# Energy Savings with Air Curtains



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# Energy Savings with Air Curtains

Presented by: Mars Air Systems
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Description: Air curtains create a seamless barrier of air over any door, window, or opening, offering significant energy savings to building owners and helping to maintain interior building temperatures. This course examines how air curtains reduce whole building energy consumption, provide thermal comfort, and maintain air quality even when a door is open. The basic principles and theory of how air curtains operate and how to properly identify applications and maximize the air curtain's energy savings potential are discussed in detail. Selection, application, and installation of the various types of air curtains are also explained.

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# Purpose and Learning Objectives

**Purpose:** Air curtains create a seamless barrier of air over any door, window, or opening, offering significant energy savings to building owners and helping to maintain interior building temperatures. This course examines how air curtains reduce whole building energy consumption, provide thermal comfort, and maintain air quality even when a door is open. The basic principles and theory of how air curtains operate and how to properly identify applications and maximize the air curtain's energy savings potential are discussed in detail. Selection, application, and installation of the various types of air curtains are also explained.

**Learning Objectives:** At the end of this program, participants will be able to:

- summarize air curtain terms, components, basic theory, and operation
- assess the design criteria to properly size and install the air curtain unit to suit the application, resulting in improved air quality and increased energy efficiency
- identify how and where air curtains can be utilized to reduce a building's energy consumption
- determine the proper air curtain configurations and controls to maintain and improve indoor air quality and occupant comfort
- recognize industry building codes and test standards and how they apply to air curtains, and
- recall past and present air curtain studies to validate air curtain effectiveness in providing thermal comfort, improved indoor air quality, increased energy savings, and dust and debris control that improves occupant comfort and safety.

# How to Use This Online Learning Course

To **view** this course, use the **arrows** at the bottom of each slide or the up and down arrow keys on your keyboard.

To **print or exit** the course at any time, press the **ESC** key on your keyboard. This will minimize the full-screen presentation and display the menu bar.

Within this course is an ★ **exam password** that you will be required to enter in order to proceed with the online examination. Please be sure to remember or write down this exam password so that you have it available for the test.

To receive a **certificate** indicating course completion, refer to the instructions at the end of the course.

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# Contents



# Air Curtains and Energy

# Introduction to Air Curtains

Air curtains create a seamless barrier of air over any door, window, or opening, offering significant energy savings to building owners and helping to maintain interior building temperatures. Air curtains also repel dirt, dust, fumes, and insects from entering the workplace, providing a sanitary and safe environment for employees.

Because air curtains are able to maintain two distinct temperature zones within a building or reduce the amount of air infiltration/exfiltration at an exterior opening, they can reduce the load requirements of the existing HVAC equipment, and reduce initial equipment costs in new construction. This can impact the total energy use within a commercial building.

The reduction in energy required will also translate to a reduction in the greenhouse gases produced and released into the environment. Using an air curtain is an economical and environmentally efficient way to reduce the energy needed to regulate internal temperatures within commercial buildings.

# Air Curtains and Validation Testing

In 2014, a contingent of air curtain manufacturers collaborated with AMCA (Air Movement and Control Association) International in order to lay the foundation for air curtain effectiveness. AMCA International is a trade organization with a mission to advance the health, growth, and integrity of the air movement and control industry consistent with the interests of the public as its focus.

They enlisted the assistance of an impartial third-party testing agency to validate the air curtain effectiveness and provide theoretical and empirical data. Detailed documentation for all test conditions with clear results was the goal.

AMCA managed the project to ensure that the testing methods and results provided were impartial and accurate. The initial study, “Investigation of the Impact of Building Entrance Air Curtain on Whole Building Energy Use,” was conducted by Dr. Leon Wang, of Concordia University, Montreal, and his team of analysts, physicists, scientists, and engineers. The hundreds of CFD (computational fluid dynamics) simulations generated were based on the vestibule study, previously conducted by Dr. Gren Yuill some 20 years prior.

# Air Curtains and Validation Testing

The results of the Concordia study show that air curtains save energy on whole-building energy use an average of 0.2% to 3.3% in climate zones 3 to 8.

Three subsequent papers have since been released:

“An Approach to Determine Infiltration Characteristics of Building Entrance Equipped with Air Curtains” (2014) by Leon Wang et al. expanded the scope of the original CFD simulations.

“Energy Saving Impact of Air Curtains in Commercial Buildings” (2016) by Sherif Goubran contains empirical validation testing based on the half-scaled CFD simulation.

“A Novel Method Relating Air Curtain Aerodynamics Performance to Air Curtain Effectiveness” (pending release in 2019) focuses on scaled wind tunnel testing to validate the half-scaled model with effectiveness curves.

Each CFD and laboratory test builds on the previous study and validates the data collected and calculated.

# Air Curtains and Energy

The impact of air curtain use on energy loss was recognized by a number of code bodies that began in 2015, just after the Concordia study. Codes began to require vestibules in 2007 to address the energy and occupant comfort cost of air infiltration at public entrance doors. A vestibule provides an air lock that reduces the amount of cool air entering a heated building or warm air entering a cooled building at a busy entrance.

As of 2015, air curtains have been added as an alternate to vestibules in a number of codes and standards: IECC, IgCC/ASHRAE 189.1, and as of 2019, ASHRAE 90.1, pending public and committee approval. These prescriptive energy codes are the basis of design for many designers, engineers, specifiers, and architects throughout the U.S. and sometimes the world. Other international code bodies have adopted their own derivative of the original U.S. codes, adding specific language and requirements to meet their regions' governing regulations, while still keeping the original intent.

# Air Curtains and Energy Codes: 2015 IgCC/ASHRAE 189.1

In 2015, the IgCC (International Green Construction Code) was the first to add air curtain language under the exceptions of 605.1.2.3. In 2018, after years of negotiations, IgCC and ASHRAE 189.1 combined their efforts and collaborated in updating the IgCC through ANSI/ASHRAE/ICC/IES/USGBC Standard 189.1, "Standard for the Design of High-Performance, Green Buildings Except Low-Rise Residential Buildings." The IgCC, which is part of the ICC (International Code Council) family, will be responsible for the scope and administration, and ASHRAE 189.1 will manage the technical contents and ensure the standard is consistent and coordinated with the ICC family of codes.

The language added to IgCC is in Chapter 6 under 605.1.2.3:

Where air curtains are provided at building entrances or building entrance vestibules, the curtain shall have a minimum velocity of 2 m/s at the floor, be tested in accordance with ANSI/AMCA 220, and installed in accordance with manufacturer's instructions. Manual or automatic controls shall be provided that will operate the air curtain with the opening and closing of the door. Air curtains and their controls shall comply with Section C408.2.3 of the International Energy Conservation Code.

These code provisions require that when an air curtain is used, it must be tested to the appropriate standard (AMCA 220), installed properly, and function as intended.

# Air Curtains and Energy Codes: 2018 IECC C402.5.7 Vestibules

The 2018 version of the IECC added air curtain language in the exception in C402.5.7 Vestibules.
All building entrances shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule, it is not necessary for the interior and exterior doors to open at the same time. The installation of one or more revolving doors in the building entrance shall not eliminate the requirement that a vestibule be provided on any doors adjacent to revolving doors.

Exceptions: Vestibules are not required for the following:

1. Buildings in climate zones 1 and 2.
2. Doors not intended to be used by the public, such as doors to mechanical or electrical equipment rooms, or intended solely for employee use.
3. Doors opening directly from a sleeping unit or dwelling unit.
4. Doors that open directly from a space less than 3,000 square feet (298 $m^2$) in area.
5. Revolving doors.
6. Doors that have an air curtain with a velocity of not less than 6.56 f/s (2 m/s) at the floor, that have been tested in accordance with ANSI/AMCA 220 and installed in accordance with the manufacturer’s instructions. Manual or automatic controls shall be provided that will operate the air curtain with the opening and closing of the door. Air curtains and their controls shall comply with Section C408.2.3.

# Air Curtains and Energy Codes: ASHRAE 90.1

In 2018, ANSI/ASHRAE Standard 90.1-2016, “Energy Standard for Buildings Except Low-Rise Residential Buildings,” Section 5 was modified to include air curtain language as part of the exceptions. The proposal was submitted to both the Envelope and Mechanical Subcommittees by the contingent of air curtain manufacturers through a CMP (Continuous Maintenance Program), used to continuously correct, update, and improve standards.

The language is in review and is proposed as follows for the 2019 edition:

5.4.3.4 Vestibules

Building entrances that separate conditioned space from the exterior shall be protected with an enclosed vestibule, with all doors opening into and out of the vestibule equipped with self-closing devices. Vestibules shall be designed so that in passing through the vestibule, it is not necessary for the interior and exterior doors to open at the same time. Interior and exterior doors shall have a minimum distance between them of not less than 7 ft when in the closed position. The floor area of each vestibule shall not exceed the greater of 50 $ft^2$ or 2% of the gross conditioned floor area for that level of the building. The exterior envelope of conditioned vestibules shall comply with the requirements for a conditioned space. The interior and exterior envelope of unconditioned vestibules shall comply with the requirements for a semiheated space.

# Air Curtains and Energy Codes: ASHRAE 90.1

Exceptions to 5.4.3.4

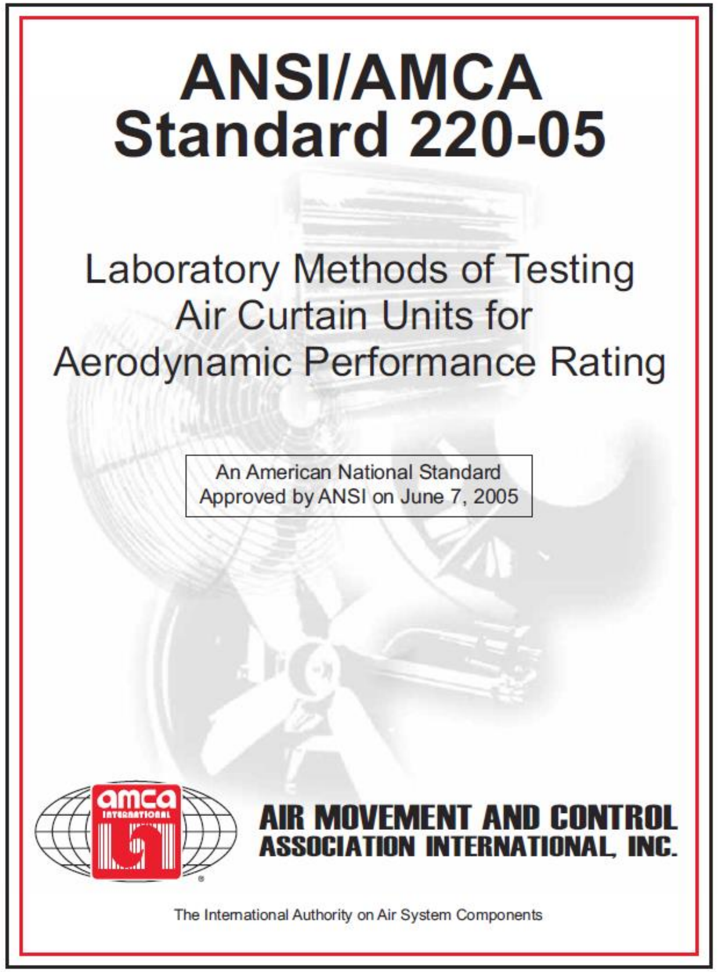
1. Building entrances with revolving doors.
2. Doors not intended to be used as a building entrance.
3. Doors opening directly from a dwelling unit.
4. Building entrances in buildings located in climate zone 1 or 2.
5. Building entrances in buildings that are located in climate zone 3, less than four stories above grade, and less than 10,000 $ft^2$ in gross conditioned floor area.
6. Building entrances in buildings that are located in climate zone 0, 4, 5, 6, 7, or 8 and are less than 1,000 $ft^2$ in gross conditioned floor area.
7. Doors that open directly from a space that is less than 3,000 $ft^2$ in area and is separate from the building entrance.
8. Semiheated spaces.
9. Enclosed elevator lobbies for building entrances directly from parking garages.
10. Self-closing doors in buildings in climate zones 0, 3, and 4 that have an air curtain complying with section 10.4.5.
11. Self-closing doors in buildings 15 stories or less in climate zones 5 through 8 that have an air curtain complying with section 10.4.5.

