STANDARD

ANSI/AMCA 99-16

Standards Handbook

An American National Standard
Approved by ANSI on November 10, 2016

This standard in English, Chinese, European Spanish, and Latin American Spanish may be purchased at 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

ANSI/AMCA Standard 99

Standards Handbook

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

AMCA Publications

Authority ANSI/AMCA Standard 99-16 was adopted by the membership of the Air Movement and Control Association International Inc. on October 31, 2016. It was approved by the American National Standards Institute on November 10, 2016

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

European AMCA
Avenue des Arts, numéro 46
à Bruxelles (1000 Bruxelles)

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

Review Committee

David Johnson	Berner International Corp
Abhishek Jain	Airflow Pvt. Ltd.
Brad Skidmore	Loren Cook Company
John Cermak	Acme Engineering and Manufacturing Corp.
Kim Osborne	Temtrol -CES Group
Fernando A. Ruiz	Equipos Electromecanicos, S.A de C.V.
Marcel Kamutzki	Daltec Canadian Buffalo
Paul Oakley	The New York Blower Company
Mark VanderKooy	Greenheck Fan Corporation
Nicholas Ang	Dongguan Wolter Chemco Ventilation Ltd.
Tim Vogel	Ruskin
Roberto Arias	ZITRON, S.A.
John Oh	Hartzell Air Movement
Robert Hassler	Kinetics Noise Control
Armin Hauer	ebm-pabst. Inc.
Joe Brooks	AMCA International Staff

Contents

ANSI/AMCA Standard 99
Standards Handbook

1. Purpose

The purpose of this standard is to serve as a repository of reference material that supports all other AMCA publications and standards.

2. Scope

This standard serves as a collection of information that can be used in the development of other AMCA documents.

It is recommended that the definitions in this document be used in all standards and publications. However, standard and publication developing committees retain the authority to create and maintain a definition specific to their document.

3. Definitions

See Annex B for ISO definitions

3.1 The AMCA vocabulary: definitions

Abrasion Resistant Fan (or Damper)
A fan or damper having parts subject to wear that are constructed of abrasion resistant and/or easily replaceable materials.

*See Annex B for ISO definition of this term

Absolute Pressure
The value of a pressure when the datum pressure is absolute zero. It is always positive.

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

Absolute Viscosity; see Viscosity

Accessory; see Appurtenance

Acoustic Attenuation Device
Any component having sound absorption as its primary function.

Acoustic Intensity; see Sound Intensity Level

Acoustic Media
Sound-absorbing material.

Acoustic Media Covering
The material that is used as a facing or bagging to protect the acoustic media from moisture absorption or air erosion.

Acoustical Duct Silencer
An air duct section containing sound-absorbing materials that reduce the transmission of sound through the air passage.

Acoustical Louver
A louver incorporating sound-absorbing material to reduce sound transmission across an opening.

Active Noise-Cancelling Device
A device that reduces sound by introducing a sound that is equal and opposite phase.

Actual Cubic Feet Per Minute (ACFM)
Actual volume airflow rate through a plane of measurement; at the defined air density, expressed in ft^3/min.

Actual Cubic Meters Per Second (ACMS)
Actual volume airflow rate through a plane of measurement; at the defined air density, expressed in m^3/s.

Actuator (Operator)
A mechanism attached to a device (for example, a damper, adjustable louver or fan) to move its blades through a specified range of motion. An actuator may be manually, electrically, pneumatically or hydraulically powered.

Adjustable Louver
A louver in which the blades may be rotated either manually or mechanically.

Adjustable Pitch
The ability to mechanically alter the angle (pitch) of an impeller blade.

Air
Term used as abbreviation for “air or other gas”; a mixture of gases and a term commonly used to denote any gaseous medium measured, moved or controlled and that may include solid or liquid particulate.

*See Annex B for ISO definition of this term

Air Curtain
A directionally-controlled stream of air moving across the entire height and width of an opening that 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 air curtain core velocities measured along the air curtain width at a defined plane.

Air Curtain Core Velocity
The maximum 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; the short dimension of the airstream.

Air Curtain Discharge Angle
The angle between the plane of the protected opening and the direction in which the airstream leaves the discharge.

Air Curtain Discharge Nozzle
An air curtain unit component that directs and controls the airstream.

Air Curtain Discharge Nozzle Depth
The inside nozzle dimension perpendicular to both the direction of airflow and the width of the airstream; the short nozzle dimension.

Air Curtain Discharge Nozzle Width
The inside nozzle dimension perpendicular to the direction of airflow and parallel to the width of the airstream; the long nozzle dimension.

Air Curtain Unit
An air moving device that produces an air curtain (or boundary of air) where the width is at least five times the depth and the discharge is not intended to be connected to unitary ductwork.

*See Annex B for ISO definition of this term

Air Curtain Unit Air Power
The useful power delivered to the air. This is proportional to the product of the air curtain unit airflow rate and total pressure.

Air Curtain Unit Effectiveness
A ratio described by the difference in energy loss through an opening without and with the use of an air curtain divided by the energy loss without the air curtain. The energy loss with the use of the air curtain includes energy consumption of the air curtain unit.

Air Curtain Unit Fan Efficiency
The ratio of the air curtain 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 Target Distance
A distance perpendicular to the discharge nozzle, determined by the sponsor of a test, for the purpose of setting up a test.

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 both the direction of airflow and the airstream depth; the long dimension of the airstream.

Air Density
The mass per unit volume of air.

Air Diffuser
A duct discharge termination arranged to direct airflow or to promote air mixing.

Air Discharge Nozzle
A component or an assembly, which may include adjustable vanes, in the air curtain unit that directs and controls the airstream.

Air Discharge Nozzle Depth
The shorter inside dimension of an air curtain airstream perpendicular to both the direction of airflow and the airstream width.

Air Discharge Nozzle Width
The longer inside dimension of an air curtain airstream perpendicular to both the direction of airflow and the nozzle depth.

Air Leakage
The volumetric rate of air passing through a device or into the atmosphere while the device is in the closed position.

Air Power; see Fan Air Power or Air Curtain Unit Air Power

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 aerodynamic axis distance an airstream travels after leaving an air outlet before the air velocity is reduced to a specific terminal value.

Airflow
A flow of air or an air current, specifically one that passes through a dimensionally defined plane.

Airflow Leakage; see Air Leakage

Airflow Measurement Station
An airflow measurement station is a multiple-point sensing device that is used to measure the airflow rate in a duct system or fan appurtenance. It may consist of a single sensor or an array of sensors in permanent position in the air system. It may be supplied as a probe to be inserted into a ductwork or supplied in a casing approximating the size of the air system in which it is installed.

Airflow Measurement Station Airflow Rate
The airflow rate, based upon the output (pressure, current or voltage of the AMS under test), calculated according to the manufacturer's instructions.

Airflow Measurement Station Differential Pressure
The observed differential pressure between the high-pressure output and the low-pressure output of a differential pressure type AMS.

Airflow Measurement Station Differential Pressure Output Type (Velocity)
Converts air velocity into a differential (velocity) pressure signal that correlates to the velocity or volume of air flowing through a duct.

Airflow Measurement Station Electronic Output
The observed voltage or current output of an electronic output type AMS that correlates directly and proportionately to the velocity of airflow in a duct.

Airflow Rate; see Volume 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-Handling Unit
A packaged assembly of components, such as coils, filters, a fan, a humidifier, etc., that provides for treatment of air before it is distributed.

Ambient Temperature Dynamic Closure
Ambient temperature (0 °C - 49 °C [32 °F - 120 °F]) dynamic closure is the ability of a damper to properly travel from the full open to the full closed position while exposed to specific airflow conditions at ambient temperature.

Ambient Temperature Operation
The ability of a damper to properly travel from the full open to full closed position and, if a motorized damper, back to a full open position while exposed to specific airflow conditions at ambient temperature.

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.

Appurtenances
Any item added to the inlet or discharge airstream that affects the performance of the basic air moving or control device.

Attenuate
To weaken a signal by reducing its amplitude.

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

Average Outlet Velocity
The airflow rate of a fan or air curtain per unit area of the discharge, calculated by dividing the airflow rate by the area of the discharge.

Average Air Velocity
The volume airflow at a plane divided by the cross-sectional area of that plane.

Axial Fan
A fan that takes in and discharges air in a direction that is generally parallel to the impeller's shaft.

*See Annex B for ISO definition of this term

Axle
A shaft on which a damper or louver blade rotates.

Backdraft Damper
A damper that, when mounted in a duct or opening, permits airflow in one direction only.

Backplate
A circular plate, a component of a centrifugal fan impeller, that 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 strip of steel, ceramic or synthetic material installed in sets, each attached to the backplate/centerplate of an impeller, adjacent to an impeller blade. These serve the purpose of protection against erosion.

Balance Quality Grade
The recommended limits for residual unbalance of a rotor, based upon the intended application. The value represents the product of the unbalance multiplied by the angular velocity and divided by the weight of the rotor.

Balancing
The process of adding or removing mass in a plane or planes on a rotor in order to move the center of gravity towards the axis of rotation.

Balancing Damper
A damper used to regulate the airflow in an air system.

Balancing Speed
That rotational speed, expressed in revolutions per minute (rpm), at which a rotor is balanced.

Barometric Damper
A backdraft damper having an adjustable start-open pressure and used for gravity ventilation or other low velocity applications.

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.

Bifurcated Fan
A direct-driven fan having the airstream-mounted drive motor separated from the airstream by means of a compartment or tunnel.

*See Annex B for ISO definition of this term

Blade
1. The flow element of an impeller that, by its shape and motion, generates airflow inside a fan, transforming impeller rotational energy to kinetic energy of airflow.
2. A movable component 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 Cladding; see Cladding

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

Blade Liner; see Cladding

Blade Pass Frequency (BPF)
The frequency of a tone generated by the fan's blades, given by: f(Hz) = (number of blades × fan revolutions per minute)/60.

Blade Support
1. A structural member, located inside the duct section of a guillotine damper frame, that 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 cutoff.

Blast Damper
A damper that reacts to sudden pressure changes in an air system to either relieve the air pressure or to isolate a space from the rapid pressure rise.

Blower
A fan that operates against air system resistance downstream of the fan; a forced draft fan.

Bonnet
The portion of a guillotine damper that supports the damper blade when the damper is in the open position. There are two types:

1. Open type — a type in which the damper blade is exposed to the atmosphere when the blade is withdrawn from the duct.
2. Fully enclosed (sealed) type — a type in which the entire bonnet encloses the damper blade when the damper is in the open position.

Box Fan
A fan used in an office or residential application and having the motor and impeller enclosed in an approximately square box with a handle.

Cabinet Fan; see Box Fan

Casing; see Housing

Centerplate; see Backplate

Centrifugal Ceiling/Wall Exhaust
A factory-assembled fan consisting of one or more centrifugal impellers connected to a motor and enclosed in a housing. It usually includes an inlet grille and a backdraft damper and is intended for installation in a ceiling or a wall.

Ceiling (Radiation) Damper
A device intended to protect an air duct opening in a fire-rated ceiling assembly. It operates to interrupt airflow automatically in the event of fire to restrict the passage of flame and heat.

Ceiling Exhaust Fan
A fan, designed for mounting in a ceiling, that serves to exhaust air from a room.

Ceiling Fan
A propeller fan, supported from a ceiling, that serves to circulate air within a given space; also known as an air circulation fan.

Centrifugal Fan; see Radial Flow Fan
*See also Annex B for ISO definition of this term

Chamber
1. A test enclosure having the following: 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.

Circulating Fan
A fan that is used for moving air within a space that is unconnected to any ducting and is usually without a housing.

*See Annex B for ISO definition of this term

Cladding
A steel, ceramic or synthetic material piece that covers a surface in part or completely to protect against erosion.

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

Closure Pressure
The differential pressure across the damper when the damper is closed.

Combination Fire/Smoke Damper
A device that functions as both a fire damper and a smoke damper.

Combination Louver-Damper
Louvers with a combination of stationary louver blades and adjustable blades.

Combustion Air Blower
A centrifugal fan that serves to supply pressurized air to a burner system combusting gas, oil or other fuel.

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

Compressibility Coefficient
A thermodynamic coefficient used to correct the perfect gas equation.

Conditioning Device
An air system designed to take air from the inlet and change its condition before discharging it at the outlet. Changes may include the temperature, humidity, pressure, contaminant level and cleanliness of the air.

Continuous Blade; see Continuous Line

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

Contra-Rotating Fan
An axial flow fan having two impellers arranged in series and rotating in opposite directions.

*See Annex B for ISO definition of this term

Control Damper
A device that, when mounted in a duct or opening, is used to vary the volume of air flowing through the duct or opening. It can be operated manually or mechanically and can have one or more blades.

Control Devices
A device used to regulate and control the flow through the system in response to some monitoring signal, usually temperature or pressure. Control devices such as dampers function by controlling the amount of airflow. In some cases, the output of the fan can be varied by other methods (variable speed motor, variable inlet vanes, variable pitch impeller, etc.).

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.

Conveying Fan
A fan suitable for transporting solids (e.g., wood chips, textile waste, pulverized material or dust).

*See Annex B for ISO definition of this term

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 corrosion.

Corrosion Resistant Fan
A fan having an impeller and housing constructed of materials that resist corrosion or having airstream or exterior components surface-treated to minimize corrosion by specified agents.

*See Annex B for ISO definition of this term

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

Critical Speed
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.

Cross-Flow Fan
A fan in which the fluid path though the impeller is in a direction substantially at right angles to its axis with air both entering and leaving radially at its periphery.

*See Annex B for ISO definition of this term

Curtain Damper
A damper that uses a folded, interlocked series of blades.

Cutoff
A baffle or plate at the narrowest radial distance between the impeller and the housing near the outlet of a centrifugal fan. It 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.

Damper
A device used to vary the volume of air passing through an opening, duct or confined cross-section by varying the cross-sectional area.

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

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

Design Air Temperature
The maximum and/or minimum air temperature for specification of process control equipment.

Design Speed
The maximum rotational speed, measured in revolutions per minute (rpm), for which the fan is designed to operate.

Design Temperature
The minimum or maximum temperature at which a device can be continuously operated.

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 for the control and discharge of air.
2. A gradual transition of a duct, located at a fan outlet, that 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; see Air Curtain Discharge Angle

Discharge Static Pressure; see Fan Static Pressure

Displacement
The distance that a body moves from a stationary or neutral position.

Distribution System
A system made up of ducts specially designed and constructed to convey air from system inlets to system outlets. In some cases, enclosed spaces in the structure such as plenums above ceilings or holes in walls may be used to confine and direct the flow.

Downdraft Fan
An exhaust fan that serves to remove heated air and moisture by inducing air to flow down to a fan inlet located below a cooking surface.

Drag Coefficient
A dimensionless quantity that is used to quantify the drag or resistance of an object in a fluid environment such as air or water.

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

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

Duct Air Density
The density of the air corresponding to the total pressure and stagnation temperature at a specific plane in the duct.

Dynamic Operational Torque
The torque at varying angles of rotation of the axle that operates the damper from the full open position to the full closed position and back.

Dynamic Similarity
A relationship between airflow systems requiring that the ratios of all corresponding forces in the two fans be equal. This includes 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, compressibility, gas specific heat ratio and tip speed Mach number at a point of operation.

Dynamic Stall Torque
The peak torque/force that an actuator, running under nominal conditions (nominal voltage/pressure and rated load), develops when subjected to a hard stop.

Dynamic Viscosity; see Viscosity

Effective Fan Outlet Velocity
Calculated air velocity based on fan thrust, inlet air density and fan outlet area.

Efficiency
The ratio of energy in the air provided by a dynamic application to the energy supplied to the system at a specific point of operation.

Electric Air Heater
A space heater having electric resistance elements as the heat source and a fan for the circulation of heated air.

Elevated Temperature Dynamic Closure
The ability of a damper to properly travel from the full open to the full closed position while exposed to specific airflow conditions at a specified elevated air temperature.

Elevated Temperature Operation
The operational ability of a damper to properly travel from the full open to the full closed position at elevated temperatures.

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 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.

Engine
A drive device that produces power through internal combustion and that uses a fuel such as gasoline.

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 De = (4ab/π)0.5

Evaporative Cooler
An assembly consisting of a fan or fans and other necessary equipment to cool by evaporation the airflow created by the fan or fans.

External Static Pressure; see Fan Static Pressure Rise

Evasé; see Diffuser

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

Face and Bypass Dampers
A pair of dampers that operate together but with opposite motion to direct an airstream either through or around a heat transfer device.

Face Area
The total cross-sectional area of a damper, louver, filter, heat exchanger airflow measurement station or silencer.

Face Area Velocity
Velocity calculated from the volume flow divided by the area.

Fan
1. A device that uses a power-driven rotating impeller or impellers 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). This limit is approximately equivalent to a pressure of 30 kPa (120 in. wg).
2. A device having a power-driven rotating impeller, without a housing, for circulating air in a room.

*See Annex B for ISO definition of this term

Fan Air Density
The density of air corresponding to the total pressure and total temperature at a fan inlet.

Fan Air Power
The product of the inlet flow rate, fan total pressure, and compressibility coefficient. Note: For incompressible flow, the compressibility coefficient is equal to 1.

Fan Airflow Rate
The volumetric airflow rate at fan air density at the fan inlet.

Fan Application Category
A grouping used to describe fan applications, their appropriate balance quality grades and recommended vibration levels.

Fan Assembly
An assembly that consists of those items typically packaged together as “a complete fan,” including, as applicable, rotor, bearings, belts, housing, motor, sheaves and mounting base/structure.

Fan Boundaries
Limit defining the interfaces between the fan and the remainder of the air system 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 Drives
Any device used to power the fan, including the motor, mechanical transmission (e.g., belt drive, coupling, etc.), motor/control system (e.g., variable frequency controller, electronic commutator, etc.).

Fan Dynamic Pressure
The conventional dynamic pressure at the fan outlet calculated from the fan average outlet velocity and the inlet density.

Fan Efficiency
Ratio of the air power to the impeller power.

Fan Efficiency, Static; see Fan Static Efficiency

Fan Efficiency, Total; see Fan Total Efficiency

Fan Efficiency Grade
The efficiency grade of a fan without consideration of the drives.

Fan Guard
A screen or other device to prevent objects from entering the inlet or outlet of a fan.

Fan Housing
A stationary enclosure for an impeller. This enclosure has an inlet and an outlet and designed to direct the flow of air through the impeller and towards the outlet.

Fan 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 protection.

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

Fan Impeller Power
The power delivered to a fan impeller, specifically the fan shaft power minus the fan shaft losses (bearings, seals, etc.).

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.

*See Annex B for ISO definition of this term

Fan Inlet Area
The gross inside area measured at the planes of inlet connections. For converging inlets without connection elements, the inlet area is considered to be the area where a plane perpendicular to the airstream first meets the inlet of the fan.

Fan Input Power Boundary
The interface between a fan and its driver.

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

*See Annex B for ISO definition of this term

Fan Outlet Area
The gross inside area measured at the plane of the outlet opening.

Fan Outlet Velocity
Average velocity of air emerging from an outlet measured in the plane of the outlet.

Fan Peak Efficiency
Maximum fan total efficiency with the fan speed and air density being fixed.

