

AMCA 222-16

Application Manual for Air Curtains



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

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

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Air Movement and Control Association International
30 West University Drive
Arlington Heights, IL 60004-1893 U.S.A.

European Air Movement and Control Association
Nutkin Cottage
Barracks Road, Assington
Suffolk CO10 5LP
UK

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

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Application Manual for Air Curtains

1. Purpose

The purpose of this application guide is to familiarize the reader with air curtain unit (ACU) technology.

2. Scope

This document covers ACU theory, construction, performance standards, applications, benefits, selection, installation, commissioning, service and maintenance.

3. Definitions/Units of Measure/Symbols

3.1 Definitions

3.1.1 Air curtain (airstream)

A directionally-controlled air curtain, 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 flying insects, dust or debris from passing through. For the purposes of this publication, “air curtain” and “airstream” are synonymous.

3.1.2 Air curtain depth

The air curtain dimension perpendicular to both the direction of airflow and the air curtain width; the short dimension of the air curtain.

3.1.3 Air curtain width

The air curtain dimension perpendicular to both the direction of airflow and the air curtain depth; the long dimension of the air curtain.

3.1.4 Air curtain unit (ACU)

An air moving device that produces an air curtain.

3.1.5 Air discharge nozzle

A component or assembly, which may include adjustable vanes in the ACU, that directs and controls the air curtain.

3.1.6 Air discharge nozzle depth (N_d)

The inside dimension perpendicular to both the direction of airflow and the air curtain width.

3.1.7 Air discharge nozzle width (N_w)

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

3.1.8 Air discharge angle (θ)

The angle between the plane of the protected opening and the direction in which the air curtain leaves the discharge.

3.1.9 Psychrometrics (From ANSI/AMCA Standard 210)

3.1.9.1 Dry-bulb temperature (t_d)

The air temperature measured by a dry temperature sensor.

3.1.9.2 Wet-bulb temperature (t_w)

The temperature measured by a temperature sensor covered by a water-moistened wick and exposed to air in motion. When properly measured, it is a close approximation of the temperature of adiabatic saturation.

3.1.9.3 Wet-bulb depression

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

3.1.9.4 Stagnation (total) temperature

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

3.1.9.5 Static temperature

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

3.1.9.6 Air density (ρ)

The mass per unit volume of the air.

3.1.9.7 Standard air

Air with a density of 1.2 kg/m^3 (0.075 lbm/ft^3), a ratio of specific heats of 1.4, a viscosity of $1.8185 \times 10^{-5} \text{ Pa}\cdot\text{s}$ ($1.222 \times 10^{-5} \text{ lbm/ft}\cdot\text{s}$). Air at 20°C (68°F) temperature, 50% relative humidity, and 101.3207 kPa (29.92 in. Hg) barometric pressure has these properties, approximately.

3.1.10 Pressure and head

3.1.10.1 Pressure

Force per unit area.

3.1.10.2 Absolute pressure

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

3.1.10.3 Barometric pressure (p_b)

The absolute pressure exerted by the atmosphere.

3.1.10.4 Gauge pressure

The value of a pressure when the datum pressure is the barometric pressure at the point of measurement. It may be positive or negative.

3.1.10.5 Velocity pressure (P_v)

The portion of the air pressure that exists by virtue of the rate of motion only. It is always positive.

3.1.10.6 Static pressure (P_s)

That portion of the air pressure that exists by virtue of the degree of compression only. If expressed as gauge pressure, it may be positive or negative.

3.1.10.7 Total pressure (P_t)

The air pressure that exists by virtue of the degree of compression and the rate of motion. It is 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.

3.1.10.8 Pressure loss

The decrease in total pressure due to friction and turbulence.

3.1.11 Air curtain unit performance variables

3.1.11.1 Unit airflow rate (volume) (Q)

The airflow volume that leaves the discharge nozzle at standard air conditions as measured in accordance with ANSI/AMCA Standard 210 and reported in m^3/s (cfm).

3.1.11.2 Average outlet air velocity (V_a)

The airflow rate produced by the air curtain unit divided by the cross-sectional area of the discharge nozzle plane at free-air delivery.

