c}{N} \right] \left[\frac{K_p}{K_{pc}} \right]$$

2nd Law:

$$\left[\frac{P_{tc}}{P_t} \right] = \left[\frac{D_c}{D} \right]^2 \left[\frac{N_c}{N} \right]^2 \left[\frac{K_p}{K_{pc}} \right] \left[\frac{\rho_c}{\rho} \right]$$

3rd Law:

$$\left[\frac{P_{vc}}{P_v} \right] = \left[\frac{D_c}{D} \right]^2 \left[\frac{N_c}{N} \right]^2 \left[\frac{\rho_c}{\rho} \right]$$

4th Law:

$$\left[\frac{H_c}{H} \right] = \left[\frac{D_c}{D} \right]^5 \left[\frac{N_c}{N} \right]^3 \left[\frac{K_p}{K_{pc}} \right] \left[\frac{\rho_c}{\rho} \right]$$

5th Law:

$$P_{sc} = P_{tc} - P_{vc}$$

Where: P_{tc} and P_{vc} are established per the 2nd and 3rd Fan Laws.

6th Law:

$$\eta_{sc} = \eta_{tc} \left[\frac{P_{sc}}{P_{tc}} \right]$$

Where: P_{sc} is established using the 5th Fan Law and P_{tc} is established using the 2nd Fan Law.

In the above, subscript c denotes the new operating condition, and:

D = Impeller diameter
 D_c = Impeller diameter, converted
 N = Impeller rotational speed
 N_c = Impeller rotational speed, converted
 Q = Volume airflow rate
 Q_c = Volume airflow rate, converted
 P_t = Pressure, total
 P_{tc} = Pressure, total, converted
 P_v = Pressure, velocity
 P_{vc} = Pressure, velocity, converted
 H = Power
 H_c = Power, converted
 P_s = Pressure, static
 P_{sc} = Pressure, static, converted
 η_{sc} = Efficiency, static, converted
 η_{tc} = Efficiency, total, converted

and K_p and K_{pc} are determined from:

$$K_p = \left[\frac{\ln(1+x)}{x} \right] \left[\frac{z}{\ln(1+z)} \right]$$

$$x = \frac{P_t}{P_{t1} + (C_b p_b)}$$

$$z = \left[\frac{\gamma-1}{\gamma} \right] \left[\frac{C_h H}{Q(P_{t1} + [C_b p_b])} \right]$$

$$\frac{z_c}{z} = \left[\frac{P_{t1} + C_b p_b}{P_{t1c} + C_b p_{bc}} \right] \left[\frac{\rho_c}{\rho} \right] \left[\frac{N_c}{N} \right]^2 \left[\frac{D_c}{D} \right]^2 \left[\frac{\gamma}{\gamma-1} \right] \left[\frac{\gamma_c-1}{\gamma_c} \right]$$

$$K_{pc} = \left\{ \left[1 + \left(\frac{\eta_t \gamma_c}{\gamma_c - 1} - 1 \right) \right] \left[\frac{z_c}{2} \right] + \left[\frac{\eta_t \gamma_c}{\gamma_c - 1} - 1 \right] \left[\frac{\eta_c \gamma_c}{\gamma_c - 1} - 2 \right] \left[\frac{z_c^2}{6} \right] \right\}^{-1}$$

An approximation derived from a series expansion, sufficiently accurate for $K_p \geq 0.9$, and fan mechanical efficiency η_t is given by:

$$\eta_t = \frac{QP_t K_p}{C_h H}$$

Note: For all fans, $\eta_t = \eta_{tc}$ (for incompressible flow only)

Where:

K_p = Compressibility coefficient
 K_{pc} = Compressibility coefficient, converted
 x = A coefficient of convenience in the equation
 z = A coefficient of convenience in the equation
 P_{t1} = Total pressure at fan inlet
 C_b = Barometer constant: SI = 1 (I-P = 13.63)

C_h = Power constant: SI = 1 (I-P = 6362)
 p_b = Barometer pressure, Pa (in. Hg)
 γ = Ratio of specific heats = 1.4

Example

The following example shows how the Fan Laws, including compressibility, are applied in aerodynamic performance predictions for a given fan design.

Known Parameters:		SI	I-P
impeller diameter	D	927 mm	36.5 inches
fan rotational speed	N	1000 rpm	1000 rpm
air density	ρ	1.152 kg/m ³	0.072 lbm/ft ³
volume airflow rate	Q	7.952 m ³ /s	16850 cfm
total pressure	P_t	953.7 Pa	3.84 in. wg
barometric pressure	p_b	97.359 kPa	28.75 in. Hg
power	H	9299 W	12.47 hp
ratio of specific heats	γ	1.4	1.4

Conversion Parameters:		SI	I-P
impeller diameter	D_c	1524 mm	60 inches
fan rotational speed	N_c	820 rpm	820 rpm
air density	ρ_c	1.2 kg/m ³	0.075 lbm/ft ³
volume airflow rate	Q_c	UNKNOWN	UNKNOWN
total pressure	P_{tc}	UNKNOWN	UNKNOWN
power	H_c	UNKNOWN	UNKNOWN
barometric pressure	p_b	101.321 kPa	29.92 in. Hg

To determine the flow rate Q_c and pressure P_{tc} , Fan Laws 1 and 2 must be used. The GIVEN and CONVERTED conditions provide all the information required for the calculations except K_p and K_{pc} .