# ANSI/AMCA 220 and Energy Codes

As part of the language, a new section was inserted and called Section 10.4.5. The language of the new section is as follows:

10.4.5 Air Curtains

Air curtain units shall be tested in accordance with ANSI/AMCA 220 or ISO 27327-1 and installed and commissioned in accordance with the manufacturer's instructions to ensure proper operation and shall have a jet velocity of not less than 6.6 feet per second (2.0 m/s) at 6.0 inches (15 cm) above the floor and direction not less than 20 degrees toward the opening. Automatic controls shall be provided that will operate the air curtain with the opening and closing of the door.

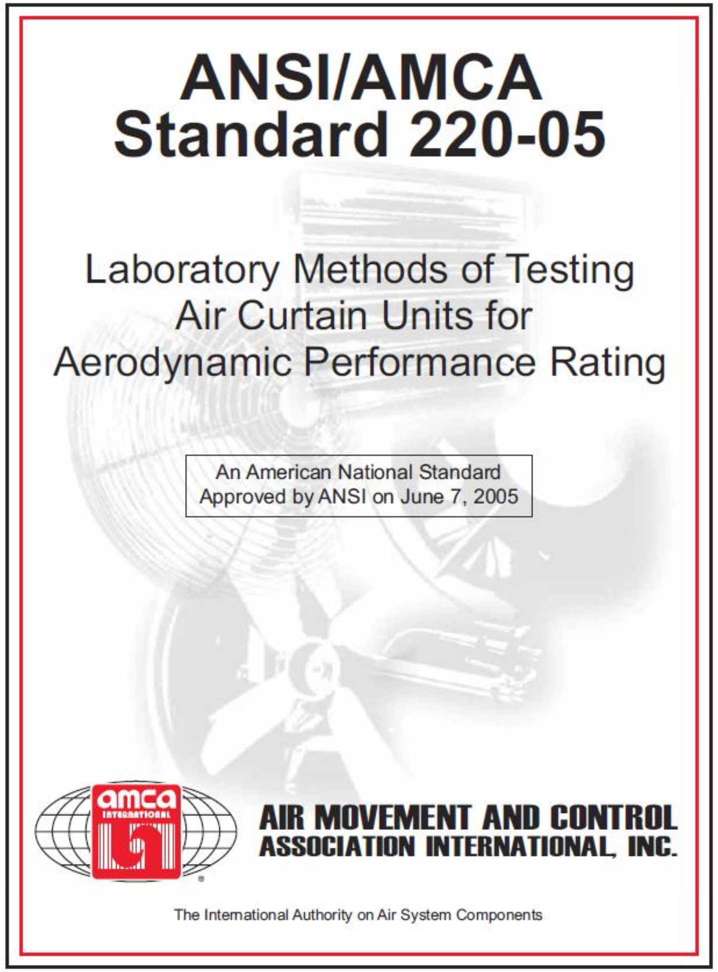


# ANSI/AMCA 220 and Energy Codes

AMCA worked with ANSI to create a standard for air curtain units that is cited in all the codes. This standard, ANSI/AMCA 220, outlines tests for aerodynamic performance in terms of airflow rate, outlet air velocity uniformity, power consumption, and air velocity projection.

The code requires that air curtains are tested in accordance with AMCA Standard 220-05, “Laboratory Methods of Testing Air Curtain Units for Aerodynamic Performance Rating.”

AMCA International’s Certified Ratings Program (CRP) ensures that a product line has been tested and rated in conformance with AMCA International’s test standards and rating requirements.



**ANSI/AMCA Standard 220-05**

Laboratory Methods of Testing Air Curtain Units for Aerodynamic Performance Rating

An American National Standard
Approved by ANSI on June 7, 2005

AIR MOVEMENT AND CONTROL ASSOCIATION INTERNATIONAL, INC.

The International Authority on Air System Components

# Air Curtains and Health Codes: NSF/ANSI 37

Air curtains have been used for food distributing and food processing applications for many years to mitigate the infiltration of flies and other insects. Their use reduces the risk of contamination and assists in increasing food safety. NSF International sets out the construction and performance requirements for pass-through windows and front/customer entrance and receiving doors; air curtains that meet these requirements will carry the NSF/ANSI 37, “Air Curtain for Entranceways for Food and Food Service Establishments,” certification. The standard establishes minimum sanitation and performance requirements for the materials, design, construction, and performance of air curtains and their related components.

Flying insect control
air curtain unit

# Air Curtains and Health Codes: NSF/ANSI 37

NSF/ANSI 37 identifies three applications for air curtains with the performance requirements below:

6.1 Service window air curtains

- a minimum 8.0 inches (200 mm) airstream depth
- an air velocity of at least 600 feet per minute (fpm) (183 meters per minute (mpm))
- the measurement point shall be at 1/3 the distance of the vertical opening above the service window counter top
- readily removable filters shall be provided at the air intake inlet

6.2 Customer entry air curtains

- a minimum 3.0 inches (75 mm) airstream depth
- an air velocity of at least 600 fpm (183 mpm)
- the measurement point shall be at 3.0 feet ± 0.25 inches (0.9 m ± 6.0 mm) above the floor

6.3 Service entry air curtains

- a minimum 3.0 inches (75 mm) airstream depth
- an air velocity of at least 1,600 fpm (488 mpm)
- the measurement point shall be at 3.0 feet ± 0.25 inches (0.9 m ± 6.0 mm) above the floor

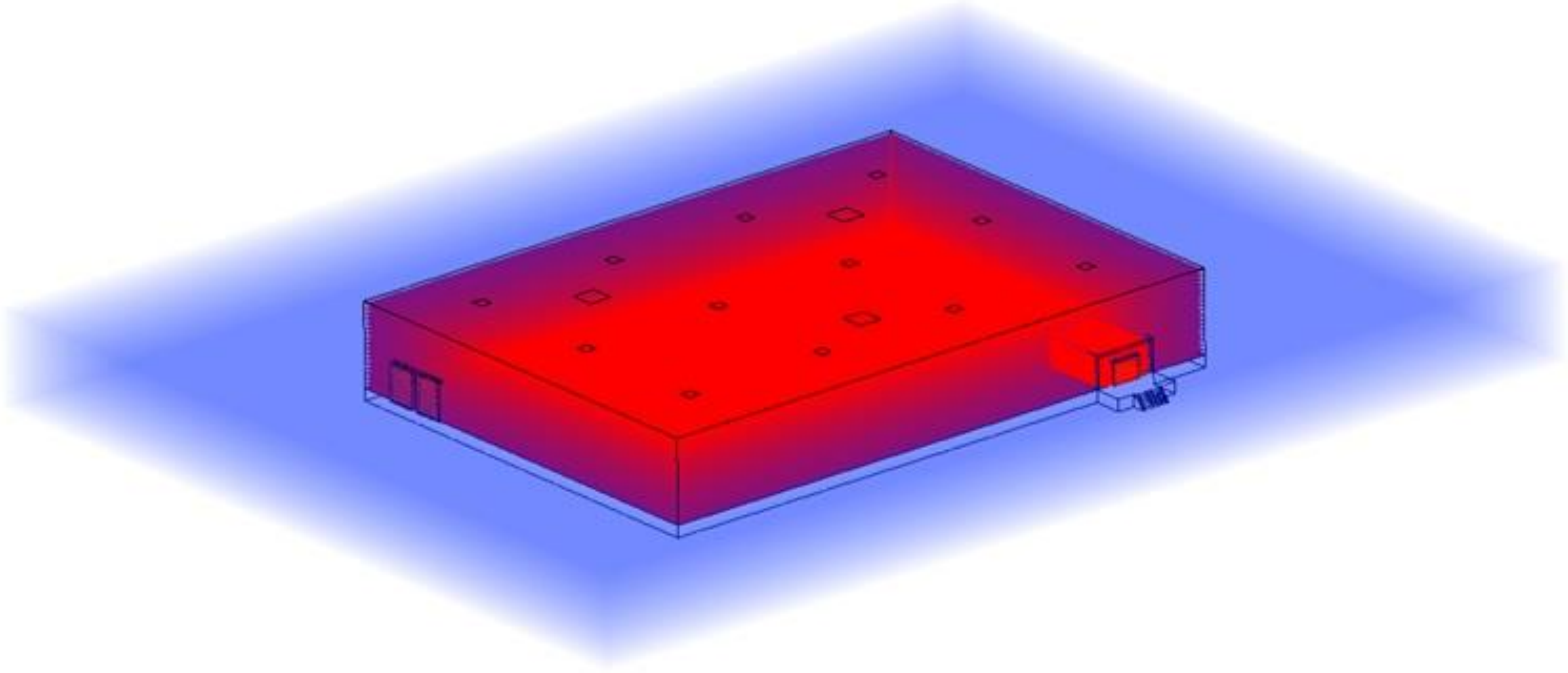
# Air Curtains and LEED®

When used properly, air curtains can help to improve energy performance, and it is common to see a payback period of one to two years depending on location and usage. Currently, air curtains are not mentioned in any LEED credits; however, air curtains may contribute to a project earning LEED credits by contributing to exceptional or innovative performance above the requirements set by the LEED BD+C rating system. The methods are as follows:

- Method #1: Energy and Atmosphere, 1 to 18 possible points
- Method #2: Indoor Environmental Quality, 1 to 6 possible points
- Method #3: Materials and Resources, 1 to 2 possible points
- Method #4: Innovation, 1 to 6 possible points

Please note that the installation of air curtains does not directly result in LEED v4 BD+C points. However, through the proper application of their many functions, air curtains can assist in meeting prerequisite and credit requirements to qualify for LEED v4 BD+C points.

The methods above must be assessed by the reviewer in order to determine if they qualify for additional LEED points.