Fan Performance Characteristics
The total or static pressure 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 power delivered to the air. It 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.

Fan Rotor
A body capable of rotation, generally with journals that are supported by bearings.

Fan Shaft
The spindle on which a fan impeller is mounted.

Fan Shaft Power
Mechanical power supplied to the fan shaft. Note: The power loss in the fan shaft bearings is considered as a fan internal loss.

Fan Sone; see Hemispherical Sone

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 Speed
The rotational speed of the impeller.

Fan Rotational Speed; see Fan Speed

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
The difference between the fan total pressure and the fan velocity pressure. Therefore, it is the difference between static pressure at the fan outlet and total pressure at the 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 density.

Fire Damper
A device arranged to interrupt airflow automatically through part of an air system so as to restrict the passage of flame. It is installed in a fire-related wall or floor to close automatically in the event of a fire in order to maintain the integrity of the fire-rated separation.

Fire/Smoke Damper; see Combination Fire/Smoke Damper

Fixed Blade Louver
A louver that has blades firmly secured in an open position.

Fixed Pitch
An axial impeller having all blades permanently secured at a given angle.

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

Flexible Connector; see Expansion Joint

Forced Draft Fan
A high pressure/high volume fan used to supply primary and secondary combustion air to a furnace/boiler and its exhaust system. See also “combustion air blower” and “blower.”

Foundation
The component to which the fan is mounted that provides the necessary support.

Foundation Stiffness
The lateral spring constant of the foundation as referenced to the fan bearing centerline.

Free Area
The minimum device area through which air can pass.

Free Area Ratio
The ratio of the free area divided by the face area of a device.

Free Area Velocity
The airflow rate through a device divided by its free area.

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

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

Gas Density; see Air Density

Gauge Pressure
The differential pressure between a reference pressure, such as barometric pressure, and the absolute pressure at the point of measurement. It may be positive or negative.

General Purpose Fan
A fan suitable for handling clean air that does not exceed a temperature of 80 °C (176 °F), or 40 °C (104 °F) if the motor or the fan bearings are in the airstream.

*See Annex B for ISO definition of this term

Geometric Proportionality; see Geometric Similarity

Geometric Similarity
A relationship between airflow systems requiring that the ratios of all corresponding dimensions for two fans be equal. This includes ratios of thickness, clearance and roughness, as well as all the other linear dimensions of the airflow passages. All corresponding angles must be equal.

Gravity Roof Ventilator
A roof-mounted hood or louvered penthouse that uses the difference in air density or internal building pressurization to vent air into or out of a building.

Grille
A perforated or bladed covering for an air inlet or outlet.

Guide Vanes
Vanes located at the impeller or cabinet inlet or discharge to reduce swirl and to enhance static pressure regain from the airflow.

Guillotine Damper
A damper used for isolation purposes and having a solid blade that is withdrawn from the duct area when the damper is fully open.

Guillotine Damper, Double-Blade
A guillotine damper having two parallel blades, the space between them capable of being pressurized to prevent duct gas leakage across the space between the blades when the damper is in the closed position.

Hazardous Location Fan or Damper
A fan or damper equipped with electrical equipment having enclosures tested as suitable to contain internal combustion without ignition of atmospheres external to the enclosures. The fan or damper itself is of spark resistant construction.

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

Heat Recovery Ventilator
A fan-powered assembly utilizing a heat exchanger or heat recovery materials to transfer energy from exhaust air to replacement air.

Heavy Duty Damper
A channel frame air control device intended to be fastened between flanged duct sections and constructed to withstand the elevated temperatures, pressures and contaminated gas flows of industrial processes.

Hemispherical Sone
The loudness, in sones, of the sound pressure level at a distance of 1.5 m (5 ft) from the acoustic center of the fan in a hemispherical free field.

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, which is connected to a shaft.

Hydraulic Diameter
A characteristic dimension used in Reynolds number calculations to determine turbulence and friction in flow, 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 devices have identical aerodynamic designs

Impeller; see Fan Impeller

Impeller Power; see Fan Impeller Power

Induced Draft Fan
A fan located downstream of a boiler that draws air or induces products of combustion from the boiler and discharges them through the exhaust system.

Industrial Fan
A fan constructed of materials capable of withstanding the elevated temperatures, pressures and contaminated airflows of industrial processes.

Induced Flow Fan
An induced flow fan is a housed fan with an outlet airflow greater than its inlet airflow due to induced airflow.

Informative
A term that indicates that the referenced material is provided as advice to the reader but does not constitute a mandatory requirement.

Inlet Box
A component, similar to a duct elbow, that 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.

Inlet Guide Vane Damper
A round damper intended for installation at or in a fan inlet and that controls and/or pre-swirls air entering the fan impeller. The damper blades are mounted radially and operate in parallel.

Inline Fan
A fan designed to be mounted between duct sections.

*See Annex B for ISO definition of this term

Isolation Damper
A low leakage damper intended to regulate or stop the airflow in branches of a duct system.

Jackshaft
1. A separate shaft used to operate one or more 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.

Jet Fan
A fan in a tunnel that induces airflow by entrainment of air with that streaming from the fan outlet.

*See Annex B for ISO definition of this term

Journal
The part of a fan 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 equal for two fans to be considered similar. The directions and points of application of all corresponding vectors must be equal.

Kinematic Viscosity
The absolute viscosity divided by mass density.

Leakage; see Air Leakage

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

Louver
A device comprising a blade or blades that permit the flow of air but inhibit the passage of water or other elements.

Louver Frame
The outermost structure of a louver assembly comprising the head, sill and jambs joined together to support the 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.

Make-Up Air Units
A packaged assembly consisting of a heat source and a fan or fans serving to supply fresh, tempered replacement air for that exhausted from a building.

Mass Airflow Rate
The mass of air that passes through a given area in a unit of time.

Material Handling Fan; see Conveying Fan

Maximum Continuous Rating (MCR)
The maximum continuous airflow, pressure and temperature values at which the fan is specified to operate.

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

Measurement Plane
A plane generally perpendicular to the airflow at which measurements are obtained.

Mechanical Draft Fan
A generic term of classification applying to any of the fans used in a furnace or boiler system.

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.

Mils
A unit of measure that describes displacement. One mil equals one one-thousandth of an inch (1 mil = 0.001 inch).

Mixed Flow Fan
A fan in which the airflow through the impeller is intermediate between the centrifugal and axial flow types, with the air moving both axially and radially.

*See Annex B for ISO definition of this term

Modulation
Controlling the airflow and/or pressure by varying the position of the damper blades.

Motor Power
The power delivered from the output shaft of the motor.

Motor Input Power
The electrical power supplied to the terminals of an electric motor.

Mullion
A frame support member between multiple section louvers or dampers.

Multi-Stage Fan
A fan having two or more impellers that work in series.

*See Annex B for ISO definition of this term

Nameplate Voltage; see Nominal Voltage

Natural Frequency
The frequency at which a system oscillates with a maximum amplitude in the absence of external forces.

Nominal Voltage
A standard value assigned to a circuit for the purpose of conveniently designating a voltage class (e.g., 120 VAC).

Non-Clogging Fan
A fan having an impeller designed to minimize clogging by virtue of its shape or by use of special materials. The fan may also incorporate other features to allow use of cleaning sprays and to facilitate the removal of any resulting materials.

*See Annex B for ISO definition of this term

Non-Ducted Fan
A fan without ductwork connected to either its inlet or its outlet.

Normal Operating Conditions; see Maximum Continuous Rating

Normative
A term that indicates that the referenced material, if applicable, constitutes a mandatory requirement.

Nose Piece
A replaceable metal, ceramic or synthetic material piece added to the leading edge of an airfoil blade.

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.

Optimum Efficiency; see Fan Peak Efficiency

Operating Speed
Rotational speed, measured in revolutions per minute (rpm), at which a rotor operates in its final installation or environment.

Outlet Area; see Fan Outlet Area

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

Overfire Air Fan
A fan that serves to deliver additional air downstream of the fuel burners in a boiler for the purpose of improving combustion.

Packaged Fan; see Utility Set

Packing Gland; see Shaft Seal

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.

Partition Fan
A fan installed in or on a partition and used for moving air from one air space to another.

*See Annex B for ISO definition of this term

Pedestal Fan
A propeller fan intended for mounting on a stand having a base and column.

Penthouse
A roofed structure incorporating louvers or louver blades in all or part of the walls, usually located on the roof of a building.

Performance Rating
Data generated from actual tested products used to derive the listed and published information.

Perimeter Air-Sealed Damper
A pair or set of dampers having a frame design that includes a chamber around the duct and the bonnet or space between dampers. The chamber must be pressurized by a seal air system.

Personnel Cooler
A type of air circulator fan having the impeller and motor enclosed in a common safety-guarded housing that is generally mounted on wheels or casters. It serves primarily to provide cooling for personnel.

Plenum Fan
A fan having an unhoused centrifugal impeller that draws air into the impeller through an inlet located in a barrier wall and having a driver located on the same side of the barrier as the impeller.

*See Annex B for ISO definition of this term

Plug Fan
A fan having an unhoused centrifugal impeller arranged such that the system into which it is inserted may act as a housing, allowing air to be drawn into impeller inlet. It is constructed such that the driver is located outside the duct system.

*See Annex B for ISO definition of this term

Point of Operation
The point on a performance curve corresponding to a particular airflow rate, pressure, power consumption and efficiency.

Point of Rating
A specified point of operation on a performance characteristic curve.

Positive Pressure Ventilator (PPV)
A portable fan that can be positioned relative to an opening of a confined space, causing it to be positively pressurized by discharge air velocity.

*See Annex B for ISO definition of this term

Power Generation Fan; see Mechanical Draft Fan

Power Roof/Wall Ventilator (PRV)
A fan consisting of a centrifugal or axial impeller with an integral driver in a housing. It has a base designed to fit over a wall or roof opening, usually by means of a curb.

Pressure
Force per unit area.

Pressure Differential
The change in pressure between two locations.

Pressure Drop
A specific case of pressure differential. It is the change in pressure across a device.

Pressure Loss
A specific case of pressure differential. It is the decrease in pressure due to friction and turbulence.

Pressure Relief Damper
A type of backdraft damper having an adjustable start-to-open pressure. It is capable of maintaining a constant pressure at various airflows, and it closes upon a decrease in differential pressure.

Primary Air Fan; see Combustion Air Blower

Product Line
A product or series of product sizes with a common design purpose and generally similar aerodynamic features.

Propeller
An impeller that moves the air in an axial direction without creating radial flow.

Propeller Fan
A fan having an axial impeller mounted in an orifice plate.

*See Annex B for ISO definition of this term

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

Purge Gas; see Seal Air

Racking
The twisting or deformation of a device out of its intended geometric arrangement.

Radial Flow Fan
Fan in which the air enters the impeller with an essentially axial direction and leaves it in a direction that is perpendicular to the axis.

Radiation Damper; see Ceiling Damper

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
The frequency at which a system oscillates with a maximum amplitude due to the presence of an external driving force.

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.

Reversible Axial Flow Fan
An axial fan capable of moving air in either direction along the fan's axis of rotation.

*See Annex B for ISO definition of this term

Reynolds Number (Re)
A dimensionless number representing the ratio of internal forces to viscous forces at a particular point of a fluid in motion.

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

Seal Air
Gas introduced into a chamber or housing at a pressure higher than that of gases either upstream or downstream to prevent the passage of gas from one system into another system.

Seal Air Fan

1. A fan that serves to pressurize an enclosure around a furnace or boiler to prevent the escape of gasses of combustion into ambient air.
2. A fan supplying air to a shaft seal chamber as a leakage barrier to process air.
3. A fan supplying air to the chamber of an isolation damper to prevent the passage of duct air across the enclosed space.

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

Shaft
A component used to support a rotating part, such as a fan impeller, and transmit torque to the supported component.

Shaft Seal
A component that creates a barrier over the circumference of a fan shaft or damper axle for the purpose of limiting or preventing the passage of 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.

Shaped Louver
A shaped louver is a non-rectangular louver having sides that are not perpendicular, such as round, oval, triangular, etc.

Shut Off
That point of operation on the fan performance curve where the airflow rate is zero.

Shutoff Damper; see Isolation Damper

Shutter; see Damper

Sight-Proof Louver
A louver that cannot be seen through from any direction.

Signal Filter
An electronic device used to allow separation of vibration on the basis of frequency.

Sill
The bottom or lowest horizontal frame member of a louver or damper.

Similarity; see Dynamic Similarity, Kinematic Similarity or Geometric Similarity

Skewing
The deviation of a frame from rectangularity or from a straight line.

Slide Gate Damper; see Guillotine Damper

Smoke Control System
A series of fans, dampers and controls used to inhibit the flow of smoke into means of egress, exit passageways, stairwells, areas of refuge or other similar areas of a building. Smoke control systems are normally activated during the early stages of a fire emergency to maintain a safe environment in the areas to be protected.

Smoke Damper
A device installed in ducts and air transfer openings that is designed to resist the passage of air and smoke. The device operates automatically and is controlled by a smoke detection system. It can also be opened or closed from a remote fire command station, if required.

Smoke Management Fan
A fan that serves to exhaust smoke and heated air from a building. It may be certified to remain operable after exposure to a given temperature for a given duration.

Sone
A unit of loudness corresponding to the loudness of a sound at a frequency of 1000 Hz and a sound pressure of 40 dB with reference to 0.02 microbar.

Sone, Hemispherical; see Hemispherical Sone

Sone, Spherical; see Spherical Sone

Sound
An auditory sensation produced by the variation of pressure through an elastic medium.

Sound Attenuation; see Attenuation

Sound Intensity Level
The sound power level per unit area.

Sound Power Level
The value, expressed in decibels (dB), of ten times the logarithm (base 10) of the ratio of the sound power W to the reference sound power W_{ref}.

Sound Pressure Level
The acoustic pressure at a point in space where a microphone or a listener's ear is situated. One decibel (dB) of sound pressure is defined as 20 times the logarithm (base 10) of the sound pressure fluctuation with reference to 0.0002 microbars (20 micropascals).

Spark Resistant Construction
A level of construction designed to reduce the potential for spark generation when the airstream is potentially combustible.

Specific Heat
The ratio of the amount of heat required to raise the temperature of a given mass of any substance one degree to that amount of heat required to raise the temperature of an equal mass of a standard substance one degree.

Specific Heat at Constant Pressure
The quantity of heat required to raise the temperature of a unit mass of a substance one degree at constant pressure.

Specific Heat at Constant Volume
The quantity of heat required to raise the temperature of a unit mass of a substance one degree at constant volume.

Specific Heat Ratio
The numeric ratio of the specific heat of a gas at constant pressure to that of the same gas at constant volume.

Speed, Balancing; see Balancing Speed

Speed, Critical; see Critical Speed

Speed, Design; see Design Speed

Spherical Sone
The loudness, in sones, of the sound pressure level at a distance of 1.5 m (5 ft) from the acoustic center of the fan in a spherical free field.

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

Stall Limit
That point near the peak of an axial fan's pressure curve (for a particular blade angle) that corresponds to the minimum airflow at which the fan can be operated without instability.

Standard Air
Air having these properties, approximately: density of 1.2 kg/m^3 (0.075 lbm/ft^3), a specific heat ratio of 1.4, a viscosity of 1.819 × 10^{-5} Pa•s (1.222 × 10^{-5} lbm/ft-s) and an absolute pressure of 101.325 kPa (406.78 in. wg). Air at 20 °C (68 °F), 50% relative humidity, and 101.325 kPa (29.92 in. Hg).

*See Annex B for ISO definition of this term

Standard Cubic Feet Per Minute (SCFM)
The volume airflow rate through a plane of measurement, corrected to standard air density of 0.075 lbm/ft^3.

Standard Cubic Meters Per Second (SCMS)
The volume airflow rate through a plane of measurement, corrected to standard air density of 1.2 kg/m^3.

Static Pressure
The pressure that exists by degree of compression only. If expressed as gauge pressure, it may be positive or negative.

Static Regain
1. The conversion of velocity pressure at a small area into static pressure at a larger area by slowing the air velocity by means of a diffuser or an evasé.
2. The amount of static pressure gained by conversion of velocity pressure to static pressure.

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

Static Ventilating Device
A device that passively facilitates air exchange.

Stop
An angle or rigid strip used to close the gap between a blade edge and frame at the top and bottom of a damper or a louver.

Stuffing Box; see Shaft Seal

Surge Limit
A point near the peak of a centrifugal fan's performance pressure curve that defines the minimum airflow rate at which a fan can be operated without instability.

System Effect Factor (SEF)
A decrease in fan performance capability, observed as a pressure loss that results from the effect of fan inlet restrictions/obstructions, fan outlet restrictions or other conditions influencing the performance of the fan when it is installed in a system.

System Pressure Losses
The sum of the static pressure losses due to friction, shock, dissipation of velocity pressure at the system discharge and the static pressure differences between the entry and discharge openings of an air system.

Tangential Fan; see Cross-Flow Fan

Table Fan
An air circulator fan intended for use on a desk, table or countertop; it may also be provided with the means for being mounted to a wall.

Terminating Duct
The duct that contains the sound pressure measurement device when a fan is under test for sound and equipped with both inlet and outlet ducts. The duct on the opposite side may be equipped with an anechoic termination and is known as the terminating duct.

Test
A series of determinations for various points of operation of a device.

Test Block
The maximum operating test point that establishes the fan selection.

Test Duct
A duct section of prescribed length and configuration that is used to control and measure airflow rate and pressure or functions as the sound measurement section.

Thrust
The reaction force due to the momentum change of the mass flow through the device.

Thrust-to-Power Ratio
Ratio of the thrust to impeller power. Note: An alternative definition of thrust efficiency is defined as thrust divided by the motor input power. This results in a lower figure as the motor losses are also included.

Tip Speed
The peripheral velocity of the fan impeller tips.

Tip Speed Mach Parameter
A dimensionless number expressing the ratio of a fan impeller's peripheral velocity to the local velocity of sound at the fan inlet.

Total Efficiency
Ratio of fan output power divided by the fan input power.

Total Pressure
The air pressure that exists by virtue of the degree of compression and rate of motion of flowing air. It is equal to the algebraic sum of the velocity pressure and the static pressure at a point. Thus, if the air is at rest, the total pressure will equal the static pressure.

Total Temperature; see Stagnation Temperature

Torsional Critical Speed
The fan rotational speed that corresponds to the natural frequency in torsion of its power transmission system, including driver, drive train components and the fan rotor.

Transverse Connector

Trim Balance
The process that makes minor unbalance corrections, which may become necessary as a result of the fan assembly or installation.

Tubeaxial Fan
An axial flow fan, in a cylindrical housing, without guide vanes.

*See Annex B for ISO definition of this term

Tubular Centrifugal Fan
A fan having a centrifugal impeller within a cylindrical housing discharging the air in an axial direction.

Utility Set
A centrifugal fan designed as a packaged unit and ready to run. It is either belt driven or directly connected to an electric motor.

Turning Gear
An intermittent fan drive arrangement consisting of a motor, a speed reducer and a unidirectional engagement clutch fastened to the outboard end of a fan shaft or motor shaft through a flexible coupling. The turning gear rotates the complete rotating assembly at a low speed to prevent distortion in the rotor assembly due to uneven cooling. The turning gear may be sized to have the capability of starting the main rotor. Axial fans generally do not require a turning gear.