Determine K_p :

$$K_p = \left[\frac{\ln(1+x)}{x} \right] \left[\frac{z}{\ln(1+z)} \right]$$

Example Calculations In SI Units:

$$x = \frac{P_t}{P_{t1} + C_b \rho_b} = \frac{953.7}{0 + ((1)(97359))} = \frac{953.7}{97,359}$$

$$x = 0.0097957$$

$$z = \left[\frac{\gamma - 1}{\gamma} \right] \left[\frac{C_h H}{Q(P_{t1} + [C_b \rho_b])} \right] = \left[\frac{1.4 - 1}{1.4} \right] \left[\frac{(1)(9299)}{7.952(0 + (1)(97,359))} \right]$$

$$z = 0.0034317$$

$$K_p = \left[\frac{\ln(1+x)}{x} \right] \left[\frac{z}{\ln(1+z)} \right] = \left[\frac{\ln(1+0.0097957)}{0.0097957} \right] \left[\frac{0.0034317}{\ln(1+0.0034317)} \right]$$

$$K_p = 0.99684$$

$$\eta_t = \frac{QP_t K_p}{C_h H} = \left[\frac{(7.952)(953.7)(0.99684)}{(1)(9299)} \right]$$

$$\eta_t = 0.813 \text{ or } 81.3\%$$

To determine K_{pc} , calculate the factors in the necessary equations:

$$\frac{z_c}{z} = \left[\frac{P_{t1} + C_b \rho_b}{P_{t1c} + C_b \rho_{bc}} \right] \left[\frac{\rho_c}{\rho} \right] \left[\frac{N_c}{N} \right]^2 \left[\frac{D_c}{D} \right]^2 = \left[\frac{0 + (1 \times 97,359)}{0 + (1 \times 101,321)} \right] \left[\frac{1.2}{1.152} \right] \left[\frac{820}{1000} \right]^2 \left[\frac{1524}{927} \right]^2$$

$$\frac{z_c}{z} = 1.81905$$

Then:

$$\frac{z_c}{z}(z) = (1.81905)(0.0034317) = (0.006242)$$

And:

$$\left[\frac{(\eta_t)(\gamma_c)}{\gamma_c - 1} \right] = \left[\frac{(0.813)(1.4)}{1.4 - 1} \right] = \left[\frac{1.1382}{0.4} \right] = 2.8455$$

$$K_{pc} = \frac{1}{1 + (2.8455 - 1) \left(\frac{0.006243}{2} \right) + (2.8455 - 1)(2.8455 - 2) \left(\frac{0.006243^2}{6} \right)}$$

Then:

$$K_{pc} = 0.994235$$

And to obtain the values for the unknowns at the converted conditions:

$$Q_c = 7.952 \left[\frac{1524}{927} \right]^3 \left[\frac{820}{1000} \right] \left[\frac{0.99684}{0.994235} \right]$$

$$= 29.05 \text{ m/s}^3$$

$$P_{tc} = 953.7 \left[\frac{1524}{927} \right]^2 \left[\frac{820}{1000} \right]^2 \left[\frac{1.2}{1.152} \right] \left[\frac{0.99684}{0.994235} \right]$$

$$= 18.10 \text{ Pa}$$

$$H_c = 9.299 \left[\frac{1524}{927} \right]^5 \left[\frac{820}{1000} \right]^3 \left[\frac{1.2}{1.152} \right] \left[\frac{0.99684}{0.994235} \right]$$

$$= 64.31 \text{ kW}$$

Example Calculations in I-P Units:

$$x = \frac{P_t}{P_{t1} + C_b \rho_b} = \frac{3.84}{0 + (13.63)(28.75)} = \frac{3.84}{391.86}$$

$$x = 0.0097994$$

$$z = \left[\frac{\gamma - 1}{\gamma} \right] \left[\frac{C_h H}{Q(P_{t1} + (C_b \rho_b))} \right] = \left[\frac{1.4 - 1}{1.4} \right] \left[\frac{(6362)(12.47)}{16,850(0 + (13.63)(28.75))} \right] = \left[\frac{0.4}{1.4} \right] \left[\frac{79334.14}{16,850(0 + 391.86)} \right]$$