# How Air Curtains Work

# General Theory

An air curtain unit (ACU) is a mechanical air moving device that generates a controlled stream of air that projects across the entire height and width of an opening. ACUs are commonly used for exterior building doors to control the infiltration of outside air and minimize the loss of conditioned interior air. They are also used in the interior to separate areas with differing air temperatures, such as freezers from food preparation areas, or clean rooms from the rest of the manufacturing area. Finally, they can be used to limit dust particulates and insects into a conditioned and/or protected space.

The ACU reduces the requirement to positively pressurize spaces in order to prevent infiltration by oversizing the HVAC equipment. This is a common practice among designers and results in both an increase in the initial equipment costs and energy costs due to constant exfiltration. Properly sized, an ACU with the addition of optional heated or conditioned air can maintain building temperatures and add localized supplemental thermal support to reduce the load requirements of the central HVAC system.

# Energy Performance

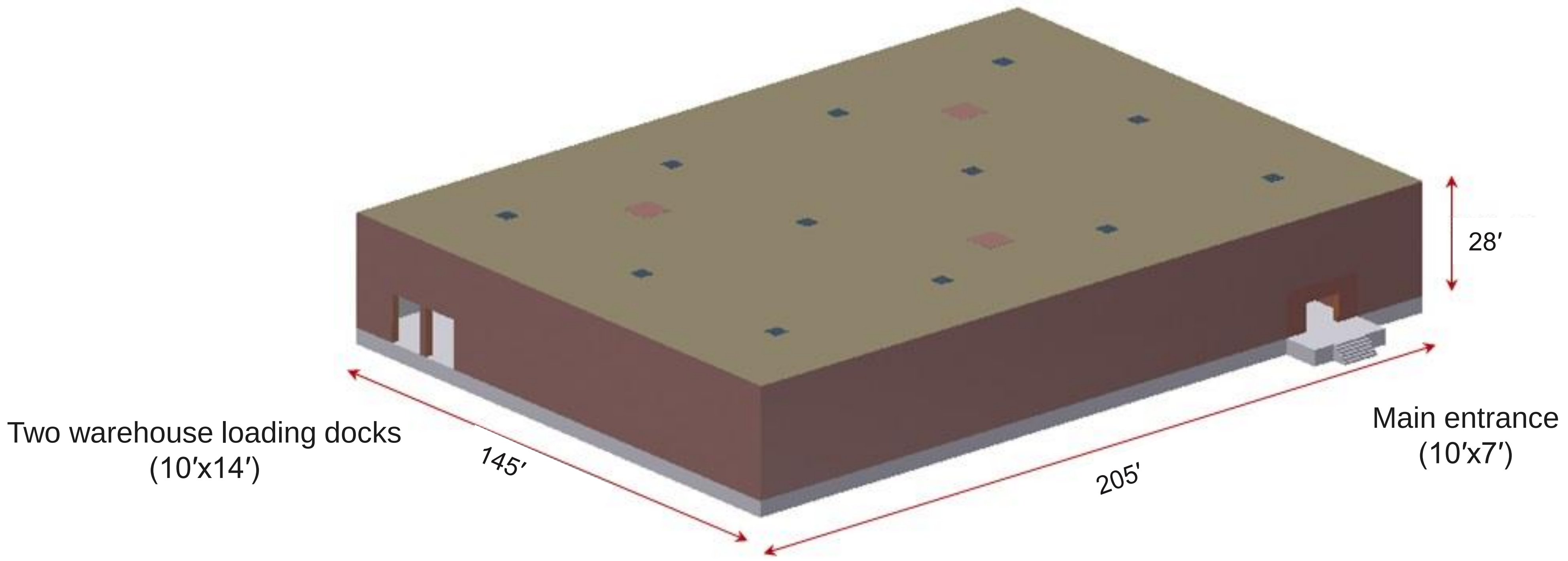
The energy performance of an air curtain can be determined by its energy effectiveness (EE).

Energy effectiveness is a product of energy loss through an opening with an air curtain plus the energy consumption of the air curtain divided by the energy loss through an opening without an air curtain. This is a unit-less ratio comparing the energy saved with the air curtain and the energy lost without the air curtain.

$$\frac{\text{energy loss through opening with air curtain} + \text{energy consumption of air curtain}}{\text{energy loss through opening without air curtain}}$$

# How Air Curtains Work

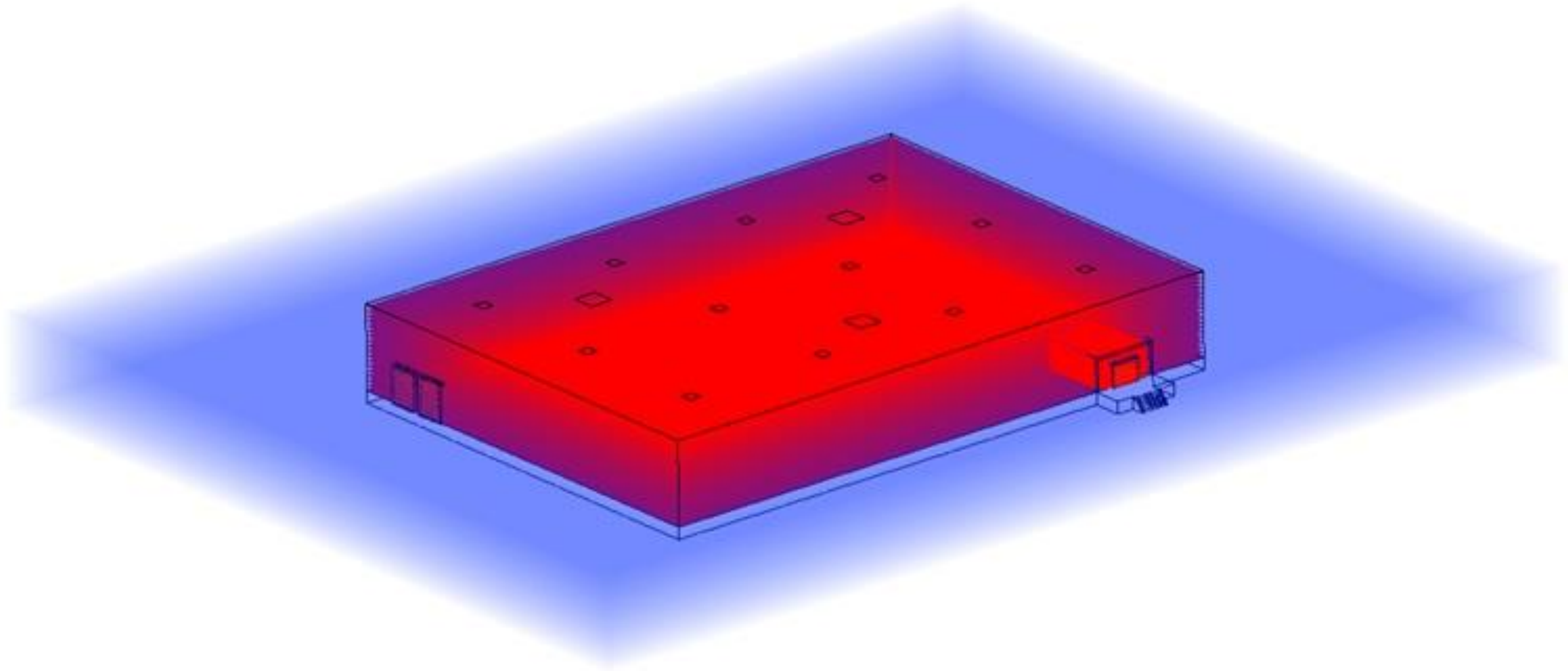
This analysis using computational fluid dynamics illustrates how air curtains stop air/heat movement across an opening. A simulated warehouse has three openings: two warehouse loading dock doors measuring to a total 10′x14′ and a 10′x7′ main entrance.



# How Air Curtains Work

The initial inside temperature is 70°F and the outside temperature is 20°F. The doors are opened for ten minutes during the simulations.

One simulation has air curtains and the other does not have air curtains.



# How Air Curtains Work: Heat Loss Simulation at 30 Seconds

The snapshots of CFD simulations provide a better understanding of how heat is lost during the simulation when the external doors have been left open.

The next slide has examples of a building without air curtains and with air curtains.

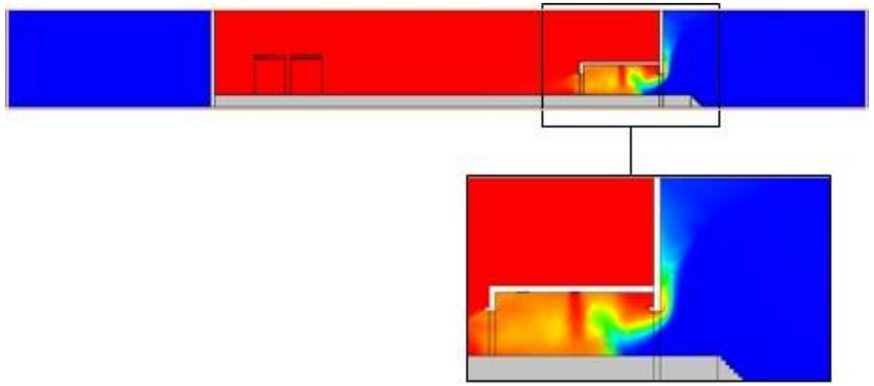
After just 30 seconds, even though the building temperature has not yet been affected, notice the infiltration of the cold air at the bottom and the loss of hot air at the top of the doors in both examples of doors without air curtains.

For now, energy exchange is still minimal.