Unbalance
A condition of a rotor in which its rotation results in centrifugal forces being applied to the rotor's supporting bearings. Unbalance is usually measured by the product of the mass of the rotor times the distance between its center of gravity and its center of rotation in a plane.

Vane
1. A stationary curved surface used to straighten or direct airflow.
2. A flat or curved surface that can be rotated about an axis to direct airflow.

Vaneaxial Fan
An axial flow fan, in a cylindrical housing, with guide vanes located upstream of the impeller, downstream of the impeller or both.

*See Annex B for ISO definition of this term

Variable Pitch Impeller
An axial impeller having a mechanism or mechanisms by which the pitch angle of each impeller blade can be changed.

Velocity Distortion Parameter
An indicator of the velocity variation (distortion) in the plane of flow measurement. It is expressed as a standard deviation calculated from measured velocities across the plane.

Velocity (Dynamic) Pressure
The pressure that exists by virtue of rate of motion only.

Velocity Profile
A graphical presentation of the distribution of velocities, shown parallel to the general direction of flow, in a moving fluid.

Velocity Projection; see Air Curtain Unit Velocity Projection

Ventilator; see Fan

Vibration
The continuing periodic motion of an elastic system. Characteristics of vibration are generally reported as displacement, velocity or acceleration.

Vibration Spectrum
A representation of vibration amplitude versus frequency.

Viscosity

1. A proportionality factor relating the shearing stress to a unit rate of change in the velocity of the flowing gas or liquid. It is expressed as absolute viscosity or dynamic viscosity, interchangeably. Viscosity is dependent on absolute pressure (the gauge pressure of the system plus the barometric pressure) and temperature.
2. The proportionality factor relating shearing stress (force per unit area) and rate of shear (incremental velocity per incremental distance) of a fluid.

Volume Airflow Rate
The volume of air that passes through a given area in unit time.

Volume Control Damper; see Control Damper

Wavelength
The distance between two adjacent points in a wave that have the same phase.

Wet-Bulb Depression
The difference between the dry-bulb and wet-bulb temperatures at the same location.

Wet-Bulb Temperature
The temperature measured by a temperature sensor covered by a water-moistened wick and exposed to air in motion. Wet-bulb temperature is a close approximation of the temperature of adiabatic saturation.

Wet Gas Fan
A fan that serves to move air that contains particles of water.

*See Annex B for ISO definition of this term

Wheel; see Impeller

Wind Driven Rain Louver
Louvers that are subjected to testing using specific rainfall rates and high wind velocities.

Wind-Milling
The rotation of a fan rotor due to a flow of air into the fan housing when the fan driver is not energized.

3.2 The AMCA vocabulary: symbols

Symbol	Description	SI	I-P
A	Area of cross section	m^2	ft^2
A	Duct width	m	ft
A_e	Area — orifice equivalent to system	m^2	ft^2
A_o	Area — nozzle with no loss	m^2	ft^2
ah	Absolute humidity, (mass) H_20/(mass) dry air	kg/kg	lbm/lbm
B	Minimum distance between the sill and bottom blade	mm	in.
B	Duct height	m	ft
BPF	Blade pass frequency	Hz	Hz
BW	Band width	Hz	Hz
b	Flow-induced absorption coefficient	dB	dB
C	Dynamic loss coefficient	---	---
C	Combined free field response correction	dB	dB
C	Nozzle discharge coefficient	---	---

C	Minimum distance between adjacent blades	mm	in.
C_m	Constant for tip speed Mach number	---	---
C_n	Nozzle discharge coefficient	---	---
C_p	Specific heat at constant pressure	J/kg-K	Btu/lbm-ºF
C_v	Specific heat at constant volume	J/kg-K	Btu/lbm-ºF
C_1	Free field microphone correction response	dB	dB
C_2	Frequency response correction of sampling tube (normal incidence)	dB	dB
C_3	Flow velocity correction for frequency response required by sampling tube	dB	dB
C_4	Modal correction for the frequency response required by sampling tube	dB	dB
c	Speed of sound	m/s	ft/s
D	Diameter of duct or impeller	m	ft
D_e	Equivalent diameter	m	ft
$D_{e/y}$	Ratio of straightener cell size (diameter to thickness of cell)	---	---
D_h	Hydraulic diameter	m	ft
D_I	Diameter of intermediate duct	m	ft
D_T	Diameter of terminating duct	m	ft
DVM	Digital voltmeter	---	---
D_{1-6}	Diameters along anechoic termination	---	---
d	Orifice diameter	m	ft
dBA	Estimated sound pressure level at a location using A-weighting network	---	---
E	Energy factor	---	---
E	System resistance curve	---	---
E_{i1-in}	Duct inlet end correction	dB	dB
E_{o1-on}	Duct outlet end correction	dB	dB
Ev	Volts, direct current, output signal of thermal flow sensor	Vdc	Vdc
e	Orifice plate end reflection	dB	dB
e_{per}	Permissible specific unbalance	µm or kg (g•mm)	in. or (lb in.)/lb
e_x	Per unit uncertainty in *x*	---	---
F	Beam load	N	lbf
FLA	Full load amps	A	A
f	Coefficient of friction	---	---
f	Frequency	Hz	Hz
f_c	Cutoff frequency	Hz	Hz
G	Water volume flow rate	L/s	gpm
G	Balance quality grade	---	---
g	Acceleration due to gravity	m/s^2	ft/s^2
H	Fan power input	kW	hp
H	Actual louver height	mm	in.

H_a	Air power of air curtain	kW	hp
H_L	Power transmission loss	kW	hp
H_m	Power input to motor	kW	hp
H_{mo}	Motor power output	kW	hp
H_o	Fan power output	kW	hp
H_r	Fan impeller power	kW	hp
H_{sr}	Fan shaft power	kW	hp
H/T	Axial fan hub-to-tip ratio	---	---
I	Index in transverse direction for velocity matrix	---	---
j	Index in axial direction for velocity matrix	---	---
K	System effect factor	---	---
K	Loss coefficient relevant to a specific damper design sample	---	---
K_E	Friction chart correction factor for elevation	---	---
K_M	Friction chart correction factor for roughness	---	---
K_p	Compressibility coefficient	---	---
K_T	Friction chart correction factor for temperature	---	---
kW	Kilowatts, electric power	kW	kW
L	Length	m	ft
L	Minimum distance between louver jambs	mm	in.
L_e	Equivalent length of straightener	m	ft
L_m	Average sound level from multiplexing six duct stations or continuous circular traverses	dB	dB
ΔL_{max}	Maximum difference of microphone readings (nose cone sampling tube)	dB	dB
L_p	Sound pressure level re: 20 μPa	dB	dB
$\overline{L_p}$	Average sound pressure level at the measuring plane	dB	dB
$L_p$max	Maximum sound pressure level within the measuring duct	dB	dB
$L_p$min	Minimum sound pressure level within the measuring duct	dB	dB
$L_{p1, pn}$	Corrected sound pressure level of the fan	dB	dB
L_{p1-p6}	Sound pressure levels at each of six stations in the test duct	dB	dB
$L_{pb1, pbn}$	Recorded sound pressure level of room background as measured over the normal microphone path	dB	dB
$L_{pm1 ,pmn}$	Recorded sound pressure level of fan and room background as measured over the normal microphone path	dB	dB
L_{pNC}	Corrected sound pressure level with nose cone	dB	dB
$L_{pq1, pqn}$	Corrected sound pressure level of reference sound	dB	dB
$L_{pqm1, pqmn}$	Recorded sound pressure level of RSS and room background as measured over the normal microphone path	dB	dB
L_{pST}	Corrected sound pressure level with the sampling tube	dB	dB
ΔL_t	Turbulence noise suppression value	dB	dB
L_w	Sound power level, re: 1×10^{-12} watts	dB	dB
L_{wA}	Sound power level of fan, A-weighted; for each band or summarized	dB	dB

L_WA	Sound power level, A-weighted, re: 1 × 10^{-12} watts	dB	dB
L_{WF}	Capacity fraction, re: 1.0 × 10^{-12} watts	dB	dB
L_{WG}	Generalized sound power level, re: 1.0 × 10^{-12} watts	dB	dB
L_{Wi}	Sound power level at the inlet, re: 1.0 × 10^{-12} watts	dB	dB
$L_{Wi}A$	Sound power level at the inlet, A-weighted, re: 1.0 × 10^{-12} watts	dB	dB
$L_{W1, Wn}$	Total sound power of the test fan	dB	dB
$L_{Wi1, Win}$	Sound power transmitted to the inlet duct of the fan	dB	dB
L_{WK}	Specific sound power level, re: 1.0 × 10^{-12} watts	dB	dB
L_{Wmi}	Measured sound power level from the inlet, re: 1.0 × 10^{-12} watts	dB	dB
$L_{wmi1, wmin}$	Measured sound power at the open inlet of a fan	dB	dB
L_{Wmo}	Measured sound power level from the outlet, re: 1.0 × 10^{-12} watts	dB	dB
$L_{wmo1, wmon}$	Measured sound power at the open outlet of a fan	dB	dB
L_{Wo}	Sound power level at the outlet, re: 1.0 × 10^{-12} watts	dB	dB
$L_{Wo}A$	Sound power level at the outlet, A-weighted, re: 1.0 × 10^{-12} watts	dB	dB
$L_{Wr1, Wrn}$	Sound power level rating of the reference sound source	dB	dB
$L_{Wo1, Won}$	Sound power transmitted to the outlet duct of the fan	dB	dB
$L_{x, x'}$	Length of duct between planes x and x'	m	ft
L_{1-5}	Lengths along anechoic termination	m	ft
l	Length of moment arm	mm	in.
Ia	Output signal of thermal flow sensor	mAdc	mAdc
M	Mach number	---	---
M	Chamber dimension	m	ft
M	Rotor mass	kg	--(see W)
M_t	Tip speed Mach parameter	---	---
N	Rotational speed	rpm	rpm
NLA	No-load amps	A	A
NPH	Nameplate power	kW	hp
NPV	Nameplate volts	V	V
n	Number of readings	---	---
P	Pressure	Pa	in. wg
ΔP	Pressure differential or pressure drop across device being tested	Pa	in. wg
ΔP_c	Pressure drop of combined dampers	Pa	in. wg
PL	Plane of measurement	---	---
ΔP_n	Pressure differential across nozzle	Pa	in. wg
ΔP_n	Pressure drop of damper *n*	Pa	in. wg
P_s	Static pressure or fan static pressure	Pa	in. wg
ΔP_s	Pressure loss across damper	Pa	in. wg

ΔP_s	Fan static pressure rise	Pa	in. wg
ΔP_s	Static pressure regain from diffuser/evasé	Pa	in. wg
P_{sx}	Static pressure at plane x	Pa	in. wg
P_t	Total pressure or fan total pressure	Pa	in. wg
ΔP_t	Total pressure loss due to friction	Pa	in. wg
P_{tx}	Total pressure at plane x	Pa	in. wg
P_v	Velocity pressure or fan velocity pressure	Pa	in. wg
P_{vx}	Fan velocity pressure or velocity at plane x	Pa	in. wg
$\Delta P_{x-x'}$	Pressure differential between planes x and x'	Pa	in. wg
p	Atmospheric pressure	kPa	in. Hg
p_b	Corrected barometric pressure	kPa	in. Hg
p_e	Saturated vapor pressure at *tw*	kPa	in. Hg
p_p	Partial vapor pressure	kPa	in. Hg
p_x	Absolute pressure at plane x	kPa	in. Hg
Q	Airflow rate or fan airflow rate	m^3/s	cfm
Q	Directivity factor	---	---
Q_d	Tested device airflow rate	m^3/s	ft^3/min
Q_i	Interpolated airflow rate	m^3/s	ft^3/min
Q_r	Test reference airflow rate	m^3/s	ft^3/min
Q_x	Airflow rate at plane x	m^3/s	ft^3/min
R	Gas constant	J/kg-K	ft-lb/lbm-ºR
R	Room constant	m^2	ft^2
R	Reflection constant	---	---
Re	Reynolds number; fan Reynolds number	---	---
RSS	Reference sound source	---	---
r	Radius	m	ft
r	Ratio of duct area to orifice area	---	---
r	Index in the radial direction in the measuring plane	---	---
r	Radial distance from test duct centerline to sampling tube location	m	ft
rh	Relative humidity	%	%
S	Area or areas of test duct	m^2	ft^2
S	Aspect parameter	---	---
S	Total loudness index	sone	sone
SEF	System effect factor	---	---
S_F	Outlet or inlet area of fan	m^2	ft^2
S_R	System resistance factor	m^4	ft^4
s_m	Maximum octave band loudness index	sone	sone
T	Number of grid velocity measurements in the transverse direction	---	---
T	Torque	N·m	ft• lbf

T	Absolute inlet total temperature or absolute temperature	K	ºR
T_a	Length of transitions T1, T2 or T3	m	ft
t	Number of velocity measurements at a given radius *r* taken in circumferential increments	---	---
t	Temperature	ºC	ºF
t_d	Dry-bulb temperature	ºC	ºF
t_t	Total (stagnation) temperature	ºC	ºF
t_w	Wet-bulb temperature	ºC	ºF
U	Number of grid velocity measurements in the axial direction	---	---
U_{per}	Permissible residual unbalance	g•mm	lb in.
u	Number of velocity measurements at a given angle θ taken at radial increments	---	---
V	Velocity or average velocity	m/s	ft/min.
$\overline{V}$	Mean velocity at plane 1	m/s	ft/min.
V_a	Velocity profile distortion in axial direction (parallel to the fan impeller shaft)	%	%
I	Mean velocity for each of the T traverses	m/s	ft/min.
j	Mean velocity along each of the U grid stations	m/s	ft/min.
r	Mean velocity at a given radius r from duct center velocity profile distortion in transverse direction	m/s	ft/min.
$\widehat{V}_t$	(Perpendicular to the fan impeller shaft)	%	%
V_θ	Mean velocity at a given angle θ in the measuring plane	m/s	ft/min.
v	Velocity at any point	m/s	ft/min.
W	Power input to motor	kW	W
W	Rainfall rate	mm/h	in./hr
W	Actual louver width	mm	in.
W	Rotor weight	(see M)	lbm
w	Weight of water	kg	ozm
X	Plotting variable	---	---
ΔX	Absolute uncertainty in *X*	---	---
x	Function used to determine K_p	---	---
x	Peak air velocity along test plane	m/s	ft/min.
Y	Nozzle expansion factor	---	---
y	Thickness of straightener element	mm	in.
Z	Altitude	m	ft
z	Function used to determine K_p	---	---
α	Static pressure ratio for nozzles	---	---
β	Diameter ratio for nozzles	---	---
γ	Ratio of specific heats	---	---
ε	Absolute surface roughness height	m	ft
η	Motor efficiency	%	%
η_{ac}	Air curtain unit efficiency	%	%

η_s	Fan static efficiency	%	%
η_t	Fan total efficiency	%	%
θ	Index in the circumferential direction in the measuring plane	---	---
λ	Wavelength	m	ft
μ	Absolute viscosity	Pa•s	lbm/(ft•s)
ν	Kinematic viscosity	m^2/s	ft^2/s
ρ	Air density	kg/m^3	lbm/ft^3
ρ_s	Air density at standard conditions	kg/m^3	lbm/ft^3
ρ_x	Air density at plane x	kg/m^3	lbm/ft^3
σ_n	Standard deviation of quantity n	---	---
$\Rightarrow$	Airflow direction	---	---
α	Average absorption coefficient for each surface	---	---
$\bar{\alpha}$	Average room absorption coefficient	---	---
ω	Angular velocity (of a rotor)	rad/s	rad/s

Subscripts	Description
a	Atmospheric conditions
b	Barometric pressure
c	Converted or calculated value
d	Dry-bulb temperature
g	Static pressure
r	Reading
w	Wet-bulb depression
x	Generalized quantity (A,b, ... , ρ)
x	Plane 0,1,2, ... as appropriate
x, x'	Between planes x and x'
0	Plane 0 (general test area)
1	Plane 1 (fan inlet)
2	Plane 2 (fan outlet)
3	Plane 3 (pitot traverse station)
4	Plane 4 (duct piezometer station)
5	Plane 5 (nozzle inlet station in chamber)
6	Plane 6 (nozzle discharge station)
7	Plane 7 (outlet chamber measurement station)
8	Plane 8 (inlet chamber measurement station)

4. 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 (see Annex A of AMCA Publication 211). 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 independent of the system of units used, as long as the units are used consistently for each ratio.

The mathematical statements that 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:

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.

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.

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 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 the Handbook of Fan Engineering, latest edition.