$$= \left[\frac{(0.2857)(79334.14)}{(16,850)(391.86)} \right] = \left[\frac{(22665.76)}{(6,602,841)} \right]$$

$$z = 0.0034327$$

To determine K_{pc} , calculate the factors in the necessary equations:

$$\frac{z_c}{z} = \left[\frac{P_{t1} + C_b p_b}{P_{t1c} + C_b p_{bc}} \right] \left[\frac{\rho_c}{\rho} \right] \left[\frac{N_c}{N} \right]^2 \left[\frac{D_c}{D} \right]^2 = \left[\frac{0 + (13.63)(3.84)}{0 + (13.63)(28.75)} \right] \left[\frac{0.075}{0.072} \right] \left[\frac{820}{1000} \right]^2 \left[\frac{60}{36.5} \right]^2$$

$$= 1.818652$$

$$z_c = (1.818652)(0.0034327) = 0.006243$$

And:

$$\left[\frac{(\eta_t)(\gamma_c)}{\gamma_c - 1} \right] = \left[\frac{(0.813)(1.4)}{1.4 - 1} \right] = \left[\frac{1.1382}{0.4} \right] = 2.8455$$

$$K_{pc} = \frac{1}{1 + (2.8455 - 1) \left(\frac{0.006243}{2} \right) + (2.8455 - 1)(2.8455 - 2) \left(\frac{0.006243^2}{6} \right)}$$

Then:

$$K_{pc} = 0.994262$$

And to obtain the values for the unknowns at the converted condition:

$$Q_c = 16,850 \left[\frac{60.0}{36.5} \right]^3 \left[\frac{820}{1000} \right]^2 \left[\frac{0.075}{0.072} \right] \left[\frac{0.99684}{0.99426} \right]$$

$$= 61,534 \text{ cfm}$$

$$P_{tc} = 3.84 \left[\frac{60.0}{36.5} \right]^2 \left[\frac{820}{1000} \right]^2 \left[\frac{0.075}{0.072} \right] \left[\frac{0.99684}{0.99426} \right]$$

$$= 7.2867 \text{ in.wg}$$

$$H_c = 12.47 \left[\frac{60.0}{36.5} \right]^5 \left[\frac{820}{1000} \right]^3 \left[\frac{0.075}{0.072} \right] \left[\frac{0.99684}{0.99426} \right]$$

$$= 86.189 \text{ hp}$$

0066 _ The AMCA Vocabulary: Definitions

Absolute Pressure

Pressure above a perfect vacuum; the sum of gauge pressure and atmospheric pressure.

Absolute Roughness

A measure of surface unevenness; the distance between high and low points on a surface.

ACFM (Actual Cubic Feet Per Minute)

Actual volume airflow rate through a plane of measurement, at the existing air density, expressed in ft³/min.

ACMS (Actual Cubic Meters Per Second)

Actual volume airflow rate through a plane of measurement, at the existing air density, expressed in m³/s.

Actuator (Operator)

A mechanism attached to a damper or adjustable louver to move its blades, or attached to a vaneaxial fan to change impeller blade pitch. An actuator may be manually, electrically, pneumatically or hydraulically powered.

Acoustic Attenuation Device

Any component having sound absorption as its primary function.

Adjustable Pitch

The ability to mechanically alter the angle (pitch) of an impeller blade with the impeller at rest.

Air Curtain (Airstream)

A directionally-controlled stream of air, moving across the entire height and width of an opening, which reduces the infiltration or transfer of air from one side of the opening to the other and/or inhibits the passage of insects, dust, or debris.

Air Curtain Average Core Velocity

The average of several air curtain core velocities measured along the width of the air curtain.

Air Curtain Core Velocity

The peak air velocity of the air curtain as measured across the air curtain depth at a specified distance from the discharge nozzle.

Air Curtain Depth

The airstream dimension perpendicular to both the height and width of the opening being protected.

Air Curtain Unit Efficiency

The ratio of the air curtain output air power to the power input to the motor, expressed as a percentage.

Air Curtain Unit Rated Throw

The distance away from an air curtain unit discharge nozzle to a point where a specified minimum air velocity is achieved.

Air Curtain Unit Velocity Projection

The average air curtain core velocity at specified distances from the air curtain unit discharge nozzle.

Air Curtain Width

The airstream dimension perpendicular to the direction of airflow and parallel to the width of the opening being protected.

Air (Gas) Density

The mass per unit volume of air or gas.

Airflow Rate – See **Volume Airflow Rate** or **Mass Airflow Rate**

Airfoil

- (1) A shape such that, when it is moved through air, has greater lift than drag.
- (2) A blade or vane having a streamlined shape.

Air System

An assembly of connected ducts, filters, conditioning devices, dampers, louvers and fans for the purpose of moving air from one place to another in a controlled fashion.