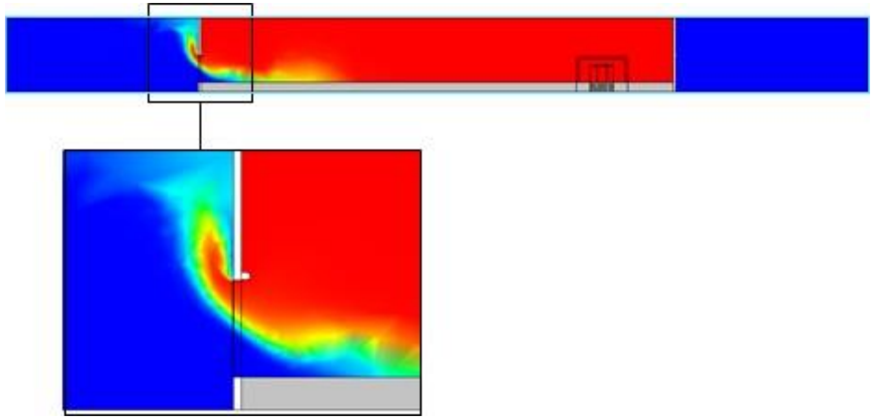
# How Air Curtains Work: Heat Loss Simulation at 30 Seconds

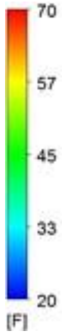
## Heat loss without air curtains

Plane 1 (main entrance)



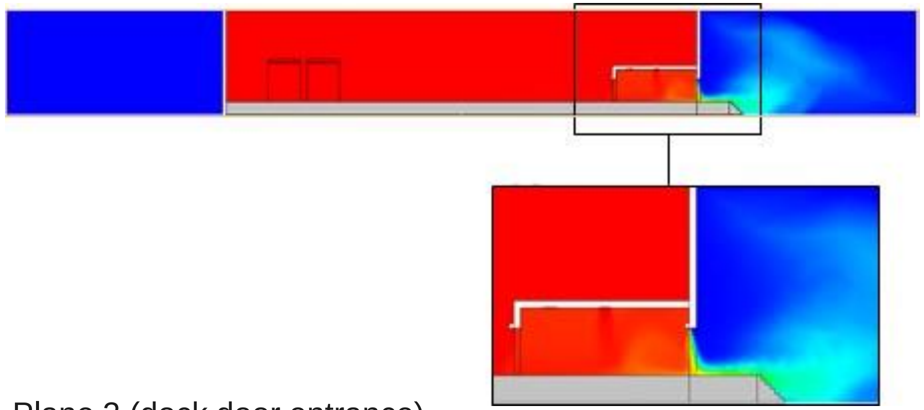
Plane 2 (dock door entrance)



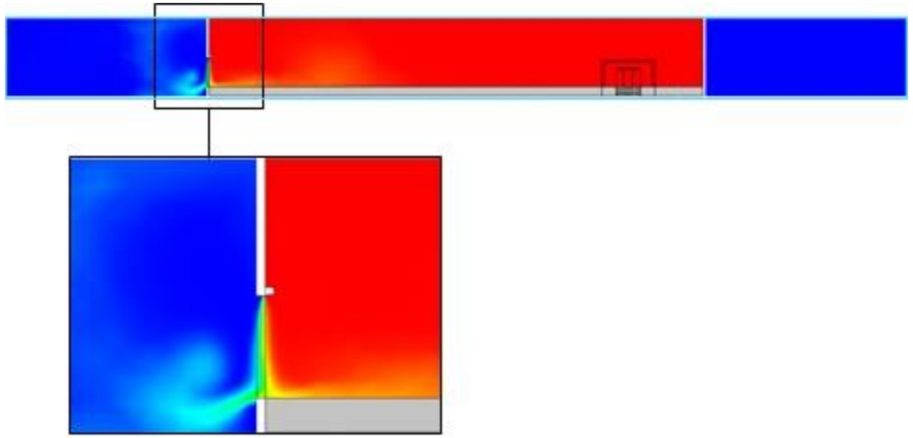



## Environmental shield by air curtain

Plane 1 (main entrance)



Plane 2 (dock door entrance)



# How Air Curtains Work: Heat Loss Simulation at 10 Minutes

However, after ten minutes the simulation without the air curtains shows a great deal of heat loss compared to the simulation with the air curtains, which shows minimal heat loss.

Studies have shown that air curtains can be particularly effective at restricting cold room air infiltration. A study in the United Kingdom by A.M. Foster et al. examined the rate of cold air infiltration from a cold room at -4°F to an interior room at 77°F. The air curtain achieved an effective rate of 60%–80% at reducing the cold air seeping into the room.

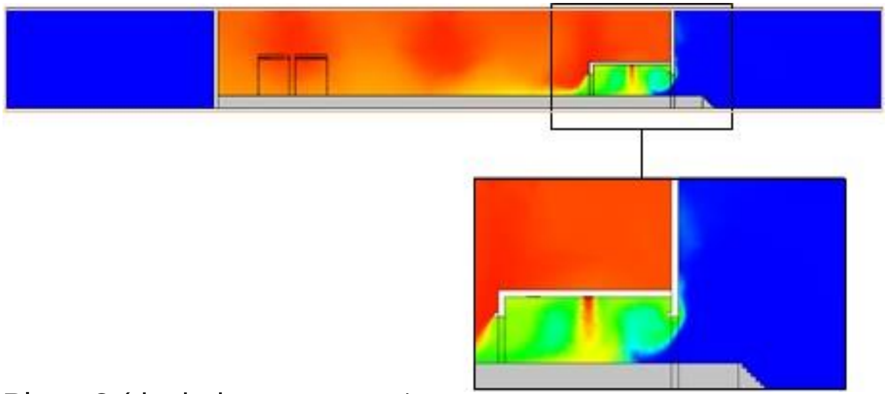
Although air curtains can reduce infiltration, they are not meant to replace doors. A long exposure (opening) time will ultimately result in larger heat losses than shown in this 10-minute example.

However, they can still contribute to significant energy savings in buildings by reducing the amount of energy required by the HVAC system to replace conditioned air within the working environment, thus reducing the amount of $CO_2$ emissions released into the atmosphere.

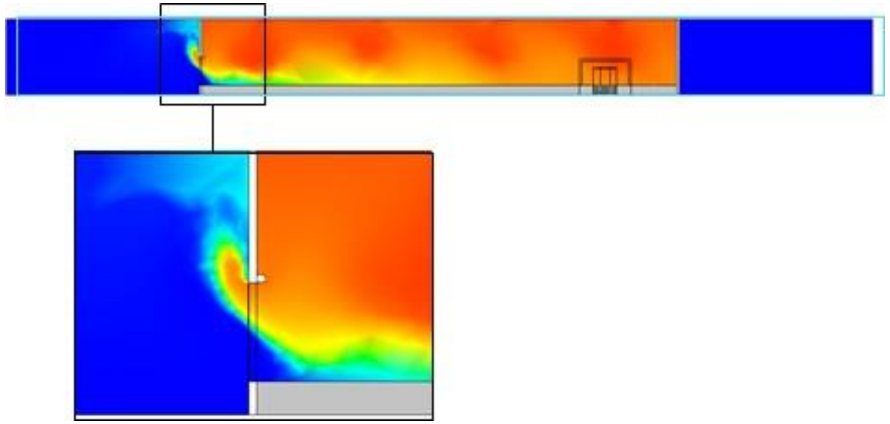
# How Air Curtains Work: Heat Loss Simulation at 10 Minutes

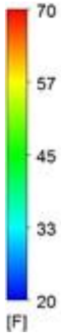
## Heat loss without air curtains

Plane 1 (main entrance)



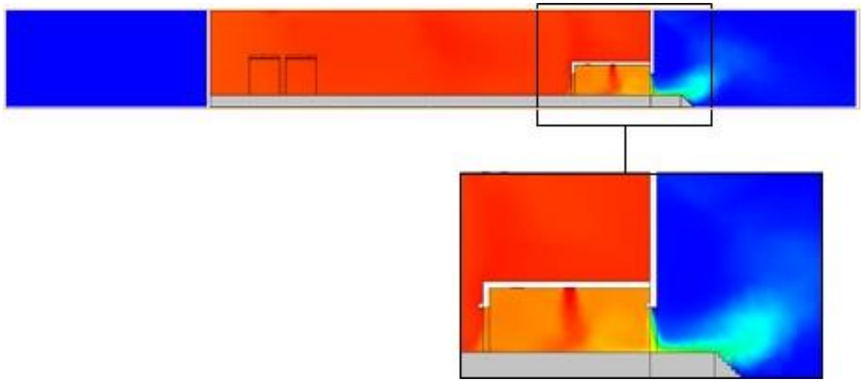
Plane 2 (dock door entrance)



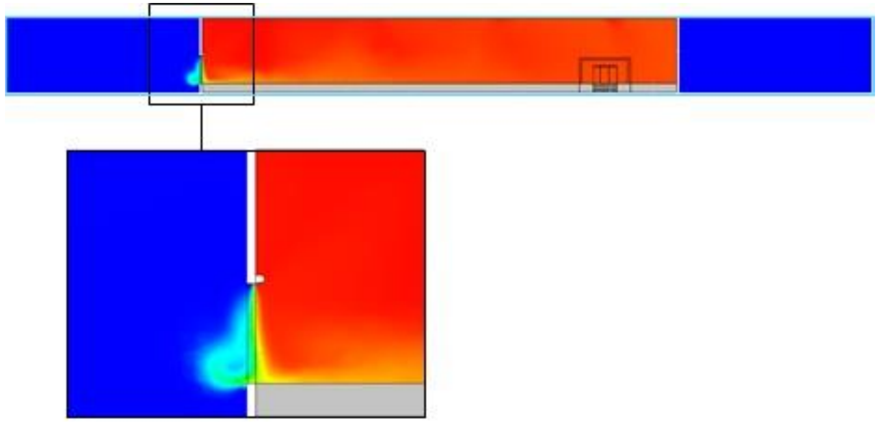



## Environmental shield by air curtain

Plane 1 (main entrance)



Plane 2 (dock door entrance)

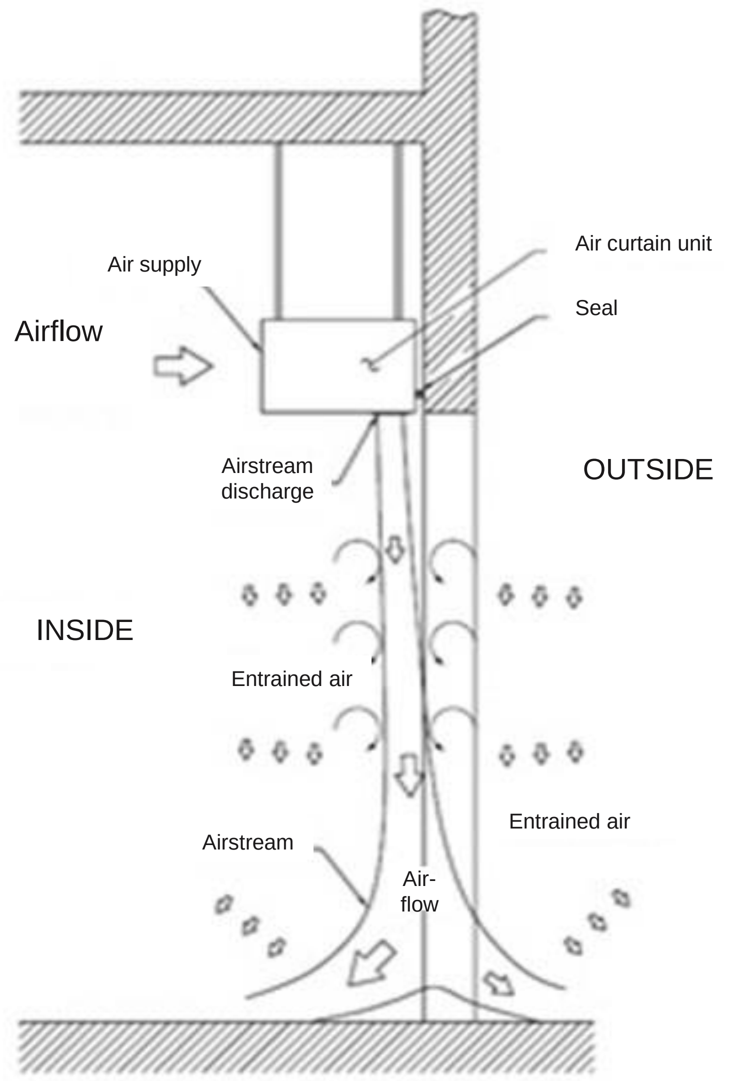


# Air Curtain Types and Components

# Nonrecirculating System

ACUs are classified by two different types: nonrecirculating and recirculating. The major differences between the two systems are the airflow path, cabinet construction, range of effectiveness, and the purchase and installation costs.

