Main Entrance Air Curtains: Improving Energy Efficiency, Health, & Comfort

BERNER AIR CURTAINS

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Purpose and Learning Objectives

Purpose:

Main entrance air curtains are used by architects and engineers in commercial, institutional, and industrial settings to both improve energy efficiency and protect occupant comfort and well-being. This course reviews the research that led to air curtains being approved as an alternative to vestibules in ASHRAE 90.1-2019 and other building codes, as well as how air curtains on main entries contribute to sustainability goals around energy conservation, public health, and indoor air quality.

Learning Objectives:

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

- state the components, operating principles, and benefits of air curtains in terms of improving occupant comfort and energy efficiency
- discuss the energy codes and performance standards related to air curtains
- summarize the air curtain studies that support their ability to reduce energy loss from air infiltration through open doors and to improve whole-building energy performance, and
- recall how air curtains can support a safe indoor environment and promote occupants' productivity, thermal comfort, and well-being.

An Overview of Air Curtain Fundamentals

Introduction

Main entrance air curtains, also referred to as air doors and fly fans, are used by architects and engineers to improve energy efficiency and protect occupant comfort and well-being in the space on the interior side of an entrance.

Designed to control air transfer across two independent temperature zones, air curtains create a seamless barrier of air over an opening, reducing the amount of air infiltration/exfiltration. They can significantly decrease the load requirements of the HVAC equipment, thereby providing an environmentally efficient method of reducing energy needed to regulate interior temperatures in commercial facilities.

Main entrance air curtains are used instead of, or to enhance or replace, a vestibule. Several building codes, including ASHRAE 90.1-2019, allow properly sized and installed AMCA certified air curtains to be used as an alternative to vestibules.

Introduction

In addition, air curtains stop infiltration of flying insects and pollutants, such as tobacco smoke, fumes, and exhaust emissions, providing a safer and more sanitary environment for building occupants.

Other ways air curtains contribute to a safe environment and good indoor air quality are by destratifying the air and increasing ventilation.

ANSI / AMCA Definitions

The Air Movement and Control Association International (AMCA) defines the product as an air curtain unit (ACU) and the airstream it produces as an air curtain. However, the term “air curtain” is used across the industry to refer to both.

ANSI/AMCA Standard 220 definitions:

- **ACU**
    - An air moving device that produces an air curtain (or boundary of air) where the width is at least five times the depth of the opening and the discharge is not intended to be connected to any ductwork.
- **Air Curtain**
    - A directionally controlled stream of air with a minimum width-to-depth aspect ratio of 5:1. When applied across the entire height and width of an opening, it reduces the infiltration or transfer of air from one side of the opening to the other and inhibits the passage of insects, dust, and/or debris.

Recirculating Air Curtains

There are two types of air curtains: recirculating and nonrecirculating. Both types are available with supplemental heat.

A recirculating air curtain (also known as an air entrance system) generates and discharges a low-velocity, thick, high-volume airstream that is sent from a discharge grille across the opening toward a receiving grille and is then recirculated using an air handler. It works by entraining large volumes of air into a barrier to counteract thermal exchange and wind loading.

Recirculating air curtains are mainly used in places with nonstop foot traffic, such as supermarket entrances, to provide both indoor air comfort and energy conservation while allowing for the unhindered flow of people. Because this type of air curtain is built into the entrance, it is usually selected for new construction or a major renovation. The unobtrusive wide stream of low-velocity air created by recirculating air curtains is less noticeable than the higher velocity air movement of nonrecirculating systems and thus is often more desirable for separating environments in key main entrances.

Recirculating Air Curtain

Nonrecirculating Air Curtains

Nonrecirculating air curtains, the focus of this presentation, are more widely used than recirculating systems because they are easier and less expensive to install, require less space, and have lower maintenance costs.

The device generates and discharges a high-velocity, thin, low-volume airstream that splits at the threshold (i.e., floor) and is not recirculated back to the intake. This high-velocity airstream works by entraining air into a barrier to counteract thermal exchange and wind loading.

Nonrecirculating air curtains are used in both new construction and existing buildings and may be mounted on the wall or hung from the ceiling. They are used with all types of door sizes—from drive-thru windows to bay doors—with all types of door traffic.