Air Throw

The horizontal or vertical axis distance an air stream travels after leaving an air outlet before the air velocity is reduced to a specific terminal value.

AMCA Testing Laboratory

The association's testing laboratory, currently located in Arlington Heights, Illinois, or an independent laboratory licensed by AMCA to perform pre-certification performance tests and performance check tests.

AMCA Accredited Laboratory

A laboratory equipped and staffed to conduct tests according to the appropriate AMCA-accepted test method, and which has been inspected by an AMCA staff engineer and duly approved for such testing.

Anechoic Termination

A device placed at the end of a test duct to prevent excessive reflection of sound waves back into the duct, thus reducing interference with the sound waves being measured.

Attenuate

To weaken a signal by reducing its amplitude.

Attenuation

The amount by which sound amplitude is decreased as it travels from a sound source to a receiver located at a given point.

Average Outlet Velocity

- (1) The airflow rate of a fan per unit area of the fan discharge, calculated by dividing the airflow rate by the area of the fan discharge.
- (2) The free-delivery airflow rate of an air curtain unit divided by the face area of the discharge nozzle.

Axle

A shaft on which a damper or louver blade rotates.

Backplate

A circular plate, a component of a centrifugal fan impeller, which is attached to the fan hub and serves as the major attachment for the impeller blades and as the means of transmitting torque to them.

Backplate / Centerplate Liner

A narrow strip of steel, ceramic or synthetic material, installed in sets, each attached to the backplate / centerplate of an impeller, adjacent to an impeller blade, for the purpose of protection against erosion.

Balancing

The process of adding or removing mass on a rotor to move the center of gravity toward the axis of rotation so as to reduce the unbalanced forces.

Barometric

Pertaining to a barometer or the results obtained by using a barometer.

Barometric Pressure

The absolute pressure exerted by the atmosphere at a location of measurement.

Bearing Loss

The power loss resulting from friction in the main bearings of a fan or motor.

Blade

- (1) The flow element of an impeller, which, by its shape and motion, generates airflow inside a fan, transforming impeller rotational energy to kinetic energy of airflow;
- (2) A movable surface in a damper or louver that can be rotated to control airflow;
- (3) A stationary louver surface intended to restrict the passage of water, sound or other airborne materials, or to limit visual see-through.

Blade Entry Seal

The sealing arrangement through which a damper blade passes in a guillotine damper.

Blade Liner

A steel, ceramic or synthetic material piece having the same size and shape as the fan blade, which covers the fan blade face in part or completely for the purpose of protection against erosion.

Blade Passage Frequency (BPF)

The tone generated by the fan's blades passing a fixed object and having a frequency given by: $f(\text{Hz}) = (\text{number of blades} \times \text{fan revolutions per minute}) / 60$.

Blade Support

- (1) A structural member, located inside the duct section of a guillotine damper frame, which supports the blade load when the damper is in the closed position;
- (2) A bracket that connects a stationary louver blade to a rear-mounted structural support.

Blast Area

The outlet area of a centrifugal fan less the projected area of its cut-off.

Bonnet

The portion of a guillotine damper that supports the damper blade when the damper is in the open position.

- (1) Open Type: The damper blade is exposed to the atmosphere when blade is withdrawn from the duct.
- (2) Fully Enclosed (Sealed) Type: The entire bonnet encloses the damper blade when the damper is in the open position.

Casing – See Housing

Centerline Support

A method of supporting a fan housing at its centerline when necessary to control differential thermal growth of the housing.

Centerplate – see Backplate

Certified Rating

A published performance rating of a product which AMCA has licensed to bear the AMCA Certified Performance logo.

Rating Seal. The seller of the product certifies that the rating is in accordance with the appropriate AMCA-approved test method and that the requirements of the AMCA Certified Ratings Program have been met.

Certified Ratings Program (CRP)

The testing and licensing program established by AMCA International to verify the published performance ratings of a product produced by a seller.

Chamber

- (1) A test enclosure having a means for settling airflow, a cross sectional area larger than the inlet/outlet of test equipment connected to it, and the capability for measuring airflow rate and pressure.
- (2) An enclosure used to regulate airflow and to absorb sound.

Class Standard

An established minimum performance level of fan aerodynamic performance in terms of pressure and airflow rate.

Compressibility

The characteristic of air or a gas whereby its density is a function of pressure.

Compressibility Coefficient

A thermodynamic coefficient used to correct the perfect gas equation when applied to air or gas.

Continuous Line (Continuous Blade)

A term describing a louver constructed with blades that present an uninterrupted horizontal or vertical line to complement or enhance architectural features.

Controllable Pitch Impeller

An axial impeller having a mechanism by which the pitch angle of all the impeller blades can be changed while the impeller is rotating.

Core Area

The front cross-sectional area (product of minimum width and minimum height) of the front opening of a louver assembly with the blades removed.