A nonrecirculating system draws air into the unit directly from the surrounding environment in both horizontal and vertical applications. An air curtain equipped with inlet ductwork, which draws air from outside the surrounding environment, is also considered to be nonrecirculating. These types of air curtains can be recess or surface mounted.




Nonrecirculating, horizontally mounted, high-velocity air curtain unit

# Nonrecirculating System

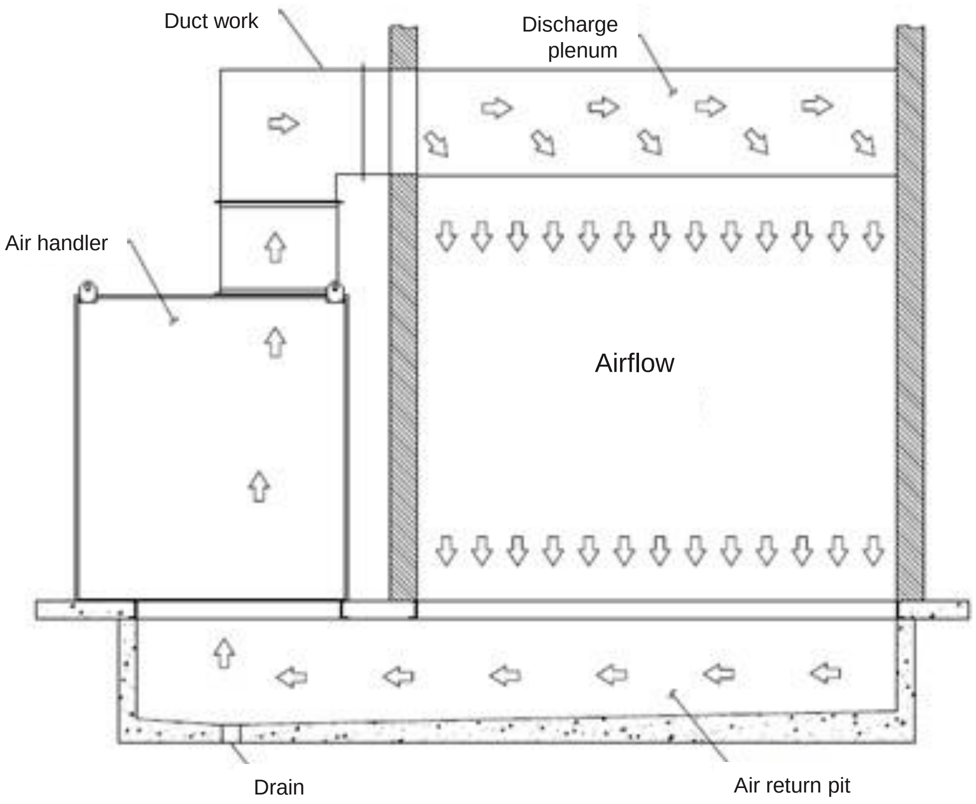
Flying insect control applications use this type of unit exclusively due to its ability to generate the high velocities and turbulent jetties required to disrupt the flying patterns of  insects. NSF 37 specifies 600 and 1,600 fpm 3 feet from the floor as the standard.

This is also the most commonly used system for environmental separation due to its low initial purchase and installation costs. Nonrecirculating systems are typically used for special applications due to their flexibility in construction, smaller size, and installation.

# Recirculating System

A recirculating system draws air from ductwork that primarily collects and returns the discharged air back to the inlet. Applications will often use a plenum with a floor return that is connected to the inlet with ductwork as seen in the image on the right. An alternate construction includes a horizontal flow that discharges and returns from side to side.

This system is recommended for doorways that are opened for extended periods of time with a high rate of traffic. While it has a higher energy effectiveness rating, this system is only suitable for thermal separation applications as it does not generate the high velocities needed for insect control. Thermal separation typically requires the lower velocity airstream provided by a recirculating system. With the low-velocity airstream and the recessed components, a recirculating system is perceived as less obtrusive than a nonrecirculating system. However, although this system is highly effective in thermal separation and is most often used for openings without doors, energy consumption is typically higher.




Recirculating,
horizontally mounted air curtain unit

# Nonrecirculating vs. Recirculating

Nonrecirculating Advantages

- lower planning, installation, and maintenance costs
- retrofittable to existing opening
- used for temperature and insect control

Nonrecirculating Disadvantages

- intrusive high velocities
- lower overall energy effectiveness, 60%–80%
- not recommended for extended open applications

Recirculating Advantages

- less intrusive lower velocities
- higher effectiveness, 80%–90%
- used for extended open applications

Recirculating Disadvantages

- higher initial cost
- requires planning for installation and maintenance
- not intended for flying insect control
- considered for more of a niche market

# Fans

Air curtain fans may be direct driven (with the fan mounted on the motor shaft) or belt driven (utilizes a variable pitch sheave on the motor and a fixed pulley on the fans, connected by a belt or series of belts). The most commonly used fans are centrifugal, axial, and cross-flow (tangential) fans and are typically direct drive. Others are available but not often utilized due to costs and size limitations.

The main types of centrifugal fans are:

- centrifugal, forward-curved (see image on right)
- centrifugal, cross-flow (tangential)
- centrifugal, backward-curved (back-inclined), and
- centrifugal, straight radial.

**Centrifugal, forward-curved**

Forward-curved blades curve in the direction of the rotation of the fan wheel. Forward-curved blowers are suited for applications with smaller airflow volumes and high static pressures. They are often called squirrel cages because of their similarity in appearance to the exercise wheel for pet rodents. They are also called scroll fans. These types of fans are especially sensitive to particulates, which may cause undue wear if the exposure rate is high.

# Fans

**Centrifugal, cross-flow (tangential)**

The cross-flow (CFF) or tangential fan, sometimes known as a tubular fan, is used extensively in the HVAC industry. The fan is usually long in relation to the diameter, so the flow approximately remains two-dimensional away from the ends, providing a relatively uniform airstream.

However, because the air does not spread as it travels across the opening, the gaps created by the motor(s) and bearings must be compensated for by utilizing internal deflectors in the nozzle.

The CFF uses an impeller with forward-curved blades, placed in a housing consisting of a rear wall and vortex wall that funnels the air toward the nozzle and discharge.

Centrifugal, cross-flow fan

# Fans

**Centrifugal, backward-curved (backward-inclined)**

Backward-curved blades curve against the direction of the fan wheel’s rotation. These types of blowers are designed to handle gas streams with low to moderate particulates.

They can be easily fitted with wear protection, but certain blade curvatures can be prone to solid buildup.

Backward-curved wheels are often lighter than corresponding forward-curved equivalents, as they don’t require so many blades.

Centrifugal, backward-curved fan

Centrifugal, straight radial fan

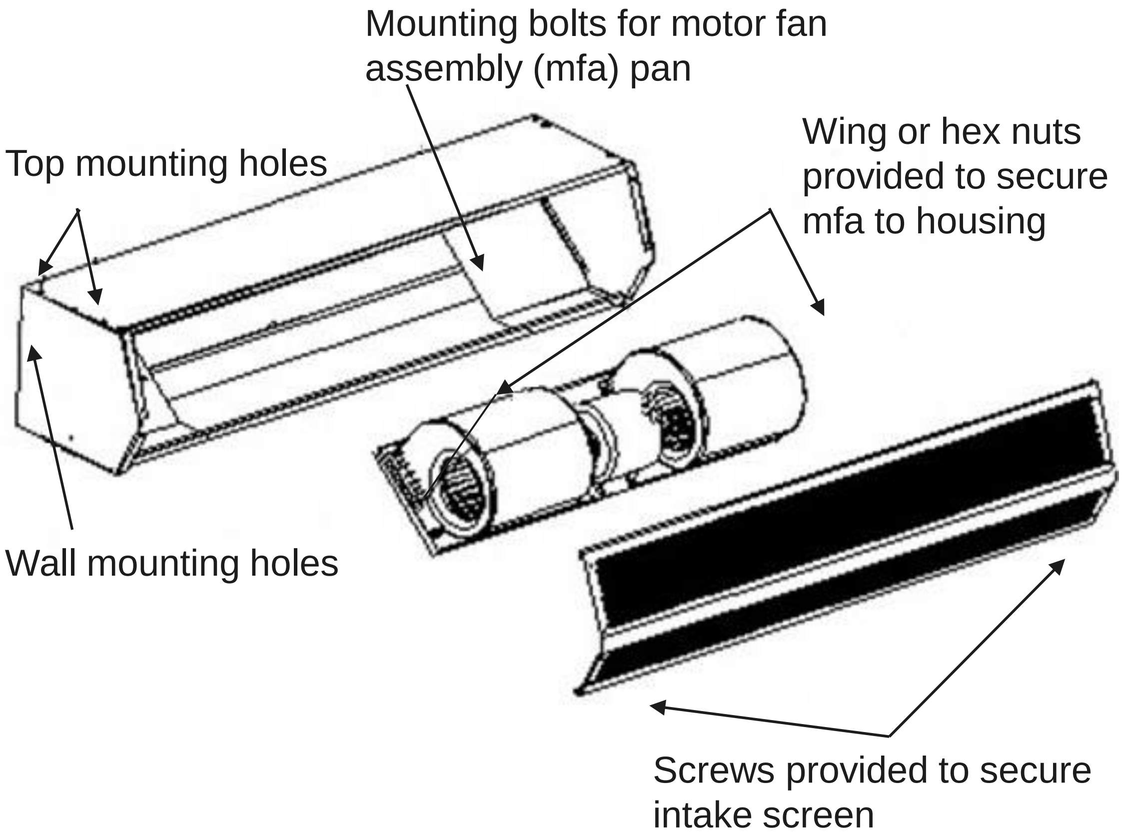
# Motors

Air curtain units may employ one or more motors in or on the cabinet, depending on the application. Most motors are available with multispeed capabilities, either with a mechanical or electronic speed controller. Panels may be required depending on the horsepower and/or voltage. They are usually built to a national and/or regional standard such as NEMA (National Electrical Manufacturers Association) and/or IEC (International Electrotechnical Commission).

The following are the most commonly used motors for air curtains:

**TEFC (Totally Enclosed, Fan Cooled)**

This type of motor is typically used for an air curtain where the motor does not have free or cool air. The motor relies on movement to circulate the air and cool the motor.



# Motors

**TEAO (Totally Enclosed, Air Over)**

This enclosure is designed to be dust tight; the motor in the cabinet relies on the airstream of the fan it is driving for cooling. This is the most commonly used motor type for most NEMA 1 air curtain applications.