Nonrecirculating Air Curtain

Noncirculating Air Curtains

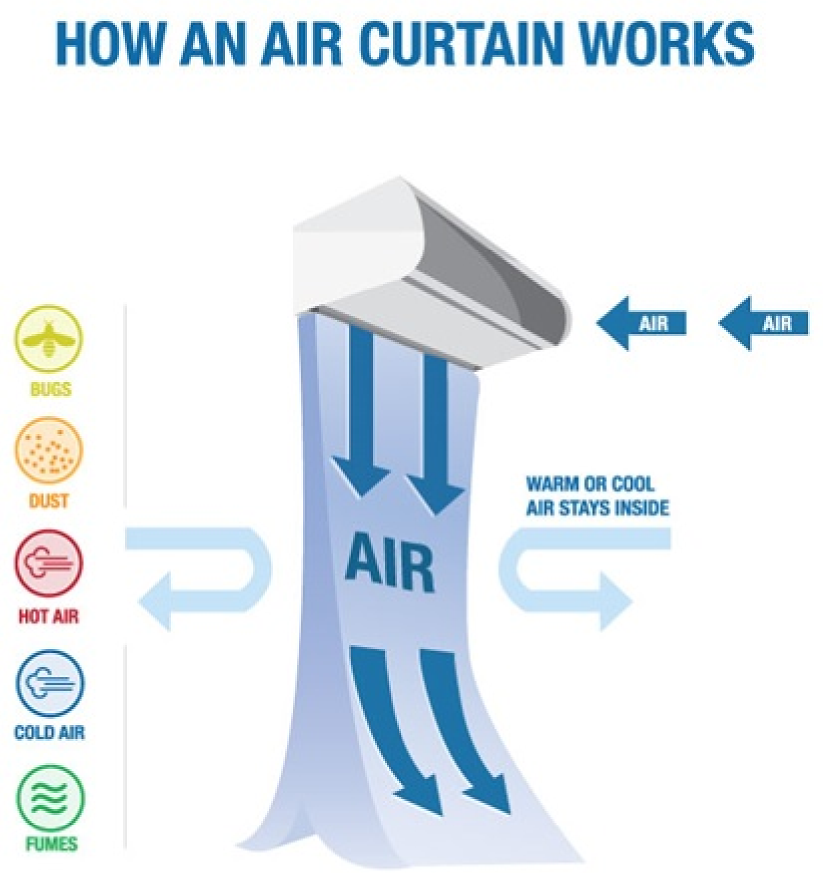
A noncirculating air curtain unit—comprising a fan, plenum, and nozzle system—blows a controlled stream of air across an opening to the other side to create an air seal. This seal separates different environments while allowing a smooth, uninterrupted flow of traffic and unobstructed vision through the opening.

When applied in commercial or industrial settings, air curtains help to contain heated or conditioned air, providing sizable energy savings and increased personal comfort.

Noncirculating Air Curtains

Let's look at how an air curtain works:

- Once activated, air is brought into the unit through the intake where it enters the fan housing and is accelerated by the fan.
- The fan discharges the air into a specialized plenum where it is pressurized, generating high uniform velocity.
- The fast-moving air is released along the full length of the discharge nozzle as an air curtain, also referred to as an "airstream."
- Aerofoil-shaped directional vanes in the nozzle help to create and direct a uniform airstream to the floor with minimal turbulence.
- Approximately 80% of the air returns to the intake side of the air curtain, and 20% goes in the opposite direction.

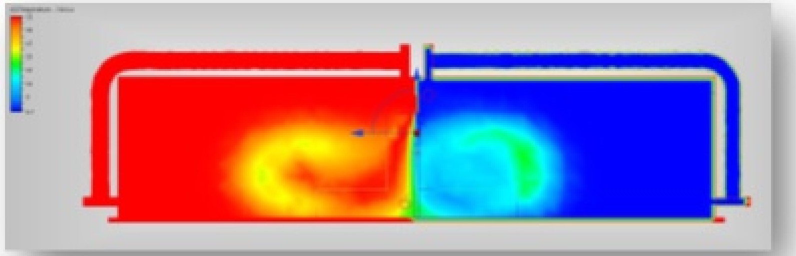


Click on the image to view the video on YouTube (no audio).