Core Area Velocity

The airflow rate through a louver divided by its core area.

Corrosion Resistant

A term descriptive of materials or surface treatments that reduce corrosive attack.

Counterbalance

Weights or springs that offset the unbalanced weight of an eccentrically pivoted damper blade.

Counterweight

An adjustable or variable weight used to offset (counterbalance) an eccentrically pivoted damper blade.

Critical Speed, First

The rotational speed of a fan corresponding to the lowest natural frequency of the rotating fan impeller and shaft assembly when mounted on rigid supports without benefit of damping.

Cut-Off

A baffle or plate at the narrowest radial distance between the impeller and the housing near the outlet of a centrifugal fan, and which directs air away from the impeller and minimizes recirculation of air.

Curb

A roof penetration with a raised perimeter to seal against the weather and to facilitate installation of roof mounted ventilation equipment such as a fan or hood.

Decibel

A dimensionless number expressing, in logarithmic terms, a level of sound pressure or power.

Density

The mass per unit volume of a gas, liquid, or solid.

Determination

The complete set of measurements for a particular point of operation for a product under test. The measurements must be sufficient to determine all performance variables.

Diffuser

- (1) A duct discharge termination through a ceiling for the control and discharge of air;
- (2) A gradual transition of a duct, located at a fan outlet, which increases in cross sectional area and permits a portion of velocity pressure to be regained as static pressure; also known as an evasé.

Discharge Angle

- (1) The angle formed by the plane of an opening and the direction of an air curtain;
- (2) The angle of air or other gas flow exiting an impeller.

Discharge Nozzle

An air curtain unit component that directs and controls the airstream.

Discharge Nozzle Depth

The inside nozzle dimension perpendicular to both the direction of airflow and the width of the airstream.

Discharge Nozzle Width

The inside nozzle dimension perpendicular to the direction of airflow and parallel to the width of the airstream.

Discharge Static Pressure – see Fan Static Pressure**Dry-Bulb Temperature**

Air temperature measured by a temperature-sensing device without modification to compensate for the effect of humidity.

Dry-Bulb Thermometer

An ordinary thermometer, especially one with an un-moistened bulb; not influenced by atmospheric humidity.

Duct

A passageway used primarily for conveying air or other gas at low pressure.

Ducted Fan

A fan having ductwork connected to the fan inlet, the fan outlet, or both.

Dynamic Similarity

A comparison that uses ratios of forces due to elasticity, viscosity, gravity, surface tension, inertia and pressure to show equivalence between two similar fans. The variables compared are fan Reynolds number, point of operation, compressibility, gas specific heat ratio, and tip speed Mach parameter.

Efficiency

A ratio of the useful energy provided by a dynamic application to the energy supplied to the system at a specific point of operation.

End Reflection

A phenomenon that occurs whenever sound is transmitted across an abrupt change in area, such as from the end of a duct into a room. When end reflection occurs, some of the sound is reflected back into the smaller area of the duct and does not escape into the room.

Energy Factor

The ratio of the total kinetic energy of airflow to the kinetic energy corresponding to the average air velocity.

Equivalent Diameter

The diameter of a circle having the same area as another geometric shape. For a rectangular cross-section having width (a) and height (b), the equivalent diameter is given by: $D_e = (4ab/\pi)^{0.5}$

Explosion-Proof Apparatus

Apparatus enclosed in a case that is capable of withstanding an explosion of a specified gas or vapor which may occur within it, and of preventing the ignition of a specified gas or vapor surrounding the enclosure by sparks, flashes, or explosion of the gas or vapor within, and which operates at such an external temperature that a surrounding flammable atmosphere will not thereby be ignited.

External Static Pressure – see Fan Static Pressure Rise

Evasé – See Diffuser

Expansion Joint (Flexible Connector)

A flexible member used to attach a fan inlet and/or outlet to a connecting duct.

Face Area

The total cross-sectional area of an air curtain unit discharge, a damper, louver, or duct.

Fan

- (1) A device that uses a power-driven rotating impeller to move air or gas. The internal energy increase imparted by a fan to air or a gas is limited to 25 kJ/kg (10.75 BTU/lbm).
- (2) A device having a power-driven rotating impeller, without a housing, for circulating air in a room.

Fan Air (Gas) Density

The density of air or gas corresponding to the total pressure, total temperature, and composition of the air or gas at a fan inlet.

Fan Airflow Rate

The volume airflow rate at a fan inlet at fan air density.

Fan Appurtenances

Accessories added to a fan for the purpose of control, isolation, safety, static pressure regain, erosion protection, etc. Common appurtenances include inlet box(es), inlet box damper, variable inlet vane, outlet damper, vibration isolation base, inlet screen, belt guard, evasé or diffuser, sound attenuator, erosion protection, and turning gear.