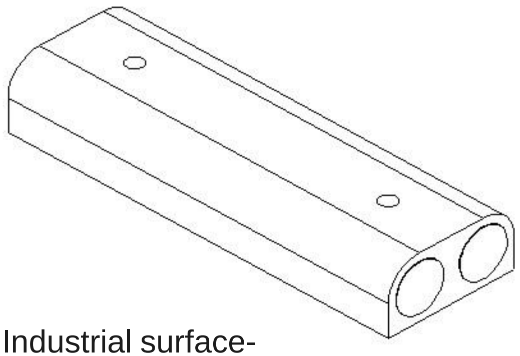
**TENV (Totally Enclosed, Nonventilated)**

This enclosure is designed to be dust tight and moderately sealed. It repels a small degree of water and radiates excess heat for cooling. Due to this motor's ability to dissipate heat without an external fan or cool air moving across its body, a TENV motor is used for special process applications such as explosion or hazardous, washdown (high-pressure cleaning with water or chemicals designed to kill bacteria), corrosive, and high-temperature areas.

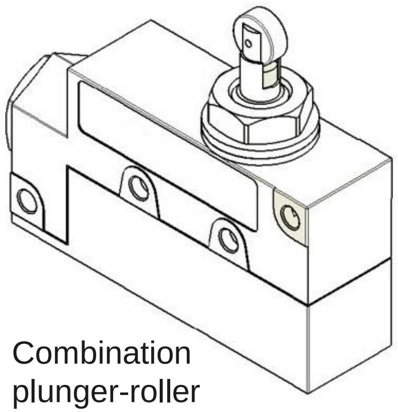
# Controls

Controls for air curtain operation range from a basic manual mechanical limit switch that turns the air curtain on when the door opens and off when the door closes, all the way to a more complex control that can interface with a computer-controlled system such as a building management system (BMS). Door limit switches and controls reduce air curtain energy consumption and reduce the wear and tear on the air curtain. They allow designers and engineers to customize the sequence of operations for the unit to optimize the air curtain operation based on the local conditions.

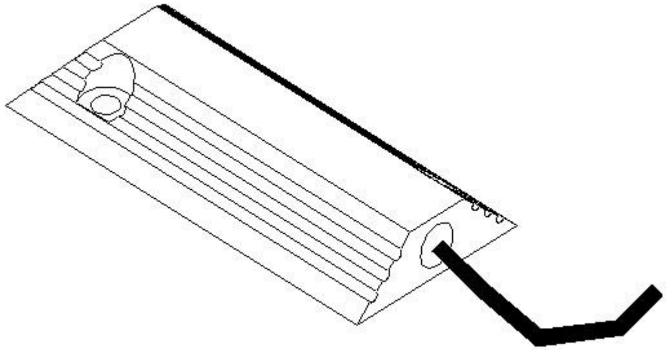
The type of control required depends on many factors including the type of motor used for the air curtain and any special requirements necessary for heating or cooling, in which case a thermostat would be incorporated. Other switches include electromechanical types, which can be mounted on the unit or used remotely.



Industrial surface-mounted switch



Combination plunger-roller type switch



Industrial floor-mounted switch

# Adaptive Smart Controls and BACnet™ Communication

Building systems today are often maintained by automated control systems. BACnet™ (Building Automation and Control (BAC) network) is a communication protocol that allows for different systems within the building, such as heating, ventilation, door access, etc., to communicate with one another. Automated and/or adaptive controls enable the building owner and operator to monitor the ACU. They can optimize the air curtain performance to reduce energy losses during operating hours.

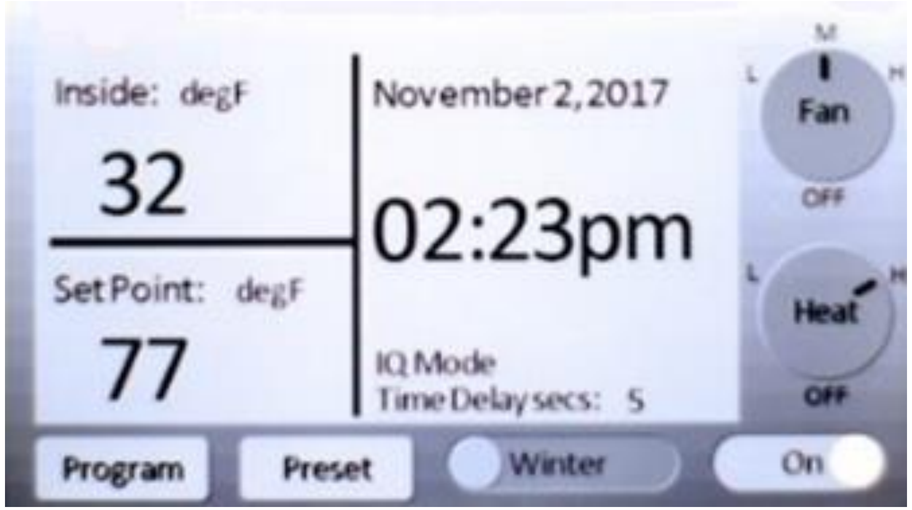
These adaptive smart controls allow automatic and intelligent control of air curtain operation to:

- maximize energy savings (adaptive motor speed)
- maximize user comfort (adaptive time delay)
- maximize motor life (adaptive time delay), and
- minimize energy consumption (adaptive heat output).

Adaptive time delay refers to the optimization of the time delay function based on door traffic. Door traffic is monitored continuously, and the time delay is automatically set every three minutes to minimize motor on–off cycles.

# Adaptive Smart Controls and BACnet™ Communication

Adaptive motor speed refers to the optimized air curtain motor speed based on thermal forces across the opening of the door. Indoor and outdoor temperatures are measured continuously, and the data is used to calculate the severity of the thermal forces (stack effect). Motor speed is then automatically increased or decreased to counter the current stack effect as opposed to running the motor constantly at high speed.




Adaptive heat output relates to the self-adjusting heat output based on desired and set point temperature. Actual room temperature and the desired room temperature data is used to calculate the optimum heat setting as opposed to running the heat at the highest setting all the time. Discharge air temperature is constantly monitored to turn the heat off in the event of overheating.

Using BACnet™ protocols to centralize communication and control of all air curtain operations results in reduced installation and maintenance costs and increased energy savings.

# Noise Control

In quiet work areas, noise control may be needed. The main source of noise pollution in an air curtain is the moving air and its interaction with the cabinet. The following are some noise reduction techniques:

- Use directional vanes with an aerofoil-shaped design.
- Use rigid housing construction to minimize metal-to-metal vibration.
- Allow a clear path for a laminar airflow pattern as opposed to a disruptive turbulent flow.
- Redirect reverberations away from the front or bottom and towards the ceiling and back where the effects will not be felt.

# Selection and Applications

# Selection

Air curtain unit selection is dependent on a number of factors, starting with the application type, for instance, environmental separation, environmental pollution control, flying insect control, cold storage, or ovens. The width and height of the opening is then considered. The air curtain unit at a minimum must cover the entire opening and, if possible, should slightly overlap. On wide openings, two vertically-mounted, lower air velocity units can be used as an alternative solution to a single horizontally-mounted, higher air velocity unit.

Further, to maximize effectiveness, other selection criteria to consider for the opening are:

- indoor or outdoor application
- for outdoor applications:
    - orientation—is the door facing towards the prevailing winds
    - is the opening protected from wind load; does it have an obstruction across from it
    - are there other doors in the area of the air curtain
    - does the building have either neutral or slightly positive pressure
- is the unit's discharge path free and clear for the entire width of the opening to maintain optimum performance
- can the air curtain provide 400 fpm (2 m/s) when measured at the floor line once installed
- is the unit AMCA 220 certified

# Selection: Safety Accreditations

Along with the code, and health requirements previously mentioned, there are a multitude of private and public testing laboratories that have the capability of testing, verifying, and certifying air curtain products to the various national and local standards for the United States and Canadian markets, and globally if required. The various safety accreditation companies are the following:

- ETL: a testing laboratory, part of Intertek
- CSA (Canadian Standards Association): in the recent past only served Canada, but now also serves as a competitive alternative for the United States
- UL (Underwriters Laboratories): United States
- NSF International: United States
- CE (Conformité Européenne): Europe

# Selection: Finishes and Aesthetics

The air curtain cabinet or housing encloses the motor(s), fans, heater(s), and other electromechanical components used to operate the air curtain. Choices of cabinet materials and/or finishes are usually made based on the type of application (customer entry doors, loading dock and receiving doors, pass-through windows, corrosive environments, etc.).

Metals such as galvanized steel, stainless steel, and aluminum are still the most commonly used materials for the air curtain cabinet, but plastics such as polyethylene, polypropylene, and polycarbonate are also available.

Finishes include painting with a liquid or powder paint, which may be air dried or kiln dried.

# Applications: Environmental Separation

## Exterior

Air curtain units in this category provide protection to an exterior 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. Related applications include: loading docks, transportation terminals, and airplane hangars.

## Interior

These units provide protection between interior rooms connected by a common opening. This application is intended to prevent the unwanted infiltration of unconditioned air or the loss of conditioned air from one room to another caused by temperature differential. This can be controlled by an air curtain unit that has an air performance requirement much smaller than what is typically needed for exterior applications.

# Applications: Environmental Pollution Management

## Pathogen and Odor Control

Airborne microbes and microbial growth can be eliminated inside the air curtain cabinet with the use of UVC light (wavelength: 254 nm). The compact and safe design directs UV light to the desired location to maximize effectiveness. Even undesirable odors can be neutralized by using a UVV light (wavelength: 185 nm).

All ACUs must be ETL certified as per UL standards, and certain safety measures must be followed to protect against accidental contamination.

Applications include: clean rooms, bathrooms, healthcare locations, compactor/dumpster areas, designated smoking areas, etc.

Pathogen and odor control air curtain unit

# Applications: Environmental Pollution Management

**Dust Control**

Air curtain units provide air quality control by removing pollen, dust, dust mites, debris, pet dander, etc.

True HEPA filtration that captures 99.97% of 0.3 micron particles is used, and additionally, a 2-inch pleated MERV 8 prefiltration filter is used to extend the life of the HEPA filter. The result is increased perishable product storage shelf life.

Applications include clean rooms, electronics assembly lines, healthcare, and pharmaceutical facilities.

Dust control
air curtain unit

# Applications: Flying Insect Control

External openings or doorways can be protected from the unwanted entry of flying insects by using an ACU. This is a common requirement in facilities that produce, process, or serve food products, such as kitchens, cafeterias, pass-through windows, and restaurants.

This application typically requires an air curtain unit with a higher airstream velocity to repel flying insects. However, when higher airstream velocity units are selected, the energy effectiveness will be reduced. In this application type, food safety requirements supersede energy savings requirements.

Flying insect control
air curtain unit

# Applications: Cold Storage

An air curtain protects against 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 air curtain unit is only required to overcome airflow due to temperature differential and not wind pressure. The lower velocities required for cold storage applications utilize smaller motors that consume less energy.