3.1.11.3 Outlet air velocity uniformity (U)

An indicator of the consistency of air velocities across the air curtain width, expressed as a percentage.

3.1.11.4 Air curtain core velocity (V_{cx})

The maximum air velocity of the air curtain at point X as measured across both the air curtain depth and width at specified distances from the discharge nozzle.

3.1.11.5 Air curtain average core velocity (V_{ca})

An average of air curtain core velocities measured along the air curtain width, at specified distances.

3.1.11.6 Air curtain velocity projection

A set of average air curtain core velocities measured along the air curtain width at distances specified in ANSI/AMCA Standard 220.

3.1.11.7 Power rating of the air curtain unit (W)

The amount of energy, expressed in kW, consumed by the drive motor(s) of the air curtain unit at free-air delivery.

3.1.11.8 Air curtain unit efficiency (η_{ac})

The ratio of the ACU air power to the power rating of the ACU. This value is based upon total fan efficiency given in ANSI/AMCA Standard 210.

3.1.11.9 Air curtain unit target distance

A distance perpendicular to the discharge nozzle depth in meters (feet), determined by the sponsor of the test, for the purpose of setting up the test.

3.1.11.10 Air power

The useful power delivered to the air. This is proportional to the product of the ACU airflow rate and total pressure.

3.1.12 Miscellaneous

3.1.12.1 Point of operation

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

3.1.12.2 Free-air delivery

That point of operation where the air curtain unit operates against zero static pressure.

3.1.12.3 Determination

A complete set of measurements for a particular point of operation for the parameter being determined.

3.1.12.4 Test

A series of determinations of various characteristics at a single point of operation of an air curtain unit.

3.2 Units of measure

SI units (The International System of Units — *Le Système International d'Unités*) are the primary units employed in this publication, with I-P units given as the secondary reference. SI units are based on the fundamental values of the International Bureau of Weights and Measures, and I-P values are based on the values of the National Institute of Standards and Technology that are, in turn, based upon the values of the International Bureau.

3.2.1 Basic units

The unit of length is the meter (m) or millimeter (mm); I-P units are the foot (ft) or inch (in.). The unit of mass is the kilogram (kg); the I-P unit is the pound-mass (lbm). The unit of time is either the minute (min) or the second (s). The unit of temperature is either the kelvin (K) or the degree Celsius (°C); I-P units are the degree Rankine (°R) or the degree Fahrenheit (°F). The unit of force is the newton (N); the I-P unit is the pound force (lbf).

3.2.2 Airflow rate and velocity

The unit of airflow rate is the cubic meter per second (m³/s); the I-P unit is the cubic foot per minute (cfm). The unit of velocity is the meter per second (m/s); the I-P unit is the foot per minute.

3.2.3 Pressure

The SI unit of pressure is the pascal (Pa). The I-P unit of pressure is either the inch water gauge (in. wg) or the inch mercury (in. Hg). Values in mm Hg or in in. Hg shall be used only for barometric pressure measurements. The in. wg shall be based on a one-inch column of distilled water at 68 °F under standard gravity and a gas column balancing effect based on standard air. The in. Hg shall be based on a one-inch column of mercury at 32 °F under standard gravity in a vacuum. The mm Hg shall be based on a one-millimeter column of mercury at 0 °C under standard gravity in a vacuum.

3.2.4 Power, energy and torque

The unit of power is the watt (W); the I-P unit is the horsepower (hp). The unit of energy is the joule (J); the I-P unit is the foot-pound (ft lb). The unit of torque is the newton-meter (N•m); the I-P unit is the pound-inch (lb in.).

3.2.5 Efficiency

Efficiency is expressed on a per-unit basis. Percentage values can be obtained by multiplying by 100.

3.2.6 Rotational speed

There is no unit of rotational speed as-such in the SI system of units. The commonly used unit in both systems is the revolution per minute (rpm).