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:

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

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:

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

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

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

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

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

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

$$\eta_t = \frac{Q P_t K_p}{C_h H}$$

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
P_{t1c} = Total pressure at fan inlet converted
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 in.
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	ρ_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 in.
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

$$x = \frac{P_t}{P_{t1} + C_b p_b} = \frac{953.7}{0 + ((1)(97359))} = \frac{953.7}{97359}$$

$x = 0.0097957$

$$z = \left[\frac{\gamma - 1}{\gamma}\right]\left[\frac{C_h H}{Q(P_{t1} + [C_b p_b])}\right] = \left[\frac{1.4 - 1}{1.4}\right]\left[\frac{(1)(9299)}{7.952(0 + (1)(97359))}\right]$$

z = 0.0034317

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

$K_p = 0.99684$

$$\eta_t = \frac{QP_tK_p}{C_hH} = \left[\frac{(7.952)(953.7)(0.99684)}{(1)(9299)}\right]$$

$\eta_t = 0.813$ or 81.3%

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

$$\frac{z_c}{z} = \left[\frac{P_{t1} + C_b p_b}{P_{t1c} + C_b p_{bc}}\right]\left[\frac{\rho_c}{\rho}\right]\left[\frac{N_c}{N}\right]^2\left[\frac{D_c}{D}\right]^2 = \left[\frac{0 + (1 \times 97359)}{0 + (1 \times 101321)}\right]\left[\frac{1.2}{1.152}\right]\left[\frac{820}{1000}\right]^2\left[\frac{1524}{927}\right]^2$$

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

Then:

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

And:

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

$$K_{pc} = \frac{1}{1 + (2.8455 - 1)\left(\frac{0.006242}{2}\right) + (2.8455 - 1)(2.8455 - 2)\left(\frac{0.006242^2}{6}\right)}$$

Then:

K_{pc} = 0.99426

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

$$Q_c = 7.952\left[\frac{1524}{927}\right]^3\left[\frac{820}{1000}\right]\left[\frac{0.99684}{0.99426}\right]$$

$$Q_c = 7.952\left[\frac{1524}{927}\right]^3\left[\frac{820}{1000}\right]\left[\frac{0.99684}{0.99426}\right]$$

= 29.05 m/s³

$$P_{tc} = 953.7\left[\frac{1524}{927}\right]^2\left[\frac{820}{1000}\right]^2\left[\frac{1.2}{1.152}\right]\left[\frac{0.99684}{0.99426}\right]$$

= 1810.11 Pa

$$H_c = 9.299\left[\frac{1524}{927}\right]^5\left[\frac{820}{1000}\right]^3\left[\frac{1.2}{1.152}\right]\left[\frac{0.99684}{0.99426}\right]$$

= 64.31 kW

Example calculations in I-P units

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

x = 0.0097994

$$z = \left[\frac{\gamma-1}{\gamma}\right]\left[\frac{C_h H}{Q\left(P_{t1}+(C_b p_b)\right)}\right] = \left[\frac{1.4-1}{1.4}\right]\left[\frac{(6362)(12.47)}{16850\left(0+(13.63)(28.75)\right)}\right] = \left[\frac{0.4}{1.4}\right]\left[\frac{79334.14}{16850(0+391.86)}\right]$$

$$= \left[\frac{(0.2857)(79334.14)}{(16850)(391.86)}\right] = \left[\frac{(22665.76)}{(6602841)}\right]$$

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:

$$Q_C = 16850 \left[\frac{60.0}{36.5}\right]^3 \left[\frac{820}{1000}\right] \left[\frac{0.99684}{0.99426}\right]$$

= 61534 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 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 hp

5. Basic Series of Preferred Numbers

Basic Series				Serial Number	Theoretical Values		Percentage differences between basic series and calculated values (%)
R5	R10	R20	R40		Base 10 Mantissa of Logarithms	Calculated Values	
1.00	1.00	1.00	1.00	0	000	1.000	0
			1.06	1	.025	1.0593	+0.07
		1.12	1.12	2	.050	1.1220	-0.18
			1.18	3	.075	1.1885	-0.71
	1.25	1.25	1.25	4	.100	1.2589	-.071
			1.32	5	.125	1.3335	-1.01
		1.40	1.40	6	.150	1.4125	-0.88
			1.50	7	.175	1.4962	+0.25
1.60	1.60	1.60	1.60	8	.200	1.5849	+0.95
			1.70	9	.225	1.6788	+1.26
		1.80	1.80	10	.250	1.7783	+1.22
			1.90	11	.275	1.8836	+0.87
	2.00	2.00	2.00	12	.300	1.9953	+0.24
			2.12	13	.325	2.1135	+0.31
		2.24	2.24	14	.350	2.2387	+0.06
			2.36	15	.375	2.3714	-0.48
2.50	2.50	2.50	2.50	16	.400	2.5119	-0.47
			2.65	17	.425	2.6607	-0.40
		2.80	2.80	18	.450	2.8184	-0.65
			3.00	19	.475	2.9854	+0.49
	3.15	3.15	3.15	20	.500	3.1623	-0.39
			3.35	21	.525	3.3497	+0.01
		3.55	3.55	22	.550	3.5481	+0.05
			3.75	23	.575	3.7584	-0.22
4.00	4.00	4.00	4.00	24	.600	3.9811	+0.47
			4.25	25	.625	4.2170	+0.78
		4.50	4.50	26	.650	4.4668	+0.74
			4.75	27	.675	4.7315	+0.39
	5.00	5.00	5.00	28	.700	5.0119	-0.24
			5.30	29	.725	5.3088	-0.17
		5.60	5.60	30	.750	5.6234	-0.42
			6.00	31	.775	5.9566	+0.73
6.30	6.30	6.30	6.30	32	.800	6.3096	-0.15
			6.70	33	.825	6.6834	+0.25
		7.10	7.10	34	.850	7.0795	+0.29
			7.50	35	.875	7.4989	+0.01
	8.00	8.00	8.00	36	.900	7.9433	+0.71
			8.50	37	.925	8.4140	+1.02
		9.00	9.00	38	.950	8.9125	+0.98
			9.50	39	.975	9.4406	+0.63
10.00	10.00	10.00	10.00	40	1.000	10.0000	0

Note: This reference standard is in harmony with ISO 497:1973. Those who wish to explore the topic of preferred numbers should refer to the ISO standard.

6. Metric Units and Conversion Factors

	SI Units[a]	I-P Units	Conversion Factor[b]
Volume flow	Cubic meter per second (m^3/s) L/s	cfm	0.00047195 0.47195
Pressure	Pascal (Pa or N/m^2)	in. wg	249.089[e]
Power	Watt (W or J/s)	hp	745.7
Torque	Newton meter (N•m)	lbf•in.	0.11298
Density	Kilogram per cubic meter (kg/m^3)	lbm/ft^3	16.018
Rotational speed[c]	Revolutions per second (rps)	rpm	1/60
Velocity	Meter per second (m/s)	fpm	0.00508[f]
Dimensions	Millimeter (mm)	in.	25.4[f]
Moment of inertia	Kilogram meters squared (kg•m^2)	lbm•ft^2	0.04214
Stress	Pascal (Pa or N/m^2)	lbf/in^2	6894.8
Temperature[d]	Kelvin (K) °Celsius (°C) Kelvin (K) °Celsius (°C)	°F °F Difference in °F Difference in °F	(°F + 459.67)/1.8 (°F - 32)/1.8 0.55556 0.55556

Notes:

a. The choice of the appropriate multiple or sub-multiple of an SI unit is governed by convenience. The multiple chosen for a particular application should be the one that will lead to numerical values within a practical range (i.e., kilopascal for pressure, kilowatts for power, megapascal for stress and liters/second for volume flow).

b. Multiply the I-P unit by this factor to obtain the SI unit, excluding kelvin and Celsius temperatures.

c. The second is the SI base unit of time, although outside SI, the minute has been recognized by CIPM as necessary to retain for use because of its practical importance.

d. The kelvin is the SI base unit of thermodynamic temperature and is preferred for most scientific and technological purposes. The degree Celsius (°C) is acceptable for practical applications.

e. The actual pressure corresponding to the height of a vertical column of fluid depends upon the gravitational acceleration and the density of the fluid, which in turn depends upon the temperature. The conversion factor given here is a reference value adopted by ISO. A gravitational acceleration of g_n = 9.80665 m/s^2, a density of water of 1000 kg/m^3, and a density of mercury of 13595.1 kg/m^3 is assumed (referenced from IEEE/ASTM SI 10-2002, Table A.1, Note 2)

f. Exact value

7. Charts and Tables [1]

Z Altitude m	*t* Temperature °C	*p* Atmospheric Pressure kPa	*ρ* Air Density kg/m^3	*μ* Dynamic Viscosity Pa•s	*ν* Kinematic Vis-cosity m^2/s	*c* Speed of Sound m/s
0	15.00	101.32	1.230	1.793×10^{-5}	1.456×10^{-5}	340.43
100	14.35	100.13	1.215	1.790×10^{-5}	1.473×10^{-5}	340.05
200	13.70	98.94	1.201	1.786×10^{-5}	1.487×10^{-5}	339.66
300	13.05	97.77	1.189	1.784×10^{-5}	1.500×10^{-5}	339.28
400	12.40	96.61	1.177	1.780×10^{-5}	1.512×10^{-5}	338.89
500	11.76	95.46	1.166	1.777×10^{-5}	1.524×10^{-5}	338.51
600	11.11	94.32	1.155	1.774×10^{-5}	1.536×10^{-5}	338.19
700	10.46	93.20	1.145	1.771×10^{-5}	1.546×10^{-5}	337.73
800	9.81	92.08	1.134	1.768×10^{-5}	1.559×10^{-5}	337.34
900	9.16	90.98	1.123	1.765×10^{-5}	1.571×10^{-5}	336.95
1000	8.51	89.88	1.112	1.761×10^{-5}	1.584×10^{-5}	336.57
1100	7.86	88.80	1.102	1.758×10^{-5}	1.595×10^{-5}	336.18
1200	7.21	87.72	1.091	1.755×10^{-5}	1.609×10^{-5}	335.79
1300	6.56	86.66	1.080	1.751×10^{-5}	1.621×10^{-5}	335.40
1400	5.90	85.61	1.069	1.748×10^{-5}	1.635×10^{-5}	335.01
1500	5.25	84.56	1.058	1.745×10^{-5}	1.649×10^{-5}	334.62
1600	4.60	83.53	1.047	1.741×10^{-5}	1.663×10^{-5}	334.22
1700	3.95	82.50	1.037	1.738×10^{-5}	1.676×10^{-5}	333.83
1800	3.30	81.49	1.026	1.735×10^{-5}	1.691×10^{-5}	333.44
1900	2.65	80.49	1.016	1.732×10^{-5}	1.705×10^{-5}	333.05
2000	2.00	79.49	1.006	1.728×10^{-5}	1.718×10^{-5}	332.66
2100	1.35	78.51	0.996	1.725×10^{-5}	1.732×10^{-5}	332.26
2200	0.70	77.54	0.986	1.722×10^{-5}	1.746×10^{-5}	331.87
2300	0.53	76.57	0.976	1.718×10^{-5}	1.760×10^{-5}	331.48
2400	-0.60	75.62	0.967	1.715×10^{-5}	1.774×10^{-5}	331.08
2500	-1.25	74.68	0.957	1.712×10^{-5}	1.789×10^{-5}	330.69
2600	-1.90	73.74	0.948	1.708×10^{-5}	1.802×10^{-5}	330.29
2700	-2.55	72.82	0.938	1.705×10^{-5}	1.818×10^{-5}	329.90
2800	-3.20	71.91	0.929	1.702×10^{-5}	1.832×10^{-5}	329.50
2900	-3.85	71.00	0.919	1.699×10^{-5}	1.845×10^{-5}	329.10
3000	-4.50	70.11	0.909	1.695×10^{-5}	1.865×10^{-5}	328.71
3100	-5.15	69.23	0.900	1.692×10^{-5}	1.880×10^{-5}	328.31
3200	-5.80	68.35	0.890	1.689×10^{-5}	1.898×10^{-5}	327.51
3300	-6.46	67.48	0.880	1.685×10^{-5}	1.914×10^{-5}	327.11
3400	-7.11	66.62	0.871	1.682×10^{-5}	1.931×10^{-5}	326.70
3500	-7.76	65.77	0.862	1.679×10^{-5}	1.948×10^{-5}	326.30

Standard Atmospheric Data Versus Altitude Chart (SI)

Z Altitude ft	t Temperature °F	p Atmospheric Pressure in. Hg	ρ Air Density lbm/ft³	μ Dynamic Viscosity lbm/ft-s	v Kinematic Vis-cosity ft²/s	c Speed of Sound ft/s
-1000	62.6	31.02	0.0787	1.212×10^{-5}	1.538×10^{-4}	1120.7
-500	60.8	30.47	0.0776	1.208×10^{-5}	1.556×10^{-4}	1118.8
0	59.0	29.92	0.0765	1.205×10^{-5}	1.576×10^{-4}	1116.9
500	57.2	29.38	0.0754	1.202×10^{-5}	1.595×10^{-4}	1115.0
1000	55.4	28.86	0.0743	1.198×10^{-5}	1.614×10^{-4}	1113.1
1500	53.7	28.33	0.0732	1.195×10^{-5}	1.633×10^{-4}	1111.1
2000	51.9	27.82	0.0721	1.192×10^{-5}	1.653×10^{-4}	1109.2
2500	50.1	27.32	0.0710	1.189×10^{-5}	1.673×10^{-4}	1107.3
3000	48.3	26.82	0.0700	1.185×10^{-5}	1.694×10^{-4}	1105.3
3500	46.5	26.33	0.0689	1.182×10^{-5}	1.714×10^{-4}	1103.4
4000	44.7	25.84	0.0679	1.179×10^{-5}	1.735×10^{-4}	1101.4
4500	43.0	25.37	0.0669	1.175×10^{-5}	1.757×10^{-4}	1099.5
5000	41.2	24.90	0.0659	1.172×10^{-5}	1.778×10^{-4}	1097.5
5500	39.4	24.43	0.0649	1.169×10^{-5}	1.800×10^{-4}	1095.6
6000	37.6	23.98	0.0639	1.165×10^{-5}	1.823×10^{-4}	1093.6
6500	35.8	23.53	0.0630	1.162×10^{-5}	1.846×10^{-4}	1091.7
7000	34.0	23.09	0.0620	1.158×10^{-5}	1.869×10^{-4}	1089.7
7500	32.3	22.65	0.0610	1.155×10^{-5}	1.892×10^{-4}	1087.7
8000	30.5	22.22	0.0601	1.152×10^{-5}	1.916×10^{-4}	1085.7
8500	28.7	21.80	0.0592	1.148×10^{-5}	1.904×10^{-4}	1083.8
9000	26.9	21.39	0.0583	1.145×10^{-5}	1.965×10^{-4}	1081.8
9500	25.1	20.98	0.0574	1.142×10^{-5}	1.990×10^{-4}	1079.8
10000	23.3	20.58	0.0565	1.138×10^{-5}	2.015×10^{-4}	1077.8

Standard Atmospheric Data Versus Altitude Chart (I-P)

Dry-Bulb Temp. °C	Density of Saturated Air for Various Barometric Conditions — kg/m³					
	Barometric Pressure k/Pa					
	97	98.5	100	101.5	103	104.5
-2.0	1.244981	1.263273	1.282390	1.302927	1.324194	1.340401
-1.5	1.242122	1.260977	1.280094	1.300086	1.322000	1.337965
-1.0	1.239396	1.258667	1.277753	1.297353	1.319731	1.335505
-0.5	1.236782	1.256345	1.275377	1.294710	1.317400	1.333027
0.0	1.234260	1.254012	1.272975	1.292141	1.315018	1.330532
0.5	1.231812	1.251672	1.270553	1.289629	1.312595	1.328024
1.0	1.229423	1.249325	1.268119	1.287163	1.310140	1.325506
1.5	1.227079	1.246973	1.265679	1.284731	1.307661	1.322979
2.0	1.224768	1.244618	1.263236	1.282324	1.305166	1.320447
2.5	1.222480	1.242261	1.260796	1.279934	1.302659	1.317912
3.0	1.220207	1.239902	1.258360	1.277553	1.300147	1.315376
3.5	1.217942	1.237545	1.255931	1.275177	1.297634	1.312841
4.0	1.215680	1.235188	1.253510	1.272800	1.295123	1.310307
4.5	1.213416	1.232834	1.251098	1.270421	1.292618	1.307778
5.0	1.211147	1.230483	1.248697	1.268037	1.290121	1.305254
5.5	1.208871	1.228135	1.246304	1.265645	1.287634	1.302735
6.0	1.206587	1.225792	1.243921	1.263247	1.285157	1.300224
6.5	1.204295	1.223453	1.241546	1.260842	1.282692	1.297720
7.0	1.201994	1.221119	1.239179	1.258431	1.280239	1.295225
7.5	1.199687	1.218791	1.236817	1.256015	1.277798	1.292738
8.0	1.197375	1.216468	1.234459	1.253595	1.275367	1.290260
8.5	1.195060	1.214150	1.232105	1.251173	1.272946	1.287790
9.0	1.192743	1.211838	1.229752	1.248752	1.270533	1.285328
9.5	1.190428	1.209530	1.227399	1.246334	1.268128	1.282875
10.0	1.188116	1.207227	1.225045	1.243920	1.265728	1.280428
10.5	1.185810	1.204927	1.222689	1.241512	1.263332	1.277988
11.0	1.183512	1.202631	1.220330	1.239113	1.260938	1.275553
11.5	1.181224	1.200338	1.217968	1.236723	1.258544	1.273122
12.0	1.178948	1.198047	1.215603	1.234343	1.256148	1.270693
12.5	1.176683	1.195757	1.213236	1.231974	1.253747	1.268266
13.0	1.174432	1.193466	1.210866	1.229616	1.251342	1.265837
13.5	1.172192	1.191174	1.208497	1.227266	1.248928	1.263406
14.0	1.169963	1.188879	1.206131	1.224925	1.246506	1.260970
14.5	1.167742	1.186581	1.203771	1.222588	1.244075	1.258527
15.0	1.165527	1.184277	1.201420	1.220251	1.241632	1.256073
15.5	1.163312	1.181965	1.199084	1.217911	1.239178	1.253607
16.0	1.161092	1.179644	1.196770	1.215560	1.236712	1.251125
16.5	1.158860	1.177313	1.194483	1.213191	1.234235	1.248624
17.0	1.156606	1.174968	1.192231	1.210795	1.231747	1.246101
17.5	1.154320	1.172609	1.190025	1.208361	1.229250	1.243553
18.0	1.151991	1.170232	1.187875	1.205877	1.226746	1.240975

Psychometric Density Table (SI) (1 of 2)

Dry-Bulb Temp. °C	Density of Saturated Air for Various Barometric Conditions — kg/m³					
	Barometric Pressure k/Pa					
	97	98.5	100	101.5	103	104.5
18.5	1.148567	1.167391	1.185062	1.203323	1.225071	1.240138
19.0	1.146325	1.164887	1.182780	1.200987	1.222584	1.237641
19.5	1.144073	1.162437	1.180492	1.198647	1.220116	1.235154
20.0	1.141813	1.160033	1.178197	1.196304	1.217665	1.232675
20.5	1.139548	1.157668	1.175897	1.193957	1.215229	1.230205
21.0	1.137279	1.155335	1.173591	1.191607	1.212804	1.227740
21.5	1.135008	1.153029	1.171279	1.189254	1.210388	1.225283
22.0	1.132735	1.150742	1.168962	1.186898	1.207980	1.222830
22.5	1.130461	1.148470	1.166639	1.184537	1.205577	1.220383
23.0	1.128188	1.146207	1.164311	1.182174	1.203177	1.217939
23.5	1.125917	1.143949	1.161977	1.179806	1.200778	1.215499
24.0	1.123646	1.141691	1.159639	1.177435	1.198380	1.213061
24.5	1.121378	1.139431	1.157295	1.175060	1.195979	1.210625
25.0	1.119111	1.137164	1.154946	1.172681	1.193576	1.208190
25.5	1.116846	1.134888	1.152592	1.170298	1.191169	1.205755
26.0	1.114582	1.132601	1.150234	1.167912	1.188756	1.203320
26.5	1.112318	1.130299	1.147871	1.165521	1.186338	1.200883
27.0	1.110055	1.127983	1.145503	1.163126	1.183912	1.198445
27.5	1.107790	1.125650	1.143131	1.160726	1.181480	1.196003
28.0	1.105523	1.123300	1.140754	1.158323	1.179039	1.193559
28.5	1.103253	1.120932	1.138373	1.155915	1.176591	1.191110
29.0	1.100978	1.118548	1.135988	1.153503	1.174134	1.188656
29.5	1.098695	1.116147	1.133599	1.151086	1.171669	1.186196
30.0	1.096404	1.113730	1.131206	1.148664	1.169195	1.183730
30.5	1.094102	1.111299	1.128809	1.146239	1.166714	1.181257
31.0	1.091787	1.108856	1.126408	1.143808	1.164226	1.178775
31.5	1.089456	1.106402	1.124004	1.141372	1.161731	1.176286
32.0	1.087106	1.103942	1.121596	1.138932	1.159230	1.173786
32.5	1.084735	1.101478	1.119184	1.136487	1.156724	1.171277
33.0	1.082339	1.099014	1.116769	1.134037	1.154213	1.168756
33.5	1.079915	1.096553	1.114351	1.131582	1.151700	1.166224
34.0	1.077460	1.094100	1.111930	1.129122	1.149185	1.163679
34.5	1.074970	1.091661	1.109506	1.126656	1.146669	1.161121
35.0	1.072440	1.089240	1.107079	1.124186	1.144155	1.158549
35.5	1.069867	1.086844	1.104649	1.121710	1.141644	1.155963
36.0	1.067247	1.084478	1.102216	1.119229	1.139139	1.153361
36.5	1.064575	1.082149	1.099780	1.116742	1.136640	1.150743
37.0	1.061846	1.079865	1.097342	1.114250	1.134151	1.148108
37.5	1.059056	1.077632	1.094902	1.111753	1.131673	1.145455
38.0	1.056198	1.075460	1.092459	1.109249	1.129210	1.142784