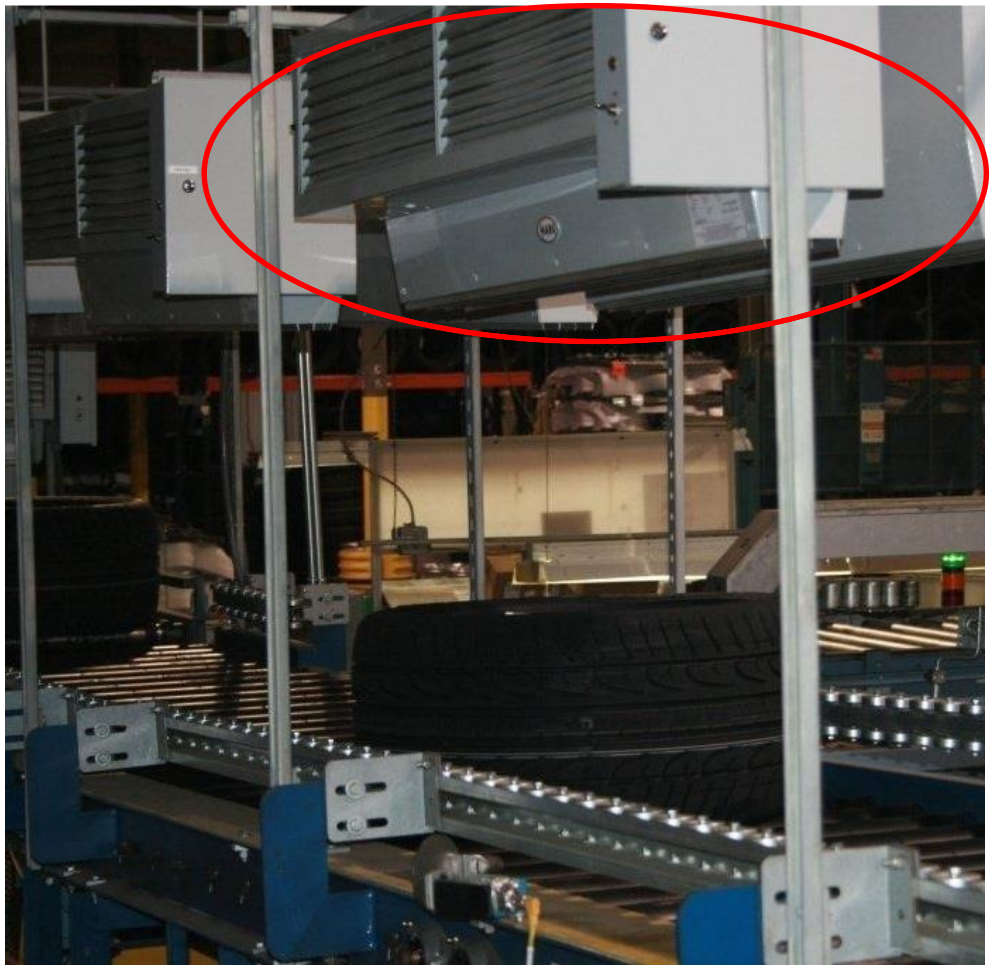
Air curtain units are typically horizontally mounted on the warm side of the doorway, so that the airstream split created can be balanced against the air trying to leave the cold room. Cold storage installations can be difficult to balance and may require a vertically mounted application, cold side mounted application, dampers, and/or multispeed motors to effectively protect the opening.

Freezer/cold room separation air curtain unit

# Applications: Ovens

Air curtain units provide protection against the loss of heated air through openings and/or doorways in ovens. Normally mounted horizontally over the oven opening, they are angled slightly inward toward the oven to prevent the hot air from escaping through the top of the opening. These types of installations are generally indoor applications so the air curtain unit is only required to overcome airflow due to temperature differential and not wind pressure.

The heating process in ovens is typically designed to maintain a neutral pressure with the surrounding environment. The air curtain unit should be adjusted to only entrain and turn back the heated air to avoid creating an unbalanced condition by forcing air into the oven. The mounting location of the ACU should also provide adequate protection from exposure to hot air that would escape the oven in the event the air curtain unit is shut down.



# Applications: Negative Building Pressure and Specialty Units

## Negative Building Pressure

These units are installed in an opening where a negative pressure, more building exhaust air than supply air, exists that requires special consideration. For typical operation of an air curtain, the building should be neutral or positively pressurized. That is because when the building is under-pressurized, standard air curtain airflow rates will not be capable of overcoming the artificial deflection created by the negative condition. However, in special cases, an increase of airflow may be used to overcome a slightly negative condition. The addition of heat will assist in tempering the air curtain discharge and adding supplemental heat to the area, providing comfort to those near and around the opening.

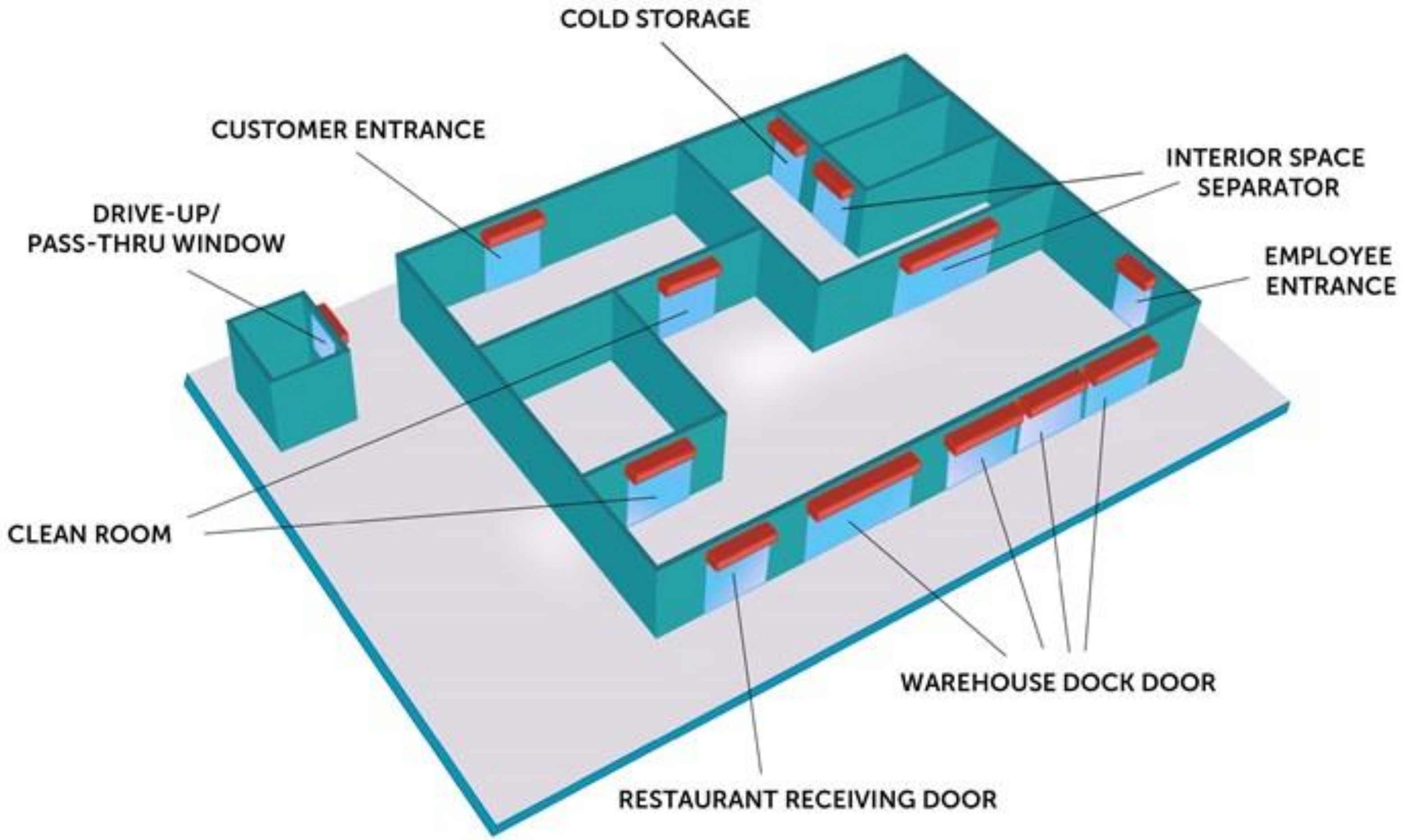
## Special/Custom

Air curtain units can be used for other applications such as protection against the infiltration of dust, water removal in drying processes, smoke and odor containment, and the defrosting of doorways, to name a few. In these cases, effectiveness will be defined by how the air curtain resolves the application issues and not energy effectiveness.

# Applications

Throughout an average building, there are various doorways and openings that could benefit from an air curtain.

For budgetary considerations, the perimeter openings are the best candidates for the initial installations and have the fastest return on investment.



# Applications: Food and Hospitality Industry

Many applications in the food and hospitality industry are well suited for air curtains, such as: coolers and cold storage, stadium concession stands, fast food and quick serve, pool bars, industrial kitchens, outdoor bars and decks, catering facilities, and hotel and restaurant entrances.

In certain applications, strict enforcement of codes is mandated. NSF/ANSI 37, “Air Curtain for Entranceways for Food and Food Service Establishments,” requires air curtains to minimize the infiltration of flying insects in the food handling and/or preparation areas.

# Applications: Industrial and Distribution Centers

Industrial and distribution center applications include building entrances and loading dock doors; interior separation areas include warehouse to processing areas and refrigerated warehouses.

These buildings have many large shipping and receiving doors that are exposed to the elements throughout the day. In some applications, the storage areas may be required to maintain and regulate internal temperatures for food safety. In areas prone to inclement weather, employee comfort is a major consideration for using air curtains.

# Applications: Transportation

In addition, transportation-related facilities such as bus and train terminals, shipyards, cargo handling areas, vehicle maintenance facilities, distribution centers, and airports may have very large doors to accommodate the large vehicles and equipment. In cold climate zones (-10°F to -50°F outside temperatures), workers may have to vacate the area when the doors open.

Some airplane service bay doors are 30 feet high and may take upwards of five to ten minutes to fully open and/or close. These openings can be exposed to the elements from ten to twenty minutes, exposing the work areas to the frigid outdoor environment. Even when the doors finally close, it may take another 30 to 60 minutes for the temperature to increase to a suitable level for the technicians to return to work.

# Installation

# Installation

Installation considerations begin during the air curtain unit selection process. Understanding the installation implications during the selection process will contribute to a successful project. When considering an air curtain unit, it is important to decide whether the unit will be mounted horizontally or vertically, and inside or outside the opening. For longevity, it is recommended that air curtains be installed inside, protected from the elements, or in the conditioned space for thermal separation. For fly control, the unit can be mounted inside or outside, but can be used only during the warmer months for extremely cold climate areas. Typically, flies are not prevalent during the winter months.


Interior horizontal installation

Exterior vertical installation

# Obstructions and Restrictions

Obstructions surrounding the opening may require special installation and maintenance considerations. Typical obstructions may include beams, piping, ductwork, electrical conduit, and door hardware.

Qualified installers should follow safety protocol and recommended work practices and adhere to the manufacturer's specific instructions.

It is recommended that outdoor installations be protected from the elements either by an overhang or weather hood; by employing special duty motors, electrical fittings, fans, or impellers; and/or by exterior finishes.