Fan Boundaries

Limits defining the interfaces between the fan and the remainder of the air system and delineated as the planes perpendicular to the airstream as it enters and leaves a fan. Various appurtenances, such as an inlet box, inlet vane, inlet cone, silencer, screen, rain hood, damper, evasé or diffuser, may be included as part of a fan between the inlet and outlet boundaries.

Fan Efficiency, Static – see Fan Static Efficiency

Fan Efficiency, Total – see Fan Total Efficiency

Fan Equipment

An assembly of a fan and its various appurtenances, as defined by the fan boundaries.

Fan Impeller Power

The power delivered to a fan impeller, specifically, the fan shaft power minus the bearing loss.

Fan Inlet

The plane perpendicular to an airstream where the airflow first meets the inlet cone or the inlet box furnished by the fan manufacturer.

Fan Inlet Area

The gross inside area measured at the plane(s) of the inlet connection(s). For converging inlets, the inlet area is considered to be a plane perpendicular to the airstream where it first meets the inlet cone.

Fan Outlet

The plane perpendicular to the airstream at the outlet opening of the fan or the manufacturer-supplied evasé or diffuser.

Fan Outlet Area

The gross inside area measured at the plane of the outlet opening. For a roof ventilator, it is the gross impeller outlet area for centrifugal types or the gross housing area at the impeller for axial types.

Fan Performance Characteristics

The pressure rise (total or static) and the volume airflow rate generated by a fan, and its power consumption at any given point of operation.

Fan Power Input

The power required to drive a fan and any elements in the drive train.

Fan Power Output

The useful power delivered to the air or a gas, and which is proportional to the product of the fan airflow rate, the fan total pressure, and the compressibility coefficient.

Fan Reynolds Number (Re)

A dimensionless parameter for judging dynamic similarity of flow in geometrically similar fans, relating inertia to viscous forces, and given by:

$$Re = (\pi ND^2 \rho) / (60\mu)$$

Where: Re = fan Reynolds number, dimensionless

π = 3.14159...

N = fan rotational speed, rpm

D = tip diameter of impeller, m (ft)

ρ = inlet air density, kg/m³ (lbm/ft³)

μ = absolute viscosity, Pa•s (lbm/ft•s)

Fan Shaft

The spindle on which a fan impeller is mounted, and upon which it rotates.

Fan Shaft Power

The power delivered to the input end of a fan shaft, exclusive of drive losses other than that due to the fan or motor bearings, and fan shaft seal friction.

Fan Sound Power

The ratio of sound power, radiated into a standard test duct, to a reference value of: 1.0×10^{-12} watts.

Fan Rotational Speed

The rotating speed of a fan impeller, in revolutions per minute.

Fan Static Efficiency

A parameter consisting of fan total efficiency multiplied by the ratio of static pressure to total pressure, at a given point of operation.

Fan Static Pressure

At a given point of fan operation, the difference between fan total pressure and fan velocity pressure; the difference between static pressure at fan outlet and total pressure at fan inlet.

Fan Static Pressure Rise

At a given point of fan operation, the increase in static pressure between fan inlet and fan outlet.

Fan Total Efficiency

At a given point of fan operation, a ratio equal to the fan power output divided by the power input to the fan.

Fan Total Pressure

At a given point of fan operation, the difference between total pressure at fan outlet and fan inlet.

Fan Velocity Pressure

The pressure corresponding to the average air velocity at a specified fan outlet.

Filter

A device used to separate vibration on the basis of frequency.

Fixed Pitch

A term descriptive of an axial impeller having all blades permanently secured at a given pitch angle.

Flashing

A sheet metal strip placed at the junction of intersecting building surfaces to resist the entrance of water.

Flow Rate

The volume flow rate of a gas at a specific gas density.

Foundation Stiffness

The lateral spring constant of the foundation as referenced to the fan bearing centerline. Factors to be considered include the foundation block, the sub-soil, piles, if any, the concrete pier supporting the steel fan supports, and the interface between the steel supports and the concrete pier.

Free Area

The minimum louver or damper area through which air can pass.

Free Area Velocity

The airflow rate through a damper or louver divided by its free area.

Free Air – see Free Air Delivery**Free Air Delivery**

That point of operation where a fan or an air curtain unit operates against zero static pressure.

Frequency

The number of complete cycles in a unit of time. When applied to sound, it is the number of complete pressure wave fluctuations which pass a given point each second. For a time period of seconds, the unit of measure is the Hertz (Hz).

Gas Density

The mass per unit volume of air or gas.

Gauge Pressure

The value of a pressure when the reference pressure is the barometric pressure at the point of measurement.

Geometric Similarity

A comparison of the ratio of corresponding dimensions of two fans, including angles, each dimension proportioned to impeller diameter. The proportional dimensions include material thickness, clearances, and roughness, as well as airflow passages.