3.2.7 Gas properties

The unit of density is the kilogram per cubic meter (kg/m³); the I-P unit is the pound-mass per cubic foot (lbm/ft³). The unit of viscosity is the pascal second (Pa•s); the I-P unit is the pound-mass per foot-second (lbm/ft•s). The unit of gas constant is the joule per kilogram Kelvin (J/kg•K); the I-P unit is the foot-pound per pound-mass degree Rankine (ft•lb/lbm•°R).

3.2.8 Dimensionless groups

Various dimensionless quantities appear in the text. Any consistent system of units may be employed to evaluate these quantities unless a numerical factor is included, in which case units must be as specified.

3.2.9 Physical constants

The value of standard gravitational acceleration shall be taken as 9.80665 m/s² at mean sea level at 45° latitude; the I-P value is 32.1740 ft/s² at mean sea level at 45° latitude. The density of distilled water at saturation pressure shall be taken as 998.278 kg/m³ at 20 °C; the I-P value is 62.3205 lbm/ft³ 68 °F. The density of mercury at saturation pressure shall be taken as 13595.1 kg/m³ at 0 °C; the I-P value is 848.714 lbm/ft³ at 32 °F. The specific weights in kg/m³ (lbm/ft³) of these fluids in a vacuum under standard gravity are numerically equal to their densities at corresponding temperatures.

3.3 Symbols and subscripted symbols

See Table 1.

Table 1 — Symbols and Subscripts

Symbol	Description	SI Unit	I-P Unit
A_n	Nozzle cross-sectional area	m ²	ft ²
H_a	Air power of air curtain unit	W	hp
H_m	Power input to motor	W	hp
η_{ac}	Air curtain unit efficiency	per unit	per unit
n	Number of data points	---	---
N	Air curtain unit speed	rpm	rpm
N_d	Air discharge nozzle depth	mm	inches
N_w	Air discharge nozzle width	mm	inches
p_b	Barometric pressure	Pa	in. Hg
P_s	Static pressure	Pa	in. wg
P_t	Total pressure	Pa	in. wg
P_v	Velocity pressure	Pa	in. wg

Q	Air curtain unit airflow rate	m^3/s	cfm
ρ	Air density	kg/m^3	lbm/ft^3
Σ	Summation sign	---	---
s	Standard deviation	---	---
θ	Air discharge angle	degrees	degrees
t_d	Dry-bulb temperature	$^{\circ}\text{C}$	$^{\circ}\text{F}$
t_w	Wet-bulb temperature	$^{\circ}\text{C}$	$^{\circ}\text{F}$
U	Outlet air velocity uniformity	%	%
V_a	Velocity, average outlet	m/s	ft/s
V_{cx}	Velocity, air curtain core, at point X	m/s	fpm
V_{ca}	Velocity, average (air curtain core)	m/s	fpm
W	Power rating of the ACU	watt	watt

4. Overview

4.1 Basic design

An ACU uses a fan or system of fans mounted inside a cabinet. The fan draws air in, raises it to a higher velocity and discharges it as an air curtain. An ACU is usually mounted above or along the side of a door or window opening. When mounted above the opening, the ACU discharges its air vertically across the opening. When mounted along the side of the opening, the ACU discharges its air horizontally across the opening.

4.2 Benefits

There are many benefits of using an ACU. When properly applied, an ACU can maintain the environmental integrity between two distinct areas, affording clear, unobstructed egress and ingress.

More specifically, when areas of different temperatures are separated or when perimeter openings are protected, an ACU can provide significant energy savings, increased comfort levels for customers and employees, increased safety at busy doorways, a decrease in equipment maintenance and a more sanitary environment.

Benefits of using an ACU will only be fully realized when the equipment is properly sized, installed, adjusted and maintained.

4.2.1 Cost/energy savings

ACUs save energy by reducing the infiltration of warm or cold air through an opening. By reducing the infiltration of outdoor air, the primary heating or air conditioning equipment will work less, resulting in reduced utility costs. These cost savings often offset the initial cost of the ACU in a relatively short period of time. The energy savings also reduce the building's overall effect on the environment.