Psychometric Density Table (SI) (2 of 2)

Dry-Bulb Temp. °F	Density of Saturated Air for Various Barometric Conditions — lbm/ft³					
	Barometric Pressure in. Hg					
	28.5	29.0	29.5	30.0	30.5	31.0
30	0.07703	0.07839	0.07974	0.08111	0.08245	0.08380
31	0.07687	0.07822	0.07957	0.08093	0.08228	0.08363
32	0.07671	0.07806	0.07940	0.08075	0.08210	0.08345
33	0.07654	0.07789	0.07924	0.08058	0.08193	0.08327
34	0.07638	0.07772	0.07907	0.08041	0.08175	0.08310
35	0.07621	0.07756	0.07890	0.08024	0.08158	0.08292
36	0.07605	0.07739	0.07873	0.07807	0.08141	0.08274
37	0.07589	0.07723	0.07856	0.07990	0.08123	0.08257
38	0.07573	0.07706	0.07840	0.07973	0.08106	0.08239
39	0.07557	0.07690	0.07823	0.07956	0.08089	0.08222
40	0.07541	0.07674	0.07806	0.07939	0.08072	0.08205
41	0.07525	0.07657	0.07790	0.07922	0.08055	0.08187
42	0.07509	0.07641	0.07773	0.07905	0.08038	0.08170
43	0.07493	0.07625	0.07757	0.07889	0.08021	0.08153
44	0.07477	0.07609	0.07740	0.07872	0.08004	0.08135
45	0.07461	0.07592	0.07724	0.07855	0.07986	0.08118
46	0.07445	0.07576	0.07707	0.07838	0.07970	0.08101
47	0.07429	0.07560	0.07691	0.07822	0.07953	0.08084
48	0.07413	0.07544	0.07674	0.07805	0.07936	0.08066
49	0.07397	0.07528	0.07658	0.07788	0.07919	0.08049
50	0.07381	0.07512	0.07642	0.07772	0.07902	0.08032
51	0.07366	0.07496	0.07625	0.07755	0.07885	0.08015
52	0.07350	0.07479	0.07609	0.07739	0.07868	0.07998
53	0.07334	0.07464	0.07593	0.07722	0.07852	0.07981
54	0.07318	0.07447	0.07576	0.07706	0.07835	0.07964
55	0.07302	0.07431	0.07560	0.07689	0.07818	0.07947
56	0.07287	0.07415	0.07544	0.07673	0.07801	0.07930
57	0.07271	0.07399	0.07528	0.07656	0.07784	0.07913
58	0.07255	0.07383	0.07512	0.07640	0.07768	0.07896
59	0.07240	0.07367	0.07495	0.07623	0.07751	0.07879
60	0.07224	0.07352	0.07479	0.07607	0.07734	0.07862
61	0.07208	0.07336	0.07463	0.07590	0.07718	0.07845
62	0.07193	0.07320	0.07447	0.07574	0.07701	0.07828
63	0.07177	0.07304	0.07430	0.07557	0.07684	0.07811
64	0.07161	0.07288	0.07414	0.07541	0.07668	0.07794

Psychometric Density Table (I-P) (1 of 2)

Dry-Bulb Temp. °F	Density of Saturated Air for Various Barometric Conditions — lbm/ft³					
	Barometric Pressure in. Hg					
	28.5	29.0	29.5	30.0	30.5	31.0
65	0.07145	0.07272	0.07398	0.07525	0.07651	0.07770
66	0.07130	0.07256	0.07382	0.07508	0.07634	0.07760
67	0.07114	0.07240	0.07366	0.07492	0.07618	0.07744
68	0.07098	0.07224	0.07350	0.07475	0.07601	0.07727
69	0.07083	0.07208	0.07333	0.07459	0.07584	0.07710
70	0.07067	0.07192	0.07317	0.07442	0.07568	0.07693
71	0.07051	0.07176	0.07301	0.07426	0.07551	0.07676
72	0.07035	0.07160	0.07285	0.07410	0.07534	0.07659
73	0.07020	0.07144	0.07268	0.07393	0.07517	0.07642
74	0.07004	0.07128	0.07252	0.07377	0.07501	0.07625
75	0.06988	0.07112	0.07236	0.07360	0.07484	0.07603
76	0.06972	0.07096	0.07220	0.07343	0.07467	0.07591
77	0.06956	0.07080	0.07203	0.07327	0.07451	0.07574
78	0.06940	0.07064	0.07187	0.07310	0.07434	0.07557
79	0.06925	0.07048	0.07171	0.07294	0.07417	0.07540
80	0.06909	0.07032	0.07155	0.07277	0.07400	0.07523
81	0.06893	0.07015	0.07138	0.07261	0.07383	0.07506
82	0.06877	0.07000	0.07122	0.07244	0.07366	0.07489
83	0.06861	0.06983	0.07105	0.07227	0.07349	0.07472
84	0.06845	0.06967	0.07089	0.07211	0.07333	0.07454
85	0.06829	0.06950	0.07072	0.07194	0.07316	0.07437
86	0.06812	0.06934	0.07056	0.07177	0.07299	0.07420
87	0.06796	0.06917	0.07039	0.07160	0.07281	0.07403
88	0.06780	0.06901	0.07022	0.07143	0.07264	0.07385
89	0.06764	0.06885	0.07005	0.07126	0.07247	0.07368
90	0.06748	0.06868	0.06989	0.07109	0.07230	0.07351
91	0.06731	0.06852	0.06972	0.07092	0.07213	0.07333
92	0.06715	0.06835	0.06955	0.07075	0.07195	0.07316
93	0.06698	0.06818	0.06938	0.07058	0.07178	0.07298
94	0.06682	0.06801	0.06921	0.07041	0.07161	0.07280
95	0.06665	0.06785	0.06904	0.07024	0.07143	0.07263
96	0.06648	0.06768	0.06887	0.07006	0.07126	0.07245
97	0.06632	0.06751	0.06870	0.06989	0.07108	0.07227
98	0.06615	0.06734	0.06853	0.06972	0.07091	0.07209
99	0.06598	0.06717	0.06835	0.06954	0.07073	0.07191
100	0.06581	0.06700	0.06818	0.06937	0.07055	0.07174

Psychometric Density Table (I-P) (2 of 2)

Altitude (Z)	m	-300	Sea Level	300	600	900	1200
Barometeric Pressure(p_b)	mm Hg kPa	787.41 104.98	760.00 101.325	733.34 97.77	707.46 94.32	682.33 90.97	657.95 87.72
Temperature °C	-20	1.200	1.158	1.117	1.078	1.040	1.003
	0	1.112	1.073	1.036	0.999	0.964	0.929
	20	1.036	1.000	0.965	0.931	0.898	0.866
	40	0.970	0.936	0.903	0.871	0.840	0.810
	60	0.912	0.880	0.849	0.819	0.790	0.762
	80	0.860	0.830	0.801	0.773	0.745	0.719
	100	0.814	0.786	0.758	0.731	0.705	0.680
	120	0.773	0.746	0.719	0.694	0.669	0.646
	140	0.735	0.710	0.685	0.660	0.637	0.614
	160	0.701	0.677	0.653	0.630	0.608	0.586
	180	0.670	0.647	0.624	0.602	0.581	0.560
	200	0.642	0.620	0.598	0.577	0.556	0.536
	220	0.616	0.594	0.574	0.553	0.534	0.515
	240	0.592	0.571	0.551	0.532	0.513	0.495
	260	0.570	0.550	0.531	0.512	0.494	0.476
	280	0.549	0.530	0.511	0.493	0.476	0.459
	300	0.530	0.511	0.494	0.476	0.459	0.443
	320	0.512	0.494	0.477	0.460	0.444	0.428
	340	0.495	0.478	0.461	0.445	0.429	0.414

Altitude (Z)	m	1500	1800	2100	2400	2700	3000
Barometeric Pressure(p_b)	mm Hg kPa	634.25 84.56	611.23 81.49	588.87 78.51	567.20 75.62	546.19 72.82	525.87 70.11
Temperature °C	-20	0.966	0.931	0.897	0.864	0.832	0.801
	0	0.896	0.863	0.832	0.801	0.771	0.743
	20	0.835	0.804	0.775	0.746	0.719	0.692
	40	0.781	0.753	0.725	0.699	0.673	0.648
	60	0.734	0.708	0.682	0.657	0.632	0.609
	80	0.693	0.668	0.643	0.620	0.597	0.574
	100	0.656	0.632	0.609	0.586	0.565	0.544
	120	0.622	0.600	0.578	0.556	0.536	0.516
	140	0.592	0.571	0.550	0.530	0.510	0.491
	160	0.565	0.544	0.524	0.505	0.486	0.468
	180	0.540	0.520	0.501	0.483	0.465	0.448
	200	0.517	0.498	0.480	0.462	0.445	0.429
	220	0.496	0.478	0.461	0.444	0.427	0.411
	240	0.477	0.459	0.443	0.426	0.411	0.395
	260	0.459	0.442	0.426	0.410	0.395	0.380
	280	0.442	0.426	0.411	0.396	0.381	0.367
	300	0.427	0.411	0.396	0.382	0.368	0.354
	320	0.412	0.397	0.383	0.369	0.355	0.342
	340	0.399	0.385	0.370	0.357	0.344	0.331

Multiply standard air density 1.2 kg/m^2 by the factor to obtain density at condition p_b.

Dry Air Density Correction Factor (SI)

Altitude (Z)	ft	-1000	Sea Level	1000	2000	3000	4000
Barometeric Pressure(p_b)	in. Hg in. wg	31.02 421.71	29.92 406.75	28.85 392.21	27.82 378.20	26.82 364.61	25.84 351.29
Temperature °F	-40	1.309	1.262	1.217	1.174	1.131	1.090
	0	1.195	1.152	1.111	1.071	1.033	0.995
	40	1.099	1.060	1.022	0.986	0.950	0.915
	70	1.037	1.000	0.964	0.930	0.896	0.864
	100	0.981	0.946	0.913	0.880	0.848	0.817
	150	0.901	0.869	0.838	0.808	0.779	0.750
	200	0.832	0.803	0.774	0.747	0.720	0.693
	250	0.774	0.746	0.720	0.694	0.669	0.645
	300	0.723	0.697	0.672	0.648	0.625	0.602
	350	0.678	0.654	0.631	0.608	0.586	0.565
	400	0.639	0.616	0.594	0.573	0.552	0.532
	450	0.604	0.582	0.561	0.541	0.522	0.503
	500	0.572	0.552	0.532	0.513	0.495	0.477
	550	0.544	0.525	0.506	0.488	0.470	0.453
	600	0.518	0.500	0.482	0.465	0.448	0.432
	700	0.474	0.457	0.440	0.425	0.409	0.394
	800	0.436	0.420	0.405	0.391	0.377	0.363
	900	0.404	0.390	0.376	0.362	0.349	0.336
	1000	0.376	0.363	0.350	0.337	0.325	0.313

Altitude (Z)	ft	-1000	Sea Level	1000	2000	3000	4000
Barometeric Pressure(p_b)	in. Hg in. wg	31.02 421.71	29.92 406.75	28.85 392.21	27.82 378.20	26.82 364.61	25.84 351.29
Temperature °F	-40	1.309	1.262	1.217	1.174	1.131	1.090
	0	1.195	1.152	1.111	1.071	1.033	0.995
	40	1.099	1.060	1.022	0.986	0.950	0.915
	70	1.037	1.000	0.964	0.930	0.896	0.864
	100	0.981	0.946	0.913	0.880	0.848	0.817
	150	0.901	0.869	0.838	0.808	0.779	0.750
	200	0.832	0.803	0.774	0.747	0.720	0.693
	250	0.774	0.746	0.720	0.694	0.669	0.645
	300	0.723	0.697	0.672	0.648	0.625	0.602
	350	0.678	0.654	0.631	0.608	0.586	0.565
	400	0.639	0.616	0.594	0.573	0.552	0.532
	450	0.604	0.582	0.561	0.541	0.522	0.503
	500	0.572	0.552	0.532	0.513	0.495	0.477
	550	0.544	0.525	0.506	0.488	0.470	0.453
	600	0.518	0.500	0.482	0.465	0.448	0.432
	700	0.474	0.457	0.440	0.425	0.409	0.394
	800	0.436	0.420	0.405	0.391	0.377	0.363
	900	0.404	0.390	0.376	0.362	0.349	0.336
	1000	0.376	0.363	0.350	0.337	0.325	0.313

Multiply standard air density 0.075 lbm/ft^3 by the factor to obtain density at condition p_b.

Dry Air Density Correction Factor (I-P)

8. Classifications for Spark Resistant Construction

Fan and damper applications may involve the handling of potentially explosive or flammable particles, fumes or vapors. Such applications require careful consideration of all system components to ensure the safe handling of such gas streams. This AMCA standard deals only with the fan and/or damper unit installed in that system. The standard contains guidelines that are to be used by both the manufacturer and user as a means of establishing general methods of construction. The exact method of construction and choice of alloys are the responsibility of the manufacturer; however, the customer must accept both the type and design with full recognition of the potential hazard and the degree of protection required.

Type	Construction
A	All parts of the fan or damper in contact with the air or gas being handled and subject to impact by particles in the airstream shall be made of nonferrous material. Ferrous shafts/axles and hardware exposed to the airstream shall be covered by nonferrous materials.
	Fans only: Steps must also be taken to assure that the impeller, bearings and shaft are adequately attached and/or restrained to prevent a lateral or axial shift in these components.
	Dampers only: Construction shall ensure that linkages, bearings and blades are adequately attached or restrained to prevent independent action. Ferrous containing bearings are acceptable if the bearings are located out of the airstream and shielded from particle impact.
B	**Fans only**: The fan shall have a nonferrous impeller and nonferrous ring about the opening through which the shaft passes. Ferrous hubs, shafts and hardware are allowed, provided construction is such that a shift of impeller or shaft will not permit two ferrous parts of the fan to rub or strike. Steps must also be taken to assure that the impeller, bearings and shaft are adequately attached and/or restrained to prevent a lateral or axial shift in these components.
	Dampers only: Construction shall ensure that linkages, bearings and blades are adequately attached or restrained to prevent independent action. Damper blades shall be nonferrous.
C	**Fans only**: The fan shall be so constructed that a shift of the impeller or shaft will not permit two ferrous parts of the fan to rub or strike.
	Dampers only: Construction shall ensure that linkages, bearings and blades are adequately attached or restrained to prevent independent action. Damper blades shall be nonferrous.

Notes:

1. No bearings, drive components, motors or other electrical devices shall be placed in the air or gas stream unless they are constructed or enclosed in such a manner that failure of that component cannot ignite the surrounding gas stream.
2. The user shall electrically ground all fan and/or damper parts.
3. For this standard, nonferrous material shall be any material with less than 5% iron or any other material with demonstrated ability to be spark resistant.
4. The use of aluminum or aluminum alloys in the presence of steel that has been allowed to rust requires special consideration. Research by the U.S. Bureau of Mines and others has shown that aluminum impellers rubbing on rusty steel may cause high intensity sparking.
5. All structural components within the airstream, including non-metallic materials, must be suitable for conducting static charge safely to ground, thus preventing buildup of electrical potential. Dampers with non-metallic bearings must include means by manufacturer of transferring electrical charge from the blades to suitable ground.

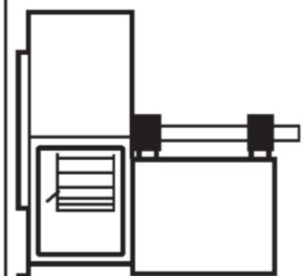
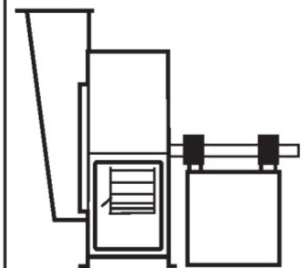
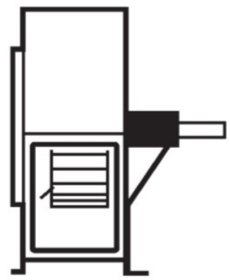
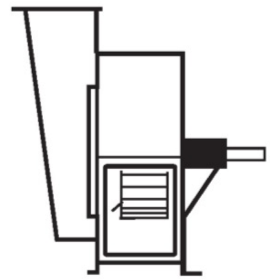
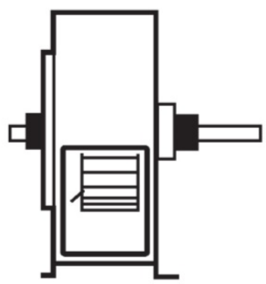
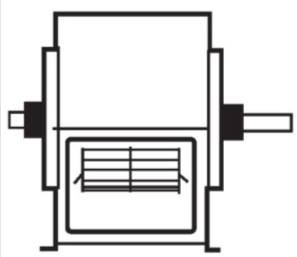
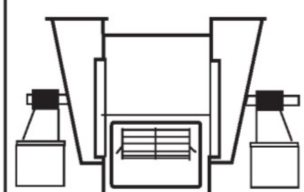
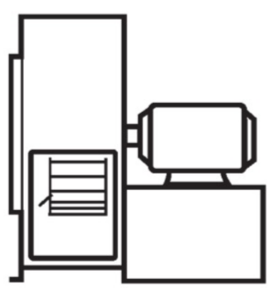
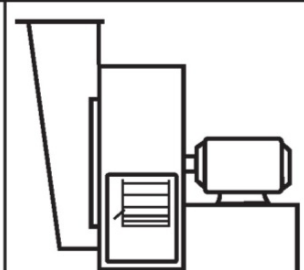
The use of the above standard in no way implies a guarantee of safety for any level of spark resistance. Spark resistant construction also does not protect against ignition of explosive gases caused by catastrophic failure or from any airstream material that may be present in a system.