Guide Vanes

Curved stationary vanes (stator vanes) located at the impeller inlet or discharge to reduce swirl and to enhance static pressure regain from the airflow.

Head

- (1) The upper or highest frame member of a damper or louver;
- (2) Fluid pressure expressed in terms of height of water column.

Housing

A stationary enclosure for an impeller, having an inlet and an outlet, and designed to direct the flow of air through the impeller and towards the outlet. The housing may also affect the energy transformation of the airstream.

Housing Sideplate Liner

A narrow strip of steel, ceramic or synthetic material fastened to the sideplate of a centrifugal fan housing at the intersection of the sideplate and the scroll, for the purpose of erosion protection.

Hub

The center portion of an impeller, by which the impeller is connected to its shaft, and through which the shaft transmits torque to the impeller.

Hydraulic Diameter

A characteristic dimension in Reynolds number calculations, taken normal to the fluid flow and equal to four times the cross-sectional area divided by the wetted perimeter.

Identical Modules

A standard for performance comparison wherein two fans have identical aerodynamic designs, including fan impeller diameter, impeller tip width, number of blades, blade pitch, blade arc, blade size, scroll configuration and angle of expansion, rotational speed, distance to the next adjacent fan or barrier, and essentially the same inlet and outlet conditions. Motor frame size and drive are the same if these are within the airstream.

Impeller

The assembled rotating component of a fan, designed to increase the energy level of the airstream.

Independent Accredited Laboratory

With respect to the AMCA International Accredited Laboratory Program, a laboratory not owned by or affiliated with an AMCA member company but which has been designated as an Accredited Laboratory by the AMCA Board of Directors for the purpose of performing pre-certification performance tests, performance check tests, and challenge tests.

Inlet Box

A component, similar to a duct elbow, which can be added to the inlet of an axial or centrifugal fan for the purpose of directing airflow into the fan inlet in line with the axis of the fan shaft.

Inlet Flow Profile

The shape of the air velocity profile just upstream of a fan inlet and which indicates variation in airflow through a plane extending across the airflow passage.

Interference Fit

A mating condition of two components wherein the limits of size are so specified that an interference always results when the mating components are assembled; either a press fit or a shrink fit.

Jackshaft

- (1) A separate shaft used to operate multiple louver or damper sections;
- (2) An intermediate shaft between motor and fan impeller.

Jamb

The vertical frame member on either side of a damper or louver.

Journal

The part of a rotor that is in contact with or supported by a bearing in which it revolves.

Kinematic Similarity

A relationship between airflow systems requiring that the ratios of all corresponding velocities be similar for two fans to be considered similar. This includes corresponding velocities of the air or gas and corresponding peripheral velocities of the impellers. The directions and points of application of all corresponding vectors must be identical.

Kinematic Viscosity

The viscosity of a fluid divided by its mass density.

Linkage

A system of bar links, pivots, and rotating members for the transfer of force and motion to louver and damper blades.

Mach Number

A ratio of fluid velocity to the speed of sound in the same fluid.

Make-Up Air

Outside air that is brought into a building to replace exhaust air and building leakage (exfiltration), or process exfiltration.

Mass Airflow Rate

The mass of air that passes through a given area in unit time and is obtained by multiplying the volumetric airflow rate by the air density.

Maximum Continuous Rating

The maximum continuous airflow, pressure and temperature values at which the fan is specified to operate.

Measurement Plane

The radial plane in the test duct, generally perpendicular to the airflow, at which measurement(s) is(are) obtained.

Mechanical Run-Out

The total actual variation in the location of a shaft surface during a complete revolution as determined by a stationary measuring device such as a dial indicator.

Motor Power

The power delivered from the output shaft of the motor.

Mullion

A frame support member between multiple section louvers or dampers.

Natural Frequency

The frequency at which a system oscillates in the absence of external forces and exhibits a maximum response to an external input.

Non-Ducted Fan

A fan without ductwork connected to either its inlet or its outlet.

Nose Piece (Replaceable)

A sacrificial metal, ceramic or synthetic material piece added to the leading edge of an airfoil blade for the purpose of erosion protection.

Nozzle

A flow-measuring device having a streamlined entrance and a sharp-edged outlet perpendicular to its longitudinal axis. Airflow rate through a nozzle is proportional to the square root of the differential pressure across the nozzle and the throat area of the nozzle.

Octave Band

A range of frequencies between two end frequencies selected such that the center frequency is twice the center frequency of the next lowest band.

One-Third Octave Band

A band of frequencies resulting from the division of an octave band into three smaller bands.

Opposed Blade Damper

A damper constructed such that adjacent blades rotate in opposite directions.

Outlet Velocity

The average velocity of air emerging from an outlet, measured in the plane of the outlet.