Air Curtain Theory

The airstream is the working component of the unit. It serves as a barrier when doors or windows are open, providing three types of protection:

- **Environmental separation**: repels physical elements (dust, insects, etc.)
- **Thermal separation**: reduces thermal mixing of two environments
- **Wind resistance**: minimizes infiltration between two environments

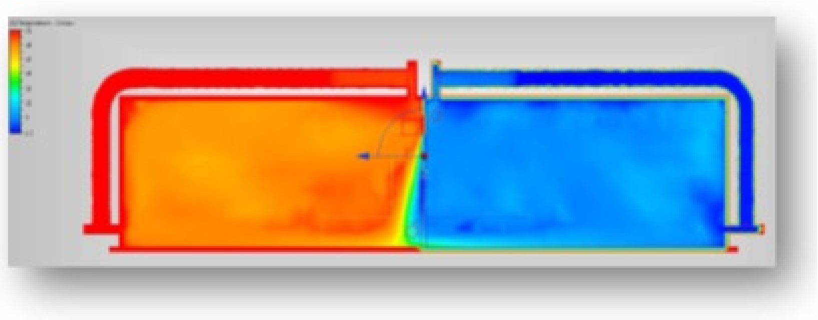


An air curtain operates on the following principles:

- **Velocity vector**: seal and stability
- **Entrainment**: separation and return
- **Building pressure**: working foundation

A review of these principles is presented in subsequent slides.

Air Curtain Theory: Velocity



Velocity refers to the speed the air is moving. The airstream must cross the opening and hit a barrier (floor, wall, etc.) or another airstream with enough velocity to create a split. Typically, the target distance should measure between 2 to 4 meters per second (m/s) or 400 to 800 feet per minute (fpm), depending on the type of application. When the airstream splits along a surface, it creates stability, strength, and direction for the air entrained on each side of the airstream.

Separation is achieved using the combination of:

- a stable airstream
- entrainment, and
- building pressure.

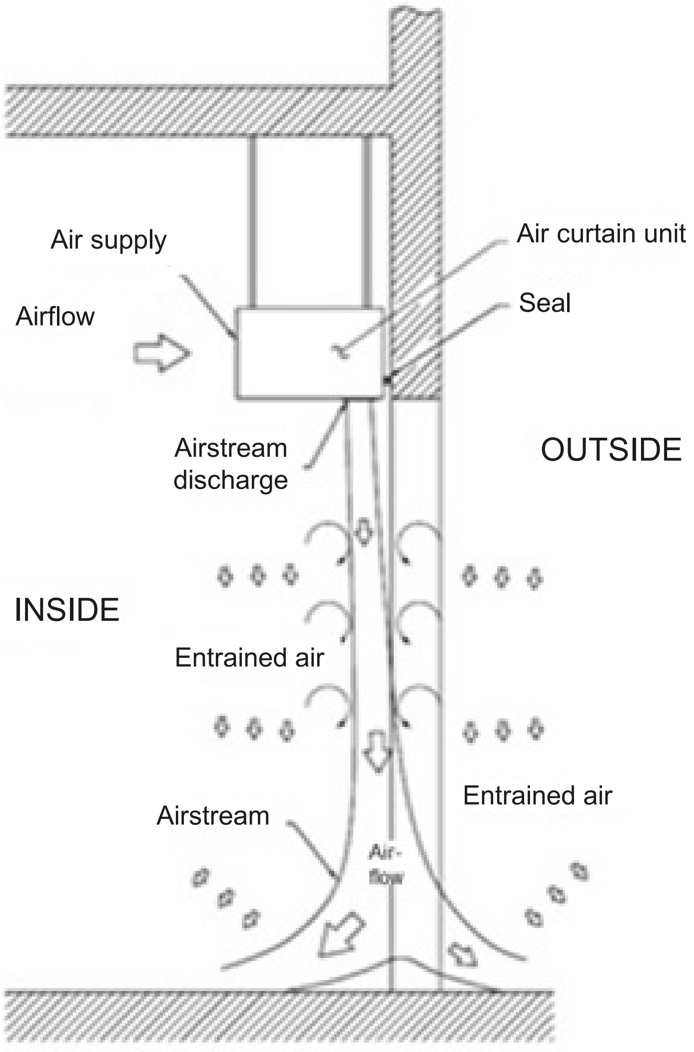
Entrainment & Resistance

Entrainment: The airstream entrains volumes of air on both sides and returns it back to respective areas at the split.

Resistance: The airstream "skins" the building (or room) pressure and resists infiltration, especially from wind.