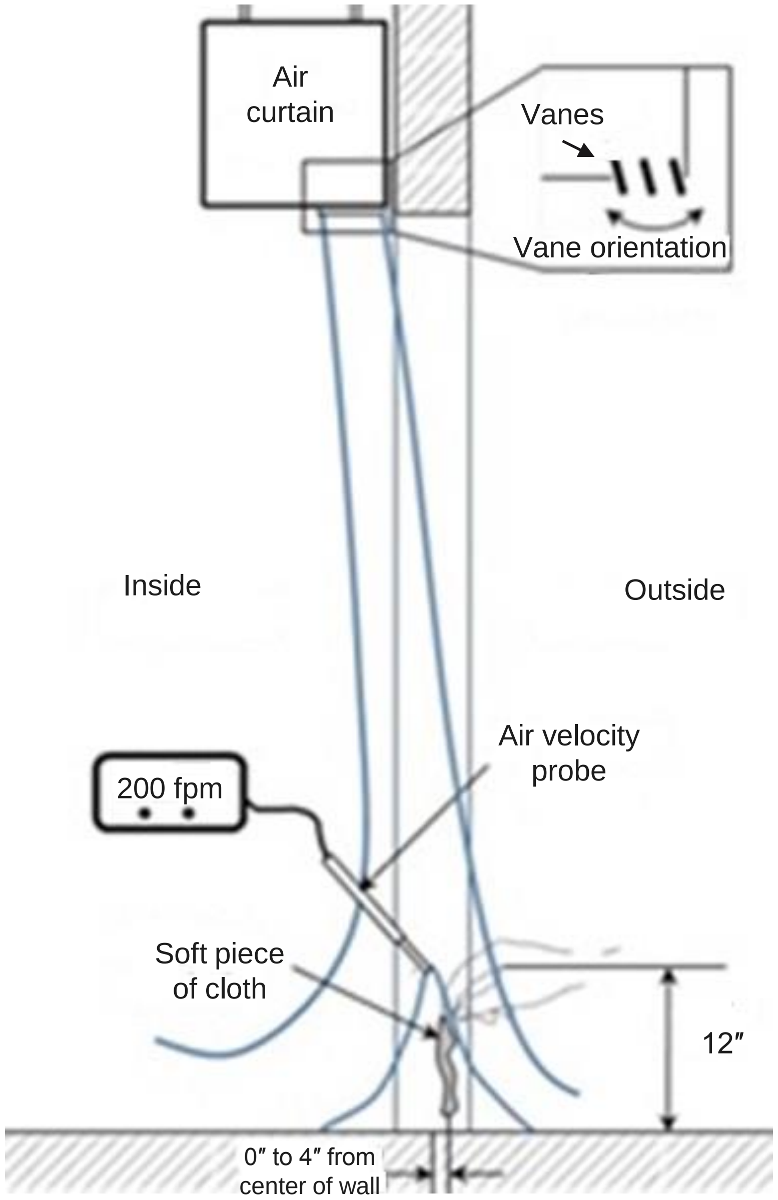
In some cases, due to limitations of headroom space, units can be installed vertically and discharge horizontally across the opening.

# Field Settings: Airflow

Discharge air speed adjustments will be performed after the air curtain unit is mechanically secured and power properly applied. The installer should validate the manufacturer's intended airflow, ensuring it properly flows over the specified opening.

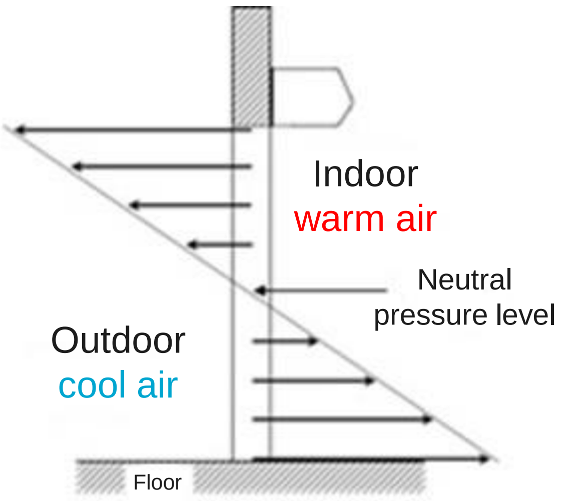
This is generally accomplished by holding a lightweight fabric such as a handkerchief approximately 12 inches from the target surface. As each manufacturer is different, make sure to consult individual instructions.

An anemometer, a device that measures wind speed, or other air measuring devices may also be used to adjust and confirm field settings.

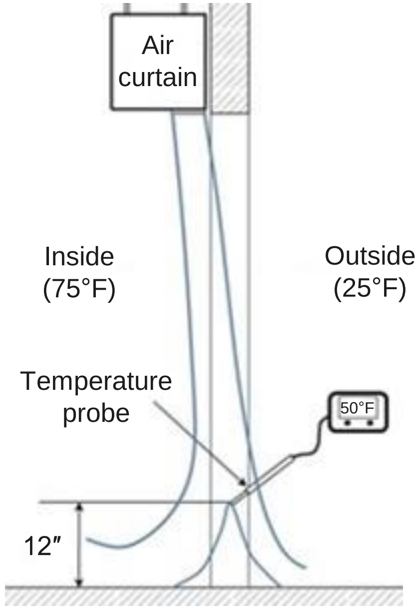


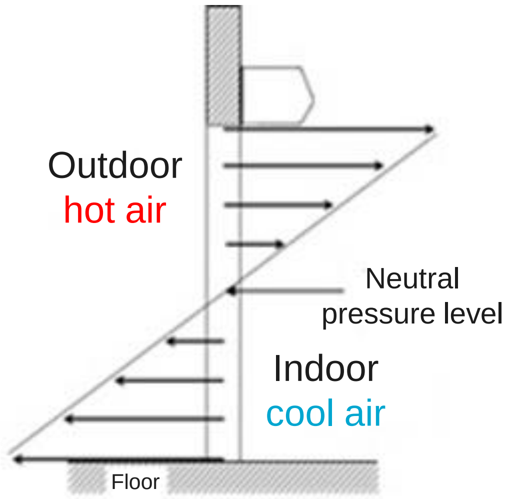
# Field Settings: Air Temperature

In addition to the air speed, installers will need to measure the air temperature. This is done approximately 12 inches above the floor in the neutral zone. The neutral zone is the area where the air splits and moves both to the inside and the outside, creating an optimal seal across the opening. The optimal temperature reading should be halfway between the inside and outside of the opening. Remember to consider the presence of unforeseen utilities or electrical wiring as some manufacturers provide units heated by gas, which require sufficient fresh air for proper combustion and exhaust for life safety. Follow the heater manufacturer’s recommendations for fuel, air supply, and exhaust, as well as NEC, NFPA, and other local codes.




Stack pressure in heating season
(pattern with air curtain OFF)




Stack pressure in cooling season
(pattern with air curtain OFF)

# Engineering Tools

There are many engineering tools available for building owners to use when designing an air curtain system. These websites often include an ROI (return on investment) calculator that can estimate the energy savings and payback periods of different types of air curtains.

A product configurator will assist in selecting the proper models, including the type of heat and power required for each application, which is beneficial to the specifiers, engineers, designers, and architects. The submittals and CSI (Construction Specifications Institute) specs assist architects and engineers in writing the air curtain specifications. Revit, a software system that works with building information modeling (BIM), provides detailed 3D models that can be inserted into the project design drawings. Using one or a combination of these tools will ensure a properly designed project.

★ Please remember the **exam password SAVINGS**. You will be required to enter it in order to proceed with the online examination.

# Case Studies

# Mena House Hotel, Cairo, Egypt

The Mena House Hotel in Cairo, Egypt, was struggling to keep the food storage area sufficiently cooled during delivery times. As the outside air temperature ranged from 94°F to 104°F, it was important to find a solution that would keep the cold air inside while maintaining ease of access to the 20′x20′ freezer for restocking purposes. With the freezer door open so many times and for so long during the day, it was beginning to overwhelm the cooling system that was trying to keep the freezer at the required operating temperature of -5.8°F.

Using a series of 42-inch custom-engineered air curtains, a wall of cold air was created sufficient enough to consistently stop the infiltration of heat and dust. Temperatures within the freezer no longer fluctuated up to 19°F when food was being delivered, and the cooling system was able to quickly re-cool the freezer back to safe food-holding temperatures. Air curtains provided an efficient and economical solution to the hotel’s food storage system.

# Driscoll's: Food Science Laboratory

For Driscoll's, the world's largest berry distributor, the breeding of fruit is a complex process that must be carried out in a lab with stringent protocols and rigorous standards for consistent and validated outcomes. Spores must be created in a lab with tightly controlled conditions as Driscoll's produces different strains for their varying growing regions. To meet the objectives and reveal the right data, the lab needs to be free of dust, contaminants, and strains of spores that are not under examination.

The lab leadership realized the entry and exit of staff to and from the lab was the likely conduit by which airborne environmental contaminants would enter. The air curtain solution selected was a powerful, focused stream of air to expel debris from the body and clothing of their scientists and workers. The unit was tucked away in the ceiling so that it didn't impede views or quick lab access. Driscoll's laboratory is an excellent example of the versatility of air curtains.

# Campbell Soup Company

The manufacturing environment demands stringent controls for safety, air quality, temperature, and cleanliness so that the work is completed within the parameters that guarantee top performance. Campbell Soup Company operates a cooler/freezer storage unit 24 hours/day alongside a 8′x16′ heavily trafficked forklift entrance with a fast-acting, vertical-lift fabric door. The hot, humid warehouse conditions collide with the cold, dry-storage area air, which produces condensation and pools of water at the base of the freezer—both inside and out. Pooled water also flowed from the freezer opening directly into the walkways that host both foot and forklift traffic, resulting in slippery floor conditions.

The precise area that needed an air burst to eliminate condensation was determined and then a bundle of door-activated, vertically-mounted, and stacked air curtains and air diffusers were installed right at the cold storage unit’s forklift entrance. The air curtain’s forced-air action stabilized cold area temperatures by creating an air seal that effectively evaporated most surface condensation. The air curtains also eliminated walkway water. To stop the condensation buildup at the inside base of the freezer door, air curtains were used in conjunction with a closed door during low traffic times, and insulating material was installed on the side walls. This unique installation eliminated the potentially dangerous pools of water while maintaining plant efficiency.

# Summary and Resources

# Summary

Air curtains can provide companies with an invisible shield of protection, separating external and internal areas as well as keeping out flying insects, dirt, and wind-borne pollutants. By effectively maintaining the conditioned air inside, air curtains can contribute to reducing whole-building energy use. As less energy is consumed, less $CO_2$ emissions are released into the environment.

Engineering tools offered by manufacturers can aid designers in proper product selection and specifications. Not only can air curtains be used for exterior building openings, they can also be used to separate internal areas, such as clean rooms from warehouses, laboratories from manufacturing areas, and food preparation from delivery areas. Air curtains offer a cost-effective, environmentally friendly, and effective energy-saving solution for building owners.

# Resources

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# Conclusion

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