4.2.2 Increased comfort

Without an ACU, there are often localized hot/cold spots near an opening due to infiltrated air working its way through the building to mix with the conditioned air or the building's main conditioning system. When an ACU is used, the infiltration of unconditioned outside air can be greatly reduced, eliminating the hot/cold spots. The increased comfort level for customers and employees can result in increased employee productivity and customer satisfaction.

4.2.3 Safety

Increased production and safety are achieved by providing a clear and unobstructed opening for both people and motorized vehicles. In industrial applications, full visibility across a doorway or opening can help prevent collisions between fork trucks, other vehicles, people or other equipment. In cold climates, ACUs may also prevent snow and sleet from entering doorways, which helps keep the floor dry and minimizes slippery spots.

4.2.4 Less door and heating/cooling equipment maintenance

ACUs allow a door to remain open during peak demand. Since an ACU can be left running when the door is open, the door does not have to cycle as often, resulting in less maintenance/repairs of the door. There may also be an increase in the life of the building's primary heating/cooling equipment due to a reduction in workload as a result of less infiltration of outside air.

4.2.5 Sanitation

ACUs provide a more sanitary environment by reducing the infiltration of flying insects, dust and airborne contaminants.

4.3 Applications

ACUs may be equipped with multiple or variable speed motors, dampers or both to control the airflow rate. ACUs used for environmental separation may use volume control to adjust for varying temperature or wind conditions. ACUs designated for flying insect control always require full volume and velocity to repel flying insects.

The general applications of ACUs fall into seven categories, as follows:

4.3.1 Environmental separation (exterior)

ACUs applied in this category provide protection to an exterior (perimeter) door from the unwanted infiltration of outdoor air and the escape of indoor air due to the effects of natural wind and/or temperature differences. In warm and cold climates, this infiltration can be reduced significantly by an ACU that is properly sized, installed and adjusted. In cold climate applications where infiltrating cold air has been reduced but still exists as a result of normal operation or where there is a wind/stack effect or exhaust ventilation, the cold air can be heated to a comfortable temperature level. This will prevent a drafty internal climate.

Benefits of using an ACU to protect an exterior door from the infiltration of outdoor air include cost and energy savings, increased comfort levels, increased safety and a decrease in equipment maintenance.

4.3.2 Environmental separation (interior)

ACUs applied in this category provide protection between interior rooms connected by a common opening. Typically, this application is intended to prevent the unwanted infiltration of unconditioned air or the loss of conditioned air from one room to another. Typically, temperature differential is the reason for the air exchange, and this can be controlled by an ACU that has an air performance requirement much smaller than the air performance requirement for exterior applications.

4.3.3 Flying insect control

ACUs applied in this category provide protection for an opening or doorway, usually exterior, from the unwanted entry of flying insects. This is a common requirement in facilities that produce or process food products, such as kitchens and cafeterias. This application typically requires an ACU with a high airstream velocity to repel flying insects.

ACUs used for flying insect control provide multiple benefits for a variety of applications, including restaurants, hospitals and food processing facilities. By reducing the infiltration of flying insects, which can cause disease and unsanitary conditions, ACUs provide a healthier environment while preventing the contamination of food products. In restaurants, an ACU can increase customer satisfaction by preventing flying insects, which are a nuisance to patrons, and allowing doors and concession windows to be left open, attracting business. In food service applications, ACUs are often used to satisfy local health codes, many of which call for an ACU that is certified to NSF International standards.

4.3.4 Coolers/chill rooms and freezers/cold stores

ACUs applied in this category provide protection from the loss of refrigerated air through openings and/or doorways in coolers and freezers. Three types of applications exist: cooler to freezer, ambient to cooler and ambient to freezer. These types of installations are generally (but not limited to) indoor applications; therefore, the ACU is only required to overcome airflow due to temperature differential and not wind pressure. Without an ACU, this airflow would result in energy loss, increased operating costs, safety hazards and potential food or product loss. ACUs are typically horizontally mounted on the warm side of the doorway so that the airstream split created can balance against the air trying to enter and leave the cold room. Cold storage installations can be difficult to balance and may require a vertical mount application, cold side mount application, dampers and/or multi-speed motors to effectively protect the opening.