Low velocities in an air curtain unit will not create a split, negating any energy savings as this results in the mixing of the indoor/outdoor environments at the opening. If the air curtain unit is heated and the velocity is too low to create a split, then while heat is being added to the entrance, it will also be escaping to the outside.

It is possible to create higher velocities at the floor to resist higher winds. However, if the velocity is too high, turbulence is created at the floor, increasing mixing of the interior/exterior environments and greatly reducing the effectiveness of the air curtain unit. In fact, air curtains that are too weak or too strong will result in greater energy losses versus having no air curtain at all.



Nonrecirculating, horizontally mounted, high-velocity air curtain unit

Air Curtain Principles

The fundamental function of an air curtain unit is to generate an airstream. The airstream has four important components that are crucial for effective function: velocity, volume, uniformity, and depth.

- **Velocity** (speed the air is moving) is a function of the nozzle and volume flow rate.
- **Volume** (how much air is moving) is a function of the volume flow rate.
- **Uniformity** (the “evenness” of the thickness of the airstream) is a function of the plenum.
- **Depth** is a function of the volume flow rate and nozzle.

An air curtain is often specified for a particular use; therefore, its airstream design is dependent on its application. Common applications include the following:

- **Environmental control** (the most common): The airstream should be thick enough to entrain the surrounding environment with enough speed to strike the floor and resist wind.
- **Insect control**: The airstream should be thick with a very high velocity to affect the flight path of flying insects.
- **Cold storage**: The airstream should be a thin, high-velocity jet to minimize thermal mixing and entrainment.

Air Curtain Benefits

A properly installed air curtain unit with a correctly sized airstream provides the following benefits:

- Reduces the load on heating and cooling equipment, resulting in energy savings
- Protects thermal comfort of the building occupants, which supports:
  - a positive in-space experience
  - increased customer and employee comfort
  - reduced HR complaints and employee turnover
- Destratifies and mixes room air
- Protects a building's interior environment from windborne dust, contaminants, and fumes
- Increases safety by providing a clear, unobtrusive view through the opening for both people and motorized vehicles
- Provides chemical-free flying insect control

Review Question

Describe how an air curtain unit works to improve energy efficiency.

Answer

Designed to control air transfer between two independent temperature zones, air curtains create a seamless barrier of air across an opening, reducing the amount of air infiltration/exfiltration. They can significantly decrease the load requirements of the HVAC equipment, thereby providing an environmentally efficient method of reducing energy needed to regulate interior temperatures in commercial facilities.

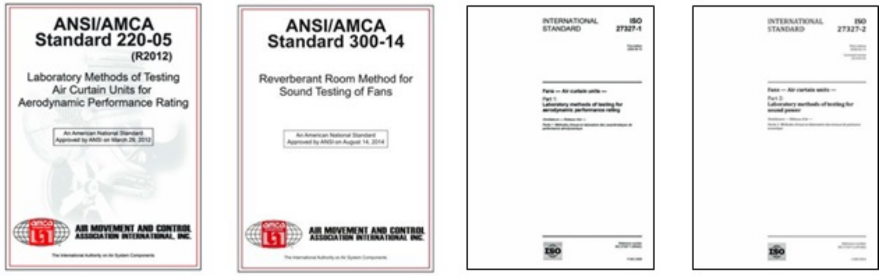
Air Curtain Performance Standards

Air Curtain Performance Standards: Introduction

There are three types of standards associated with air curtain units: performance, health, and safety.

The performance standards, including aerodynamic performance and sound tests, are reviewed in this section of the course.

Health and safety standards covered under UL and NSF International will not be addressed in this presentation.



Aerodynamic Performance Standards

The types of performance data measured in the standards include the following.

Aerodynamic

- ANSI/AMCA 220-05, Laboratory Methods of Testing Air Curtains for Aerodynamic Performance Rating
- ISO-27327-1:2009 Fans - Air curtains - Part 1: Laboratory methods of testing for aerodynamic performance rating
- Air volume: measured on test chamber (AMCA 210/ASHRAE 51)
- Average outlet velocity: calculation of CFM/discharge area (reference only)
- Velocity projection: velocity RMS (root mean square) value of peak velocity across discharge at a specified distance
- Uniformity: standard of deviation of peak velocity across discharge depth of the unit
- Power rating: measured kW of power consumed during air volume test

Sound Performance Standards

Sound

- ANSI/AMCA 300-14, Reverberant Room Method for Sound Testing of Fans
- ISO-27327-2:2014 - Fans - Air curtains - Part 2: Laboratory methods of testing for sound power
- Installation Type A: free inlet, free outlet
- Expressed in octave and one-third bands

AMCA Certified Air Curtains

Note that AMCA tests air curtains for power, air volume, velocity, and uniformity. Under their Certified Rating Program (CRP), AMCA has test standards and rating requirements for testing products consistently and accurately.