This standard applies to:

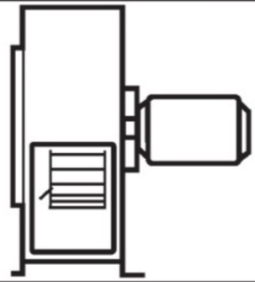
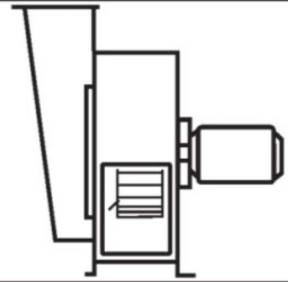
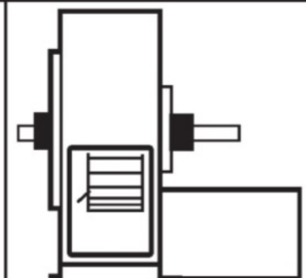
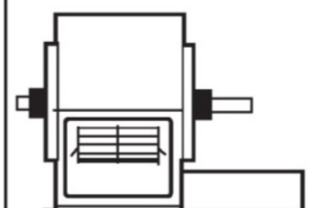
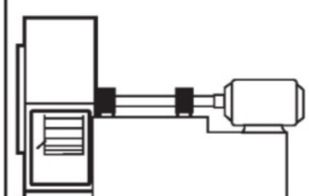
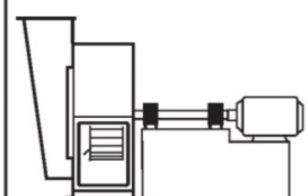
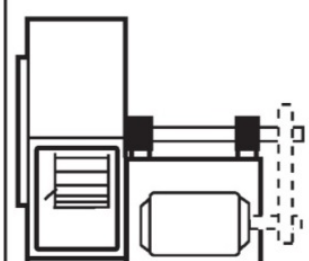
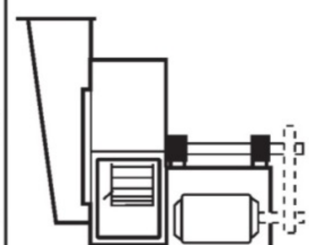
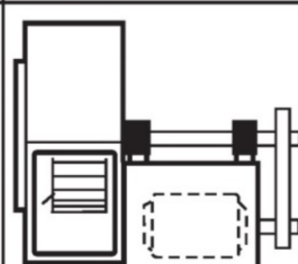
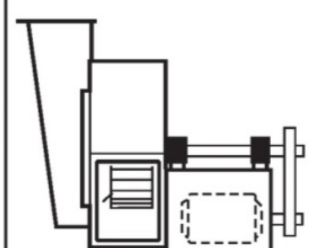
- Centrifugal fans
- Mixed flow fans
- Axial and propeller fans
- Power roof ventilators
- Dampers

9. Drive Arrangements

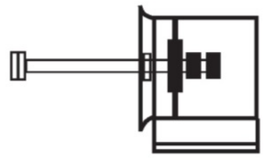
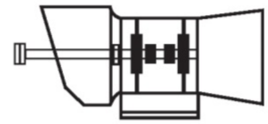
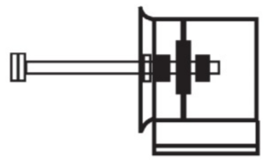
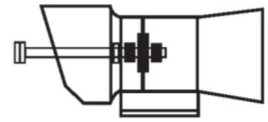
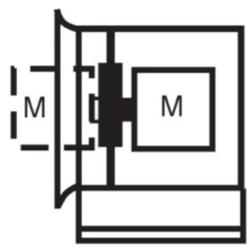
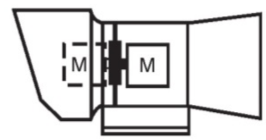
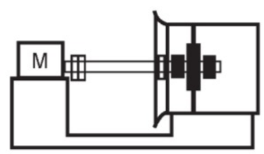
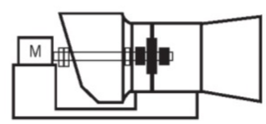
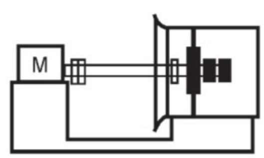
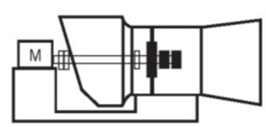
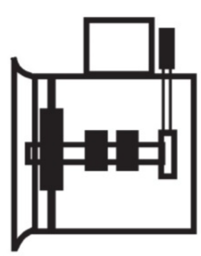
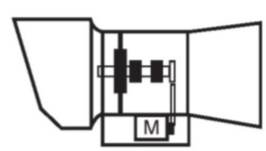
9.1 Drive arrangements for centrifugal fans

AMCA Drive Arrangement	ISO 13349 Drive Arrangement	Description	Fan Configuration	Alternative Fan Configuration
1 SWSI	1 or 12 (Arr. 1 with sub-base)	For belt or direct drive Impeller overhung on shaft, two bearings mounted on pedestal base Alternative: bearings mounted on independent pedestals, with or without inlet box		
2 SWSI	2	For belt or direct drive Impeller overhung on shaft, bearings mounted in bracket supported by the fan casing Alternative: with inlet box		
3 SWSI	3 or 11 (Arr. 3 with sub-base)	For belt or direct drive Impeller mounted on shaft between bearings supported by the fan casing Alternative: bearings mounted on independent pedestals, with or without inlet box		
3 DWDI	6 or 18 (Arr. 6 with sub-base)	For belt or direct drive Impeller mounted on shaft between bearings supported by the fan casing Alternative: bearings mounted on independent pedestals, with or without inlet boxes		
4 SWSI	4	For direct drive Impeller overhung on motor shaft. No bearings on fan. Motor mounted on base Alternative: with inlet box		

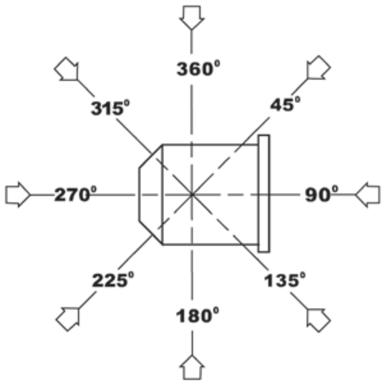
Note: All fan orientations may be horizontal or vertical

AMCA Drive Arrangement	ISO 13349 Drive Arrangement	Description	Fan Configuration	Alternative Fan Configuration
5 SWSI	5	For direct drive. Impeller overhung on motor shaft. No bearings on fan. Motor flange mounted to casing. Alternative: With inlet box.		
7 SWSI	7	For coupling drive. Generally the same as Arr. 3, with base for the prime mover. Alternative: Bearings mounted on independent pedestals with or without inlet box.		
7DWDI	17 (Arr. 6 with base for motor)	For coupling drive. Generally the same as Arr. 3 with base for the prime mover. Alternative: Bearings mounted on independent pedestals with or without inlet box.		
8 SWSI	8	For direct drive. Generally the same as Arr. 1 with base for the prime mover. Alternative: Bearings mounted on independent pedestals with or without inlet box.		
9 SWSI	9	For belt drive. Impeller overhung on shaft, two bearings mounted on pedestal base. Motor mounted on the outside of the bearing base. Alternative: With inlet box.		
10 SWSI	10	For belt drive. Generally the same as Arr. 9 with motor mounted inside of the bearing pedestal. Alternative: With inlet box.		

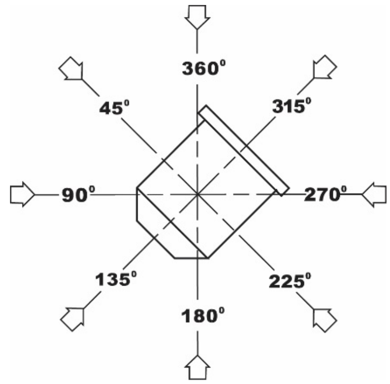
9.2 Drive arrangements for axial fans

AMCA Drive Arrangement	ISO 13349 Drive Arrangement	Description	Fan Configuration	Alternative Fan Configuration
1	1 12 (Arr. 1 with sub-base)	For belt or direct drive. Impeller overhung on shaft, two bearings mounted either upstream or downstream of the impeller. Alternative: Single stage or two stage fans can be supplied with inlet box and/or discharge evasé		
3	3 11 (Arr. 3 with sub-base)	For belt or direct drive. Impeller mounted on shaft between bearings on internal supports. Alternative: Fan can be supplied with inlet box, and/or discharge evasé		
4	4	For direct drive. Impeller overhung on motor shaft. No bearings on fan. Motor mounted on base or integrally mounted. Alternative: With inlet box and/or with discharge evasé		
7	7	For direct drive. Generally the same as Arr. 3 with base for the prime mover. Alternative: With inlet box and/or discharge evasé		
8	8	For direct drive. Generally the same as Arr. 1 with base for the prime mover. Alternative: Single stage or two stage fans can be supplied with inlet box and/or discharge evasé		
9	9	For belt drive. Generally same as Arr. 1 with motor mounted on fan casing, and/or an integral base. Alternative: With inlet box and/or discharge evasé		

10. Inlet Box Positions for Centrifugal Fans



Clockwise fan rotation
(90° inlet box position shown)



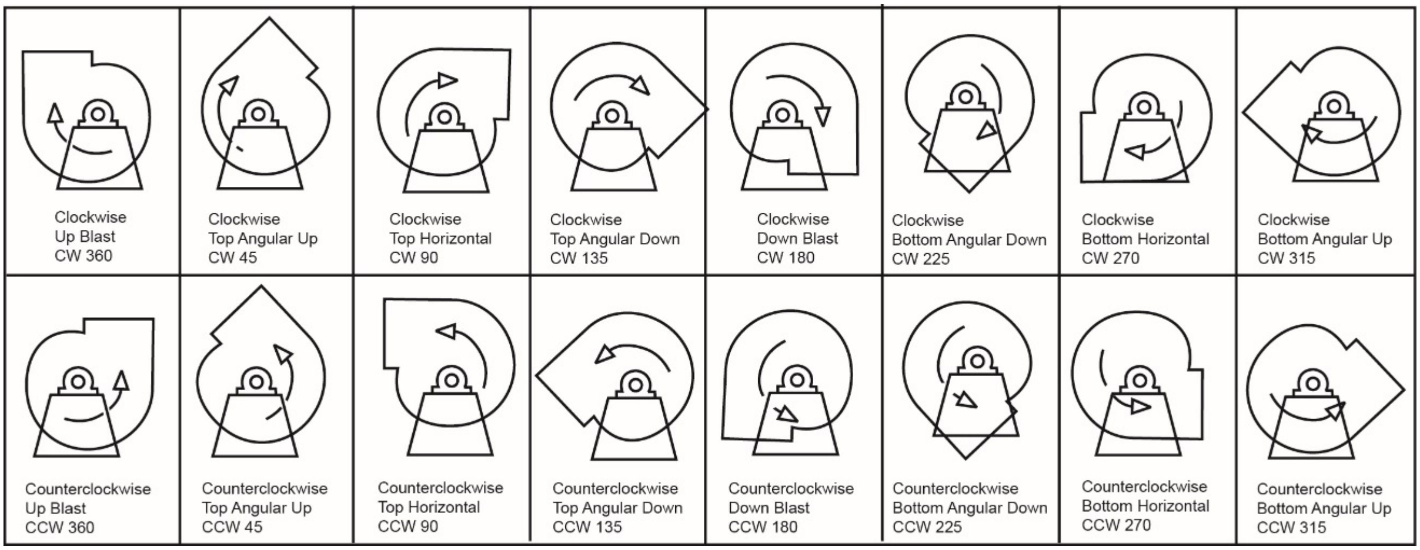
Counterclockwise fan rotation
(315° inlet box position shown)

Opening toward fan housing not shown and may be on either side of box

Notes:

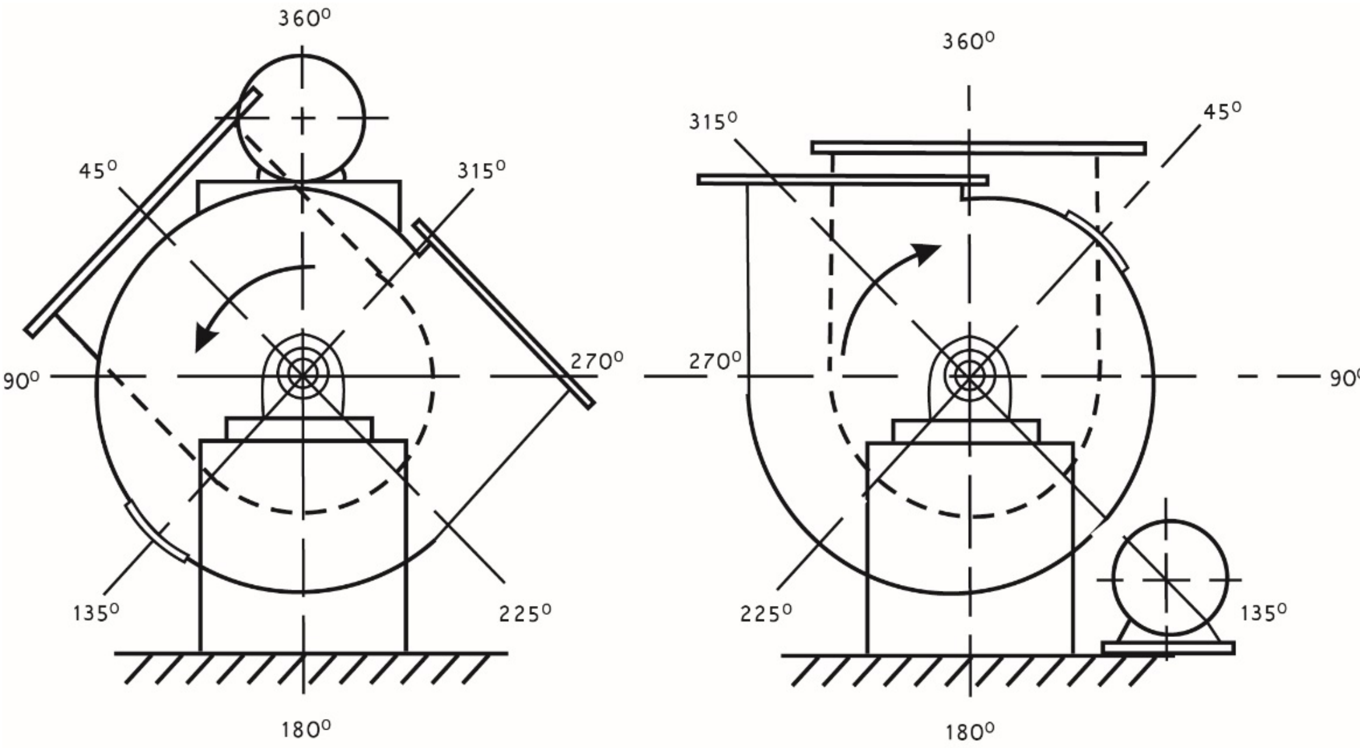
1. Position of inlet box and air entry to inlet box is determined from the drive side as defined below:
   a. On single inlet fans: the drive side is that side opposite of the fan inlet
   b. On double inlet fans:
      i. With a single driver, the side with the driver is considered the drive side
      ii. With multiple drivers, the side with the higher total power is considered the drive side. If the total power on each side is equal, then the side that has the fixed (non-expansion) bearing is considered the drive side
2. Position of inlet box is determined in accordance with diagrams. Angle of air entry to box is referred to the top vertical axis of fan in degrees as measured in the direction of fan rotation. Angle of air entry to box may be any intermediate angle as required
3. Positions 135º to 225º in some cases may interfere with floor structure.

11. Designation for Rotation and Discharge of Centrifugal Fans



Notes:

1. Direction of rotation and angular reference is determined from the drive side as defined below:
    a. On single inlet fans, the drive side is the side opposite of the fan inlet
    b. On double inlet fans:
        i. With a single driver, the side with the driver is considered the drive side
        ii. With multiple drivers, the side with the higher total power is considered the drive side. If the total power on each side is equal, then the side that has the fixed (non-expansion) bearing is considered the drive side
2. Direction of discharge is determined in accordance with diagrams. Angle of discharge is referred to the top vertical axis of fan and designated in degrees as measured in the direction of fan rotation. Angle of discharge may be any intermediate angle as required.
3. A fan inverted for ceiling suspension or rotated for side wall mounting will have its direction of rotation and angle of discharge determined when fan is located as if floor mounted.
4. This standard is in harmony with ISO 13349. In ISO 13349, CCW fans are referred to as LG, i.e., left or gauche, while CW fans are referred to as RD, i.e., right- or droit-handed rotation.



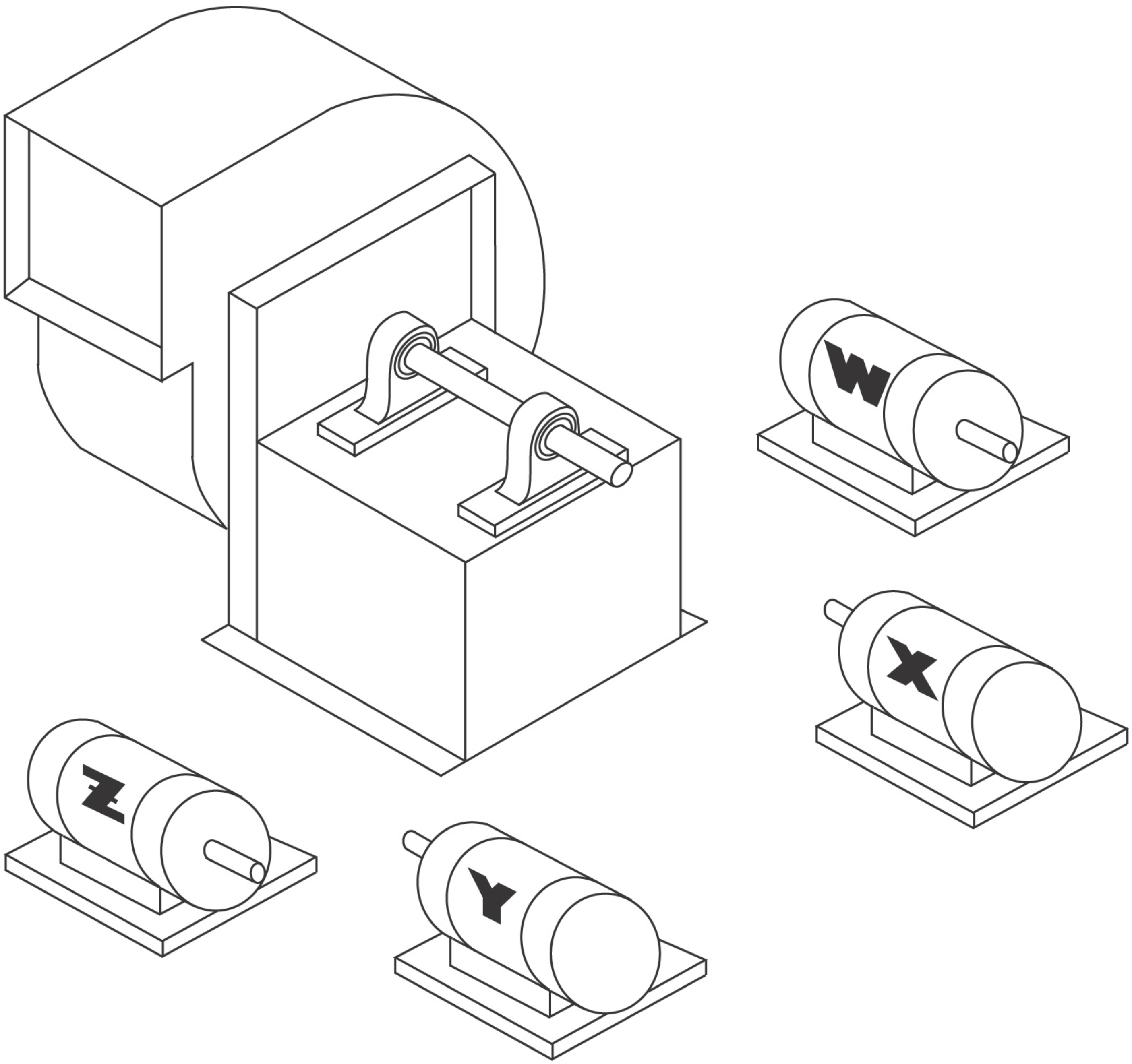
CCW Example 1 CW Example 2

Outlet	CCW	315°
Inspection door	CCW	135°
Inlet box	CCW	45°
Motor	CCW	360°

Outlet	CW	360°
Inspection door	CW	45°
Inlet box	CW	360°
Motor	CW	135

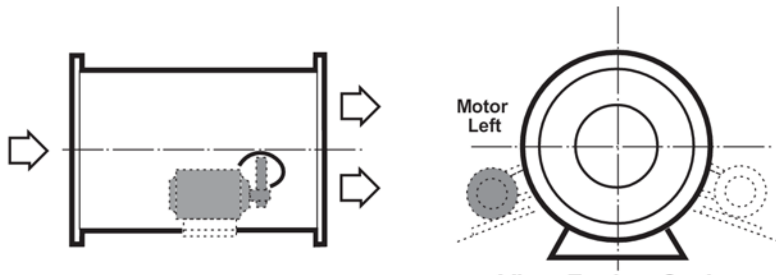
Methods of Designation of the Angular Position of Component Parts of a Centrifugal Fan

12. Motor Positions for Belt or Chain Drive Centrifugal Fans



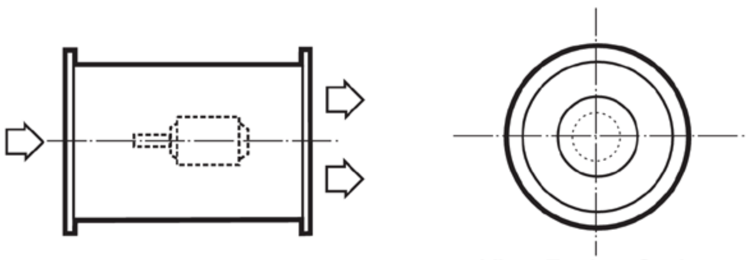
Note:
Location of motor is determined by facing the drive side of the fan and designating the motor position by letters W, X, Y or Z as the case may be.