Outlet Velocity Uniformity

A measure of test velocity variation equal to the standard deviation of measured test velocities divided by the average of those test values, the ratio being subtracted from one (1.0).

Packing

Sealing material used to minimize or eliminate leakage at the shaft penetration of a housing or frame.

Parallel Blade Damper

A damper in which the blades rotate in the same direction.

Partial Blade Liner

A narrow piece of metal, ceramic or synthetic material located at the intersection of the impeller blade and backplate or centerplate for erosion protection.

Peak Design Temperature

The maximum temperature at which a piece of equipment can operate for a specific duration.

Point Of Operation

The relative position on a fan or air curtain unit performance curve corresponding to a particular airflow rate, pressure, power consumption, and efficiency.

Point of Rating

The specified fan operating point on its characteristic curve.

Power Rating

The amount of power consumed by the drive motor(s) of the air curtain unit.

Pressure

- (1) Force per unit area;
- (2) Stress per unit volume of a fluid, corresponding to the energy per unit volume of a fluid.

Pressure Differential

Commonly, the change in static pressure across a device. The term is seldom if ever associated with velocity pressure or total pressure.

Pressure Drop

Commonly,

- (1) The static pressure difference between two points in an airflow system, due to frictional resistance along system walls, or in passing over or through an obstruction;
- (2) A measure of the resistance to airflow across a device, which is expressed as the difference in static pressure across the device at a specific rate of airflow. The term is seldom if ever associated with velocity pressure or total pressure.

Pressure Loss

The change in total pressure due to friction and turbulence.

Product Line

A product or series of product sizes with a common design purpose and generally similar aerodynamic features, but not necessarily homologous, cataloged under the same product description or name and/or identifying references.

Propeller

A bladed device (impeller) that rotates on a shaft to produce a useful thrust of air or gas in a direction parallel with the shaft axis.

Psychrometric

Pertaining to the measurement and determination of water vapor content in atmospheric air.

Racking

The twisting of a frame out of its intended planar arrangement.

Rate Of Temperature Change

The increase or decrease in temperature per unit time.

Relative Roughness Factor

The measurement of surface unevenness, from peaks to valleys, divided by a dimension such as pipe diameter.

Resonance

A condition of high vibration response that occurs when the frequency of an external driving force approaches the natural frequency of the system.

Resonant Frequency – see Natural Frequency**Resonant Speed, Design**

The calculated fan rotational speed corresponding to the lowest natural frequency of the combined fan shaft in bending, considering the fan rotor, oil film, bearing housing, and bearing supports, but excluding the effect of foundation stiffness.

Resonant Speed, Installed

The calculated fan rotational speed corresponding to the lowest natural frequency of the combined fan shaft in bending, considering the fan rotor, oil film, bearing housing, and bearing supports, and including the effect of foundation stiffness.

Reynolds Number (Re)

A dimensionless number representing the ratio of internal forces to viscous forces at a particular point of a fluid in motion. Its value is calculated as: the fluid's density times the flow velocity at the point of interest, multiplied by a characteristic length, and the product divided by the fluid's viscosity.

$$Re = (\rho VD / \mu) = (VD / \nu)$$

Where: Re = Reynolds number, dimensionless

ρ = inlet air density, kg/m³ (lbm/ft³)

V = Velocity of air, m/s (ft/s)

D = Diameter, m (ft)

μ = absolute viscosity, Pa•s (lbm/ft•s)

ν = kinematic viscosity, m²/s (ft²/s)

Rotor

An assembly consisting of a fan impeller mounted on its shaft.

Sampling Tube

A windscreen tube designed for minimum sensitivity to airflow noise, and designed to be attached to a standard 13 mm (0.5 in.) microphone.

Scroll Liner

A metal, ceramic or synthetic material piece attached to a fan scroll for the purpose of erosion protection.

Seal Air

- (1) Air introduced into the air chamber of an isolation damper at a pressure higher than that of gases either upstream or downstream, to prevent passage of duct gas across the enclosed damper space;
- (2) Pressurized air introduced into a shaft seal chamber to function as a leakage barrier to process gas;
- (3) Pressurized air introduced into a housing around a furnace to prevent the escape of products of combustion.

Seating Torque

The amount of torque required to compress the seals or hold the louver or damper blades in the closed position.

Seismic Qualification

Documentation supplied with an item of equipment that substantiates the ability of the equipment to withstand the effects of an earthquake of specified magnitude.

Shaft

A cylindrical piece of metal, usually solid, that is used to support a rotating part such as a fan impeller, and transmit torque to the supported component.

Shaft Seal

A device that creates a barrier over the circumference of a fan shaft or damper axle for the purpose of limiting or preventing the passage of air or gas across the barrier.

Shall and Should

In this and other AMCA standards, the word *shall* is understood to be mandatory, and the word *should* as advisory.