13. Drive Arrangements for Tubular Centrifugal Fans

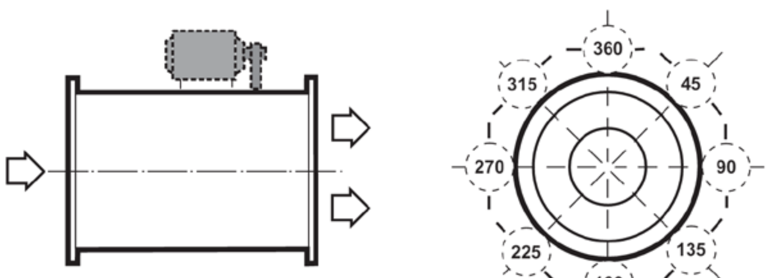


View Facing Outlet

Arrangement 1
For belt drive. Impeller overhung on a shaft supported by bearings mounted within casing. Motor mounted independent of casing. Horizontal discharge.


View Facing Outlet

Arrangement 4
For direct drive. Impeller overhung on motor shaft. Motor supported within casing. For horizontal or vertical discharge. Duct mounting shown.



Motor Shown in Position 360

View Facing Outlet

Arrangement 9
For belt drive. Impeller overhung on a shaft supported by bearings mounted within casing. Designed for mounting of motor on outside of casing in one of the standard locations shown. For horizontal and vertical discharge. Duct mounting shown.

Arrow ⇨ designates the direction of airflow

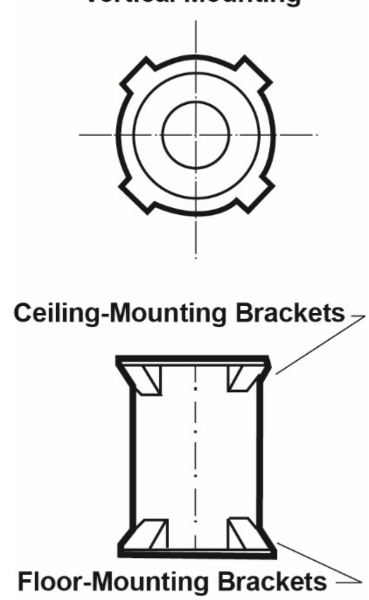
Specify either up blast or down blast discharge for vertically-mounted fans.

The locations of motors, supports, access doors, etc., are determined by viewing the outlet of the fan and resting location 180 on the floor as shown for Arrangement 9.

Arrangements 4 and 9 can be furnished with supports for floor, wall or ceiling mounting. The position of these supports determines which motor locations are available for motor placement. Generally motor locations 135, 180 and 225 are not available on floor, wall or inverted ceiling-mounted fans and motor locations 45, 90, 270 and 315 may not be available for ceiling-hung fans.

Another method of mounting vertical fans is shown in the view to the right. Specify that the fan is to be furnished with ceiling-mounting brackets, floor mounting brackets or both.

Vertical Mounting



14. Operating Limits for Centrifugal Fans

To be designated by the manufacturer as meeting the requirements of a specified class as defined in this standard, a fan must be physically capable of operating at every point of rating on and below the minimum performance limit for that class.

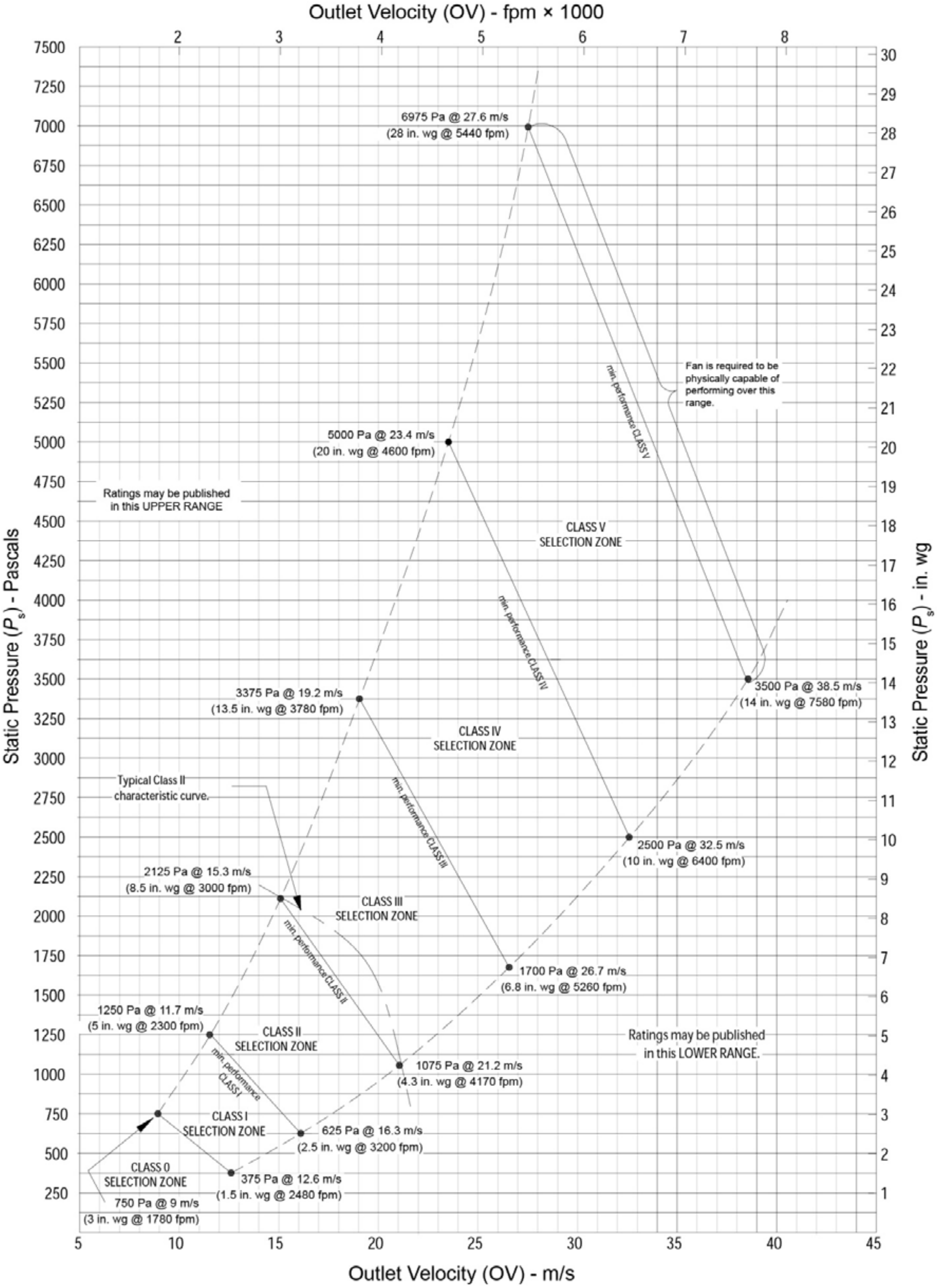


Figure 1 — Ventilating Airfoils & Backward Inclined: Single Width

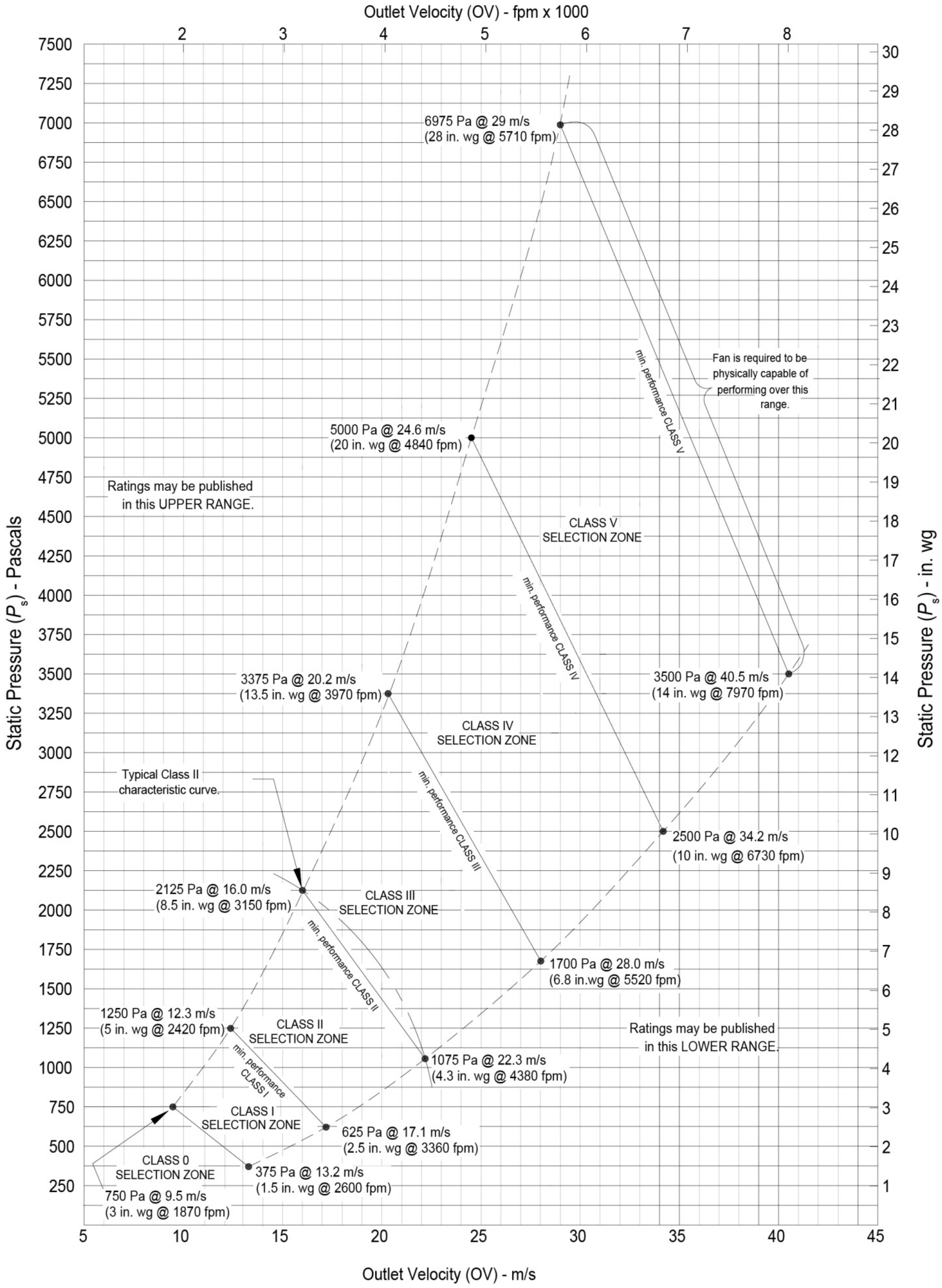


Figure 2 — Ventilating Airfoils & Backward Inclined: Double Width

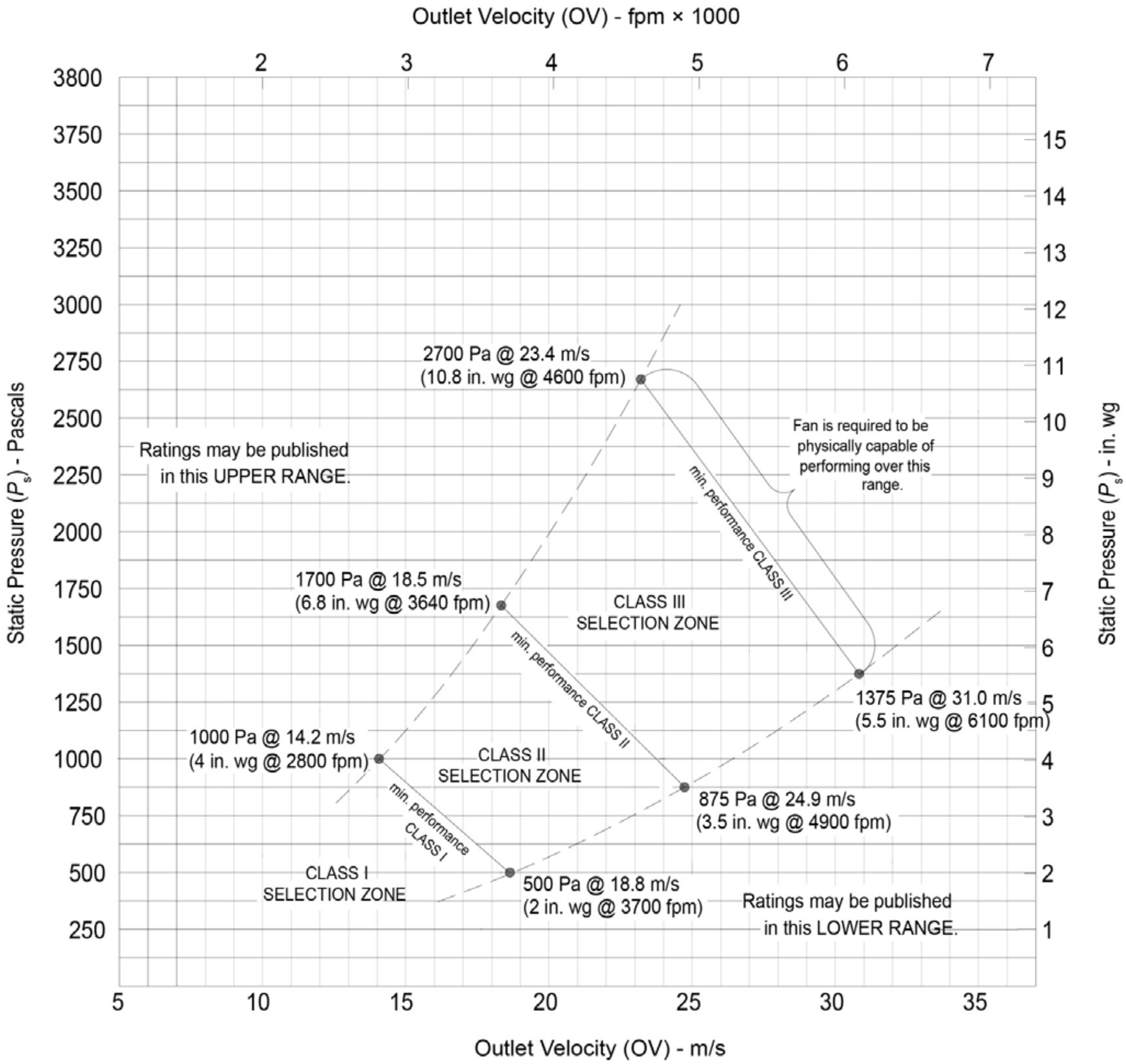


Figure 3 — Ventilating Forward Curved: Single Width

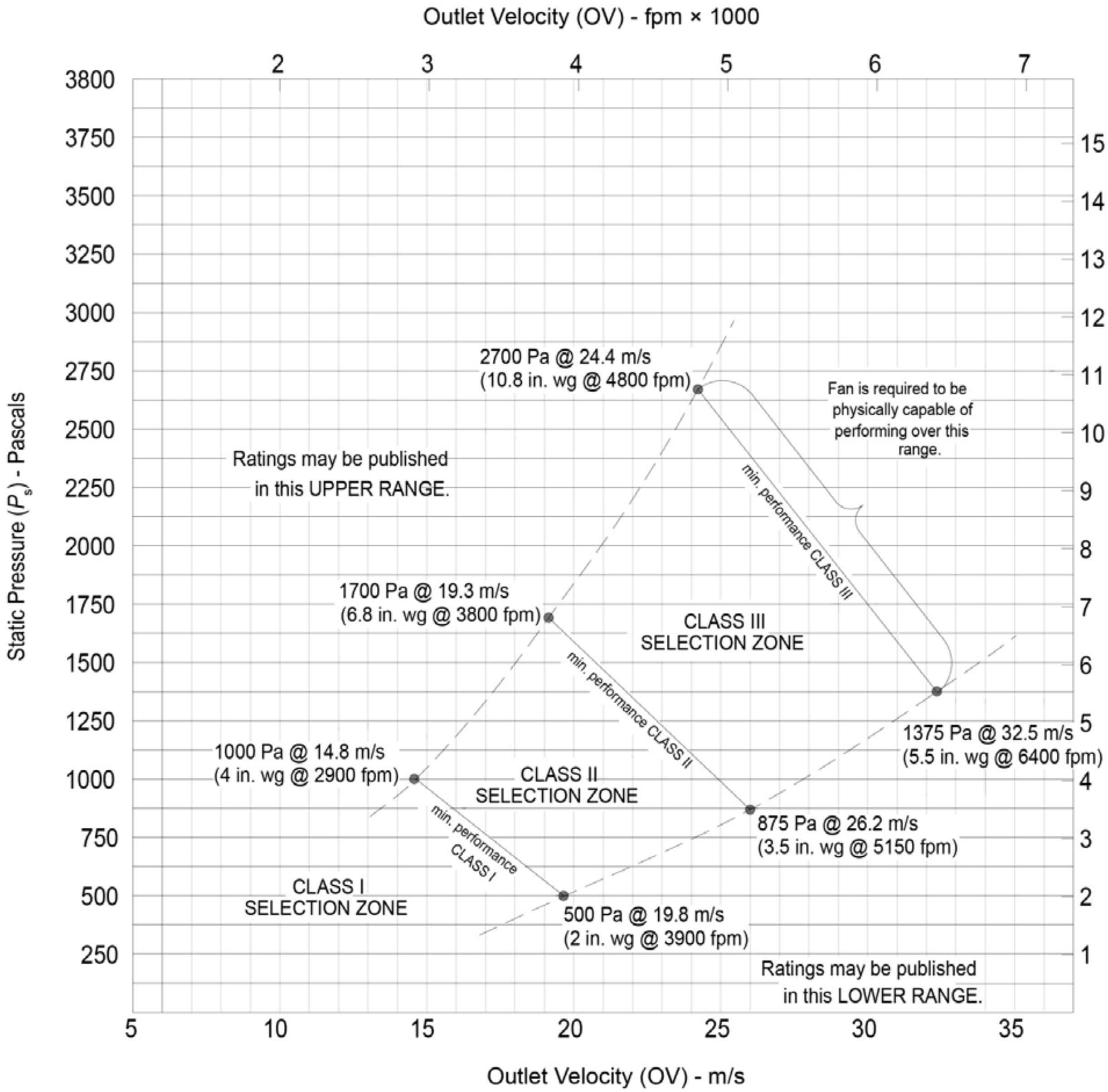


Figure 4 — Ventilating Forward Curved: Double Width

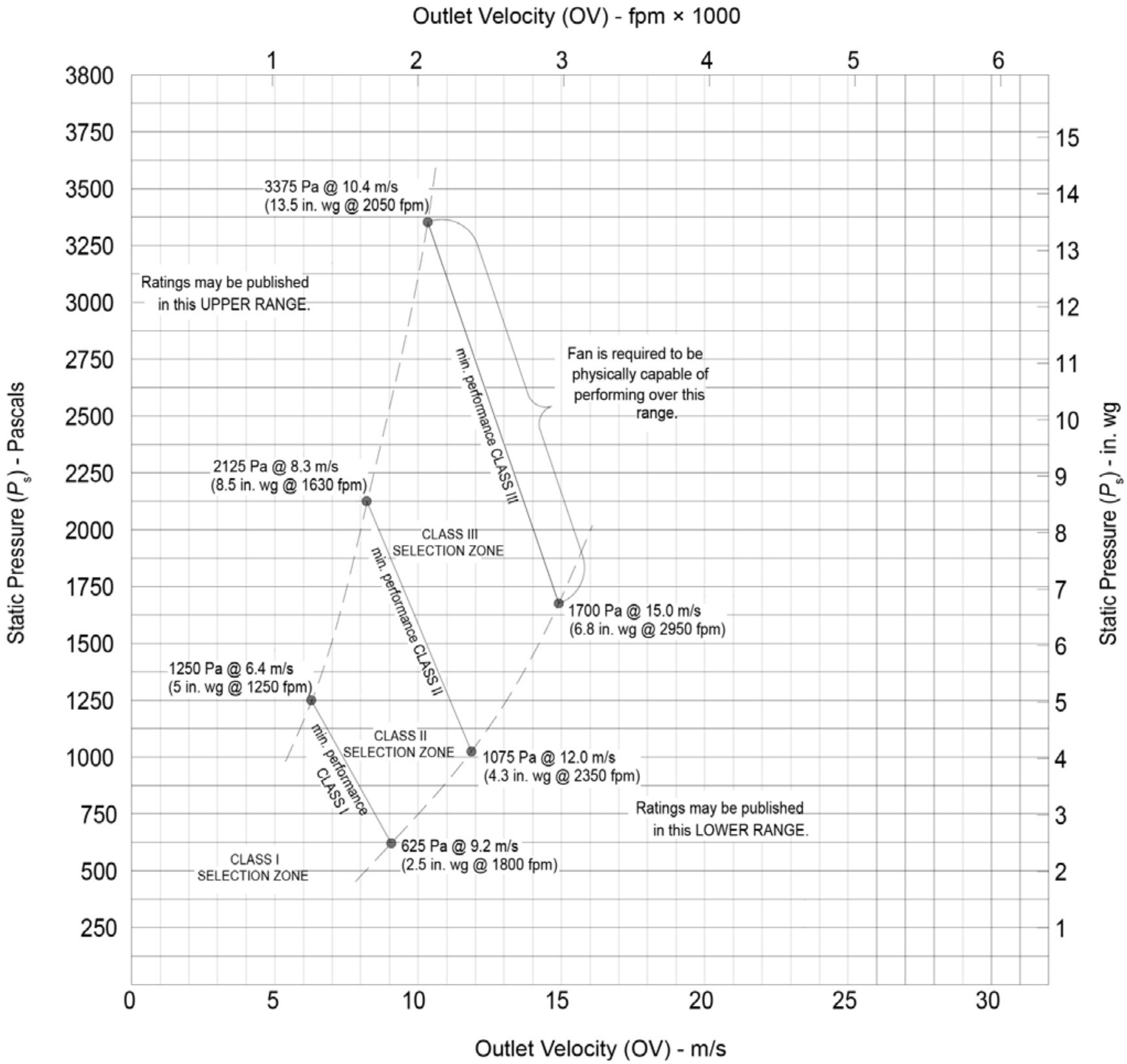


Figure 5 — Tubular

Annex A
References

[1] Tables generated based on equations from
Handbook of Chemistry and Physics. Edited by David R. Lide. 84th ed. Boca Raton, FL: CRC Press, 2003.

[2] ISO 13349. Fans — Vocabulary and definitions of categories. 2nd ed. Brussels: ISO, 2010.

Annex B
ISO Definitions (Informative)

The following is excerpted from ISO 13349, Section 3 [2].

Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 5167-1 and ISO 5801 and the following apply

3.1 Fans

3.1.1
Fan
Rotary-bladed machine that receives mechanical energy and utilizes it by means of one or more impellers fitted with blades to maintain a continuous flow of air or other gas passing through it and whose work per unit mass does not normally exceed 25 kJ/kg

NOTE 1 The term “fan" is taken to mean the fan as supplied, without any addition to the inlet or outlet, except where such addition is specified.

NOTE 2 Fans are defined according to their installation category, function, fluid path and operating conditions.

NOTE 3 If the work per unit mass exceeds a value of 25 kJ/kg, the machine is termed a turbocompressor. This means that, for a mean stagnation density through the fan of 1,2 kg/m^3, the fan pressure does not exceed 1,2 x 25 kJ/kg, i.e. 30 kPa, and the pressure ratio does not exceed 1,30 since atmospheric pressure is approximately 100 kPa.

3.1.2
Bare shaft fan
Fan without drives, attachments or apperturnances

See ISO 12759.

3.1.3
Driven fan
Impeller fitted to or connected to a motor, with or without a drive mechanism, a housing or a means of variable speed drive

See ISO 12759.

3.2
Air
Abbreviated term for the expression “air or other gas”

3.3
Standard air
By convention, air with a density of 1,2 kg/m^3

Fan installation categories according to the arrangement of ducting

See Figure 1.

3.4.1
Installation category A
Installation with free inlet and free outlet with a partition See ISO 5801 and ISO 5802.

3.4.2

Installation category B
Installation with free inlet and ducted outlet See ISO 5801 and ISO 5802.

3.4.3
Installation category C
Installation with ducted inlet and free outlet See ISO 5801 and ISO 5802.

3.4.4
Installation category D
Installation with ducted inlet and ducted outlet See ISO 5801 and ISO 5802.

3.4.5
Installation category E
Installation with free inlet and free outlet without a partition

Types of fan according to their function

3.5.1
Ducted fan
Fan used for moving air within a duct

NOTE This fan can be arranged in installation category B, C or D (see Figures 2, 3, 4 and 5).

3.5.2
Partition fan
Fan used for moving air from one free space to another, separated from the first by a partition having an aperture in which or on which the fan is installed

NOTE This fan can be arranged in installation category A (see Figure 6).

3.5.3
Jet fan
Fan used for producing a jet of air in a space and unconnected to any ducting

See Figure 7.

NOTE The air jet can be used, for example, for adding momentum to the air within a duct, a tunnel or other space, or for intensifying the heat transfer in a determined zone.

3.5.4
Circulating fan
Fan used for moving air within a space which is unconnected to any ducting and is usually without a housing

See Figure 8.

3.5.5
Air curtain unit
Air moving device which produces an air curtain

See Figure 30.

3.5.5.1
Air curtain airstream
Directionally controlled airstream, moving across the entire height and width of an opening, which can reduce the infiltration or transfer of air from one side of the opening to the other, and inhibits insects, dust or debris from passing through

Types of fan according to the fluid path within the impeller

3.6.1
Centrifugal fan
Fan in which the air enters the impeller with an essentially axial direction and leaves it in a direction perpendicular to this axis

See Figure 2.

NOTE 1 The centrifugal fan is also known as a radial-flow fan.

NOTE 2 The impeller can have one or two inlet(s) and might include a shroud and/or a backplate (centreplate) (see Figure 16).

NOTE 3 The impeller is defined as "backward-curved or inclined", "radial" or "forward-curved", depending on whether the outward direction of the blade at the periphery is backward, radial or forward relative to the direction of the rotation (see Figures 9 and 16).

NOTE 4 A centrifugal fan can be of the low-, medium- or high-pressure type, according to the aspect ratio of fan inlet diameter to outside diameter of the impeller. These terms indicate that the pressure generated at a given flow rate is low, medium or high.

NOTE 5 Figure 9 shows a cross-section through a family of impellers having the same inlet diameter. Fans with ratios of fan inlet/outside impeller diameter of greater than approximately 0,63 mm are considered "low aspect ratio", and lower than approximately 0,4 mm are considered "high aspect ratio". Medium aspect ratio centrifugal fans are intermediate between these two.

NOTE 6 The impeller diameter and the casing scroll radii increase with the pressure range for which the fan is designed.

NOTE 7 These categories are also affected by the ability to run at the necessary peripheral speed (see 5.2 and Table 1).

3.6.2
Axial-flow fan
Fan in which the air enters and leaves the impeller along essentially cylindrical surfaces coaxial with the fan

See Figure 3.

NOTE 1 An axial-flow fan can be of the low-, medium- or high-pressure type, according to the aspect ratio of hub diameter to outside impeller diameter. These terms indicate that the pressure generated at a given flow rate is low, medium or high.

NOTE 2 Figure 10 shows a cross-section through a family of impellers having the same outside diameter. Fans with ratios of hub/outside impeller diameter of less than approximately 0,4 mm are considered "low aspect ratio", and greater than approximately 0,71 mm are considered "high aspect ratio". Medium aspect ratio axial fans are intermediate between these two figures.

NOTE 3 These categories are also affected by the ability to run at the necessary peripheral speed.

3.6.2.1
Contra-rotating fan
Axial-flow fan which has two impellers arranged in series and rotating in opposite directions.

See Figure 32.

3.6.2.2
Reversible axial-flow fan
Axial-flow fan that is specially designed to rotate in either direction, regardless of whether or not the performance is identical in both directions

3.6.2.3
Propeller fan
Axial-flow fan having an impeller with a small number of broad blades of uniform material thickness and designed to operate in an orifice

3.6.2.4
Plate-mounted axial-flow fan
Axial-flow fan in which the impeller rotates in an orifice or spigot of relatively short axial length, the impeller blades being of aerofoil section

3.6.2.5
Vane-axial fan
Axial-flow fan suitable for ducted applications, which has guide vanes before or after the impeller, or both

3.6.2.6
Tube-axial fan
Axial-flow fan without guide vanes, suitable for ducted applications

3.6.3
Mixed-flow fan
Fan in which the fluid path through the impeller is intermediate between the centrifugal and axial-flow types

See Figures 5 and 11.

3.6.4
Cross-flow fan
Fan in which the fluid path through the impeller is in a direction essentially at right angles to its axis both entering and leaving the impeller at its periphery

See Figure 12.

3.6.5
Peripheral or side channel fan
Air moving device for which the circulation of fluid in the toric casing is helicoidal

NOTE The rotation of the impeller, which contains a number of blades, creates a helicoidal trajectory, which is intercepted by one or more blades depending on the flow rate. The impeller transfers energy to the fluid (see Figure 15).

3.6.6
Multi-stage fan
Fan having two or more impellers working in series

EXAMPLE A two-stage fan or a three-stage fan.

NOTE 1 Multi-stage fans can have guide vanes and interconnecting ducts between successive impellers.

NOTE 2 The blades of an impeller can be either of a profiled section (as an aerofoil) or of uniform thickness (see Figure 16).

3.6.7
In-line centrifugal fan
Fan having a centrifugal impeller used in an in-line ducted configuration

See Figure 4.

3.6.8
Bifurcated fan

Fan having an axial-flow, mixed-flow or centrifugal impeller in an in-line configuration where the direct-drive motor is separated from the flowing air stream by means of a compartment or tunnel

See Figure 27 c.

3.6.9
Plug fan
Fan having an unhoused impeller arranged such that the system into which it is inserted acts as a housing, allowing air to be drawn into the impeller inlet

See Figure 13.

3.6.10
Plenum fan
Fan having an unhoused centrifugal impeller which draws air into the impeller through an inlet located in a barrier wall, and having a driver located on the same side of the barrier as the impeller

See Figure 14.

3.6.11
In-line and box fan
Fan that incorporates centrifugal/mixed-flow impellers

See Figures 4 and 31.

Types of fan according to operating conditions

3.7.1
General-purpose fan
Fan suitable for handling air which is non-toxic, unsaturated, non-corrosive, non-flammable, free from abrasive particles and within a temperature range from -20 °C to +80 °C

NOTE For temperatures greater than 40 °C, the motor is especially taken into consideration.

3.7.2
Special-purpose fan
Fan used for special operating conditions See 3.7.2.1 to 3.7.2.12.

NOTE 1 A fan can have a combination of special features.

NOTE 2 The operating conditions stated below (3.7.2.1 to 3.7.2.12) represent a typical range, but the list is not necessarily complete. It is intended that the manufacturer and purchaser agree on other types having special features to suit specific applications.

3.7.2.1
Hot-gas fan
Fan used for handling hot gases continuously

NOTE 1 Special materials can be incorporated, as necessary, for the fan which can have a direct or indirect drive.

NOTE 2 The motor on a direct-drive fan can be either in the air stream or separated from it.

NOTE 3 Indirect-drive fans can incorporate a means for cooling belts, bearings or other drive components, where necessary (for designation, see 5.3.2).

3.7.2.2
Smoke-ventilating fan
Fan suitable for handling hot smoke for a specified time/temperature profile

NOTE 1 Special materials can be incorporated, as necessary, for the fan, which can have a direct or indirect drive.

NOTE 2 The motor can be either in the air stream on a direct-drive fan or separated from it.

NOTE 3 Indirect-drive fans incorporate a means for cooling belts, bearings or other drive components, where necessary (for designation, see 5.3.2).

3.7.2.3
Wet-gas fan
Fan suitable for handling air containing particles of water or any other liquid

3.7.2.4
Gas-tight fan
Fan with a suitably sealed casing to match a specified leakage rate at a specified pressure

NOTE Depending upon the leakage specification, this can involve special attention being paid to all services which penetrate the casing, such as inspection means, lubricator fittings and electrical supply, as well as the details of the connecting flanges (for categorization, see 5.3.4).

3.7.2.5
Dust fan
Fan suitable for handling dust-laden air, designed to suit the dust being handled

3.7.2.6
Conveying fan
Transport fan
Fan suitable for the conveying of solids and dust entrained in the air stream, designed to suit the material being conveyed

NOTE 1 A conveying/transport fan can be of direct or indirect drive type, depending on whether or not the handled material passes through the impeller.

NOTE 2 Examples of solids are wood chips, textile waste and pulverized materials.

3.7.2.7
Non-clogging fan
Fan having an impeller designed to minimize clogging by virtue of its detailed shape or by the use of special materials

NOTE The fan can also incorporate other features to allow the use of cleaning sprays and facilitate the removal of any material.

3.7.2.8
Abrasion-resistant fan
Fan designed to minimize abrasion, having parts that are especially subject to wear, constructed from suitably abrasion-resistant materials and easily replaceable

3.7.2.9
Corrosion-resistant fan
Fan constructed from suitably corrosion-resistant materials or suitably treated to minimize corrosion by specified agents

3.7.2.10
Spark-resistant fan ignition-protected fan
Fan with features designed to minimize the risk of sparks or hot spots resulting from contact between moving and stationary parts that may cause the ignition of dust or gases

NOTE No bearings, drive components or electrical devices are placed in the air or gas stream, unless they are constructed in such a manner that failure of that component cannot ignite the surrounding gas stream (for categorization, see 5.3.4).

3.7.2.11
Powered-roof ventilator
Fan designed for mounting on a roof and having exterior weather protection

3.7.2.12
Positive-pressure ventilator
Portable fan that can be positioned relative to an opening of a confined space and cause it to be positively pressurized by discharge air velocity

NOTE It is principally used by fire-fighters to mitigate the effect of smoke and is also used to assist in inflating hot air balloons.

Fan elements

3.8.1
Fan inlet
Opening, usually circular or rectangular, through which the air first enters the fan casing

NOTE 1 If the fan is provided with an inlet-connecting flange or spigot, the fan inlet dimensions are measured inside this connection. The inlet area is the gross area measured inside this flange, i.e. No deductions are made for blockages, such as motors and bearing supports.

NOTE 2 When the inlet area is not clearly defined, agreement can be reached between the parties to the contract.

3.8.2
Fan outlet
Opening, usually circular or rectangular, through which the air finally leaves the fan casing

NOTE 1 If the fan is provided with an outlet connecting flange or spigot, the fan outlet dimensions are measured inside this connection. When the fan is delivered with a diffuser and the performance is quoted with this fitted, the area of the fan outlet can be taken as equal to the outlet area of the diffuser.

NOTE 2 When the outlet area is not clearly defined, agreement can be reached between the parties to the contract.

NOTE 3 For the special requirements of jet fans, see ISO 13350.

NOTE 4 For roof ventilators and unhoused fans, the outlet area can be considered as the product of the maximum circumference of trailing edges by the width of the impeller blade or the gross casing area at the impeller for axial types.

3.8.3
Impeller tip diameter
Maximum diameter measured over the tips of the blades of the impeller

NOTE This is expressed in millimetres.

See ISO 13351.

3.8.4
Size designation
Nominal impeller tip diameter, defined as the impeller tip diameter on which the design of that fan is based.

AMCA Membership Information
http://www.amca.org/members/members.php

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-listed/cpsearch.php

VISIT THE AMCA STORE

AMCA provides its Publications (no cost) and Standards (cost) through the AMCA Store. Any document selected will be 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 MyAMCA or click on MyAMCA 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