Several air curtain manufacturers test their units and publish AMCA-certified performance data. The AMCA seal on a product’s data sheet means that AMCA has independently tested the product and certifies the published performance data for that product is accurate. Building professionals can search for AMCA-certified air curtains on the “Certified Product Search” page. (Accessed Mar. 2021.)

Review Question

Describe the airstream design for each application:

- Environmental control
- Insect control
- Cold storage

Answer

Environmental Control

- The airstream should be thick enough to entrain the surrounding environment with enough speed to strike the floor and resist wind.

Insect Control

- The airstream should be thick with a very high velocity to affect the flight path of flying insects.

Cold Storage

- The airstream should be a thin, high-velocity jet to minimize thermal mixing and entrainment.

Air Curtains & Energy Conservation

Main Entries

Architectural air curtains are often specified by designers for main entries if the space near the open door is conditioned. When the door is open, the air curtain prevents cross contamination of treated air (air-conditioned or heated air) with outside air, decreasing run times of the heating or cooling system.

Effective in the fall of 2019, air curtains tested in accordance with ANSI/AMCA 220 are allowed as an **exception to a vestibule** under ASHRAE 90.1, ASHRAE 189.1, and IECC 2018.

This section of the course begins with a review of the research that supports the ability of air curtains to reduce energy loss from air infiltration through open doors and thus improve whole-building energy performance.

Impact on Whole-Building Energy Use

In the late 1990s, a vestibule requirement was added to ASHRAE 90.1 using a building annualized energy study by Dr. Grenville K. Yuill, a professor of architectural engineering at The Pennsylvania State University.

In a 1996 study, Dr. Yuill calculated discharge coefficient for 15 different configurations of single and vestibule entrance doors. The project produced a series of simplified equations and figures that can be used to estimate infiltration through entrance doors of buildings.

Confusion ensued during the 2000s over the permissiveness of using air curtains, as they were not addressed in the energy codes. Although the energy savings air curtains provide has been thoroughly documented in research since the 1960s, these studies pertained to only single-door applications; nothing existed on the impact on whole-building annualized energy savings.

A 2008 research study titled “Air Curtains: A Proven Alternative to Vestibule Design” confirmed that air curtains provide a better environmental separation and save an amount of energy equal to or slightly more than vestibules.

In 2012, AMCA commissioned Concordia University of Montreal to analyze and validate air curtain performance and compare it to that of vestibules using the same methodology utilized by Dr. Yuill. A review of this study is presented in the following slide.

Initial Study

"Investigation of the Impact of Building Entrance Air Curtain on Whole Building Energy Use" (Wang & Zhong, 2013)

This study was conducted by Liangzhu (Leon) Wang, PhD, Assistant Professor at the Department of Building, Civil and Environmental Engineering of Concordia University, Montreal, Canada. Energy modeling software was used to determine air pressure, infiltration, and annual building energy use and loss in a variety of door configurations in a three-story, U.S. Department of Energy (DOE) reference commercial office building. The door configurations included a single door without vestibule or air curtain, a single door with an air curtain, and a vestibule with two sets of doors.

Results of the study:

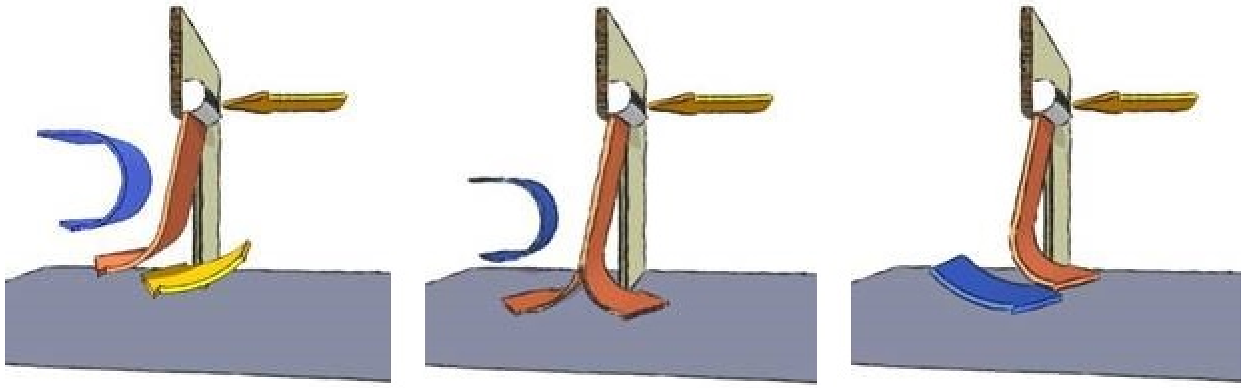
- Analysis of computational fluid dynamics (CFD) software showed the air curtain unit reduced air infiltration significantly across a building entrance door under various pressure conditions.
- The air curtain unit allowed less infiltration than a vestibule and much less than a single door.
- The result was a reduction in total building energy use by a factor of 0.3 to 2.2%.
- The air curtain unit energy savings were equal to or better than energy savings in all climate zones in which ASHRAE 90.1 and IECC required vestibules.

Subsequent Studies

The initial study was primarily numerically based, was conducted for only one building, and did not account for true-to-life applications and configurations.

Therefore, the success of this original study led to three subsequent studies commissioned by AMCA International and completed by Dr. Wang at Concordia University.

These successive studies experimentally validated the numerical analysis and took into account additional building models and the impact of wind and people on the effectiveness of air curtain units.



Studies showing airflow under different conditions

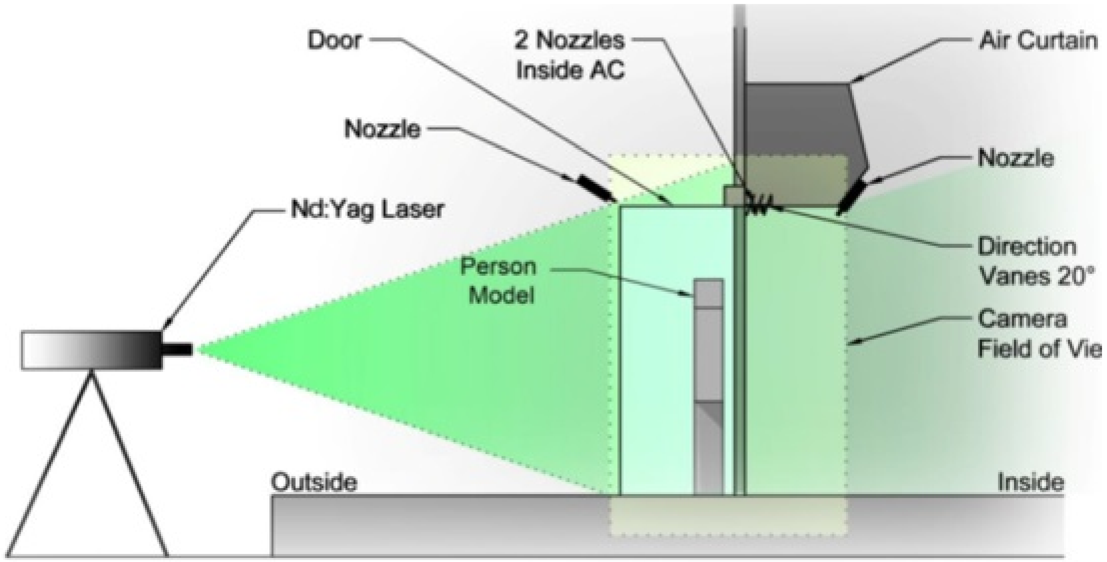
Second Study

"Energy Saving Impact of Air Curtain Doors in Commercial Buildings" (Wang, 2016)

This study added CFD validation and expanded the numerical study and energy simulations to two additional building configurations: a strip mall and an outpatient healthcare facility. It utilized a small-scale test chamber dimensioned to the Yuill vestibule study in order to validate the theoretical modeling results.

Validation of CFD Simulations

A two-dimensional particle image velocimetry (PIV) system with Nd:YAG laser and helium-filled-bubble seeding apparatus was used to visualize the airflow of two vertical planes in a door with an isothermal air curtain.



YAG laser field of view with seeding locations and person model in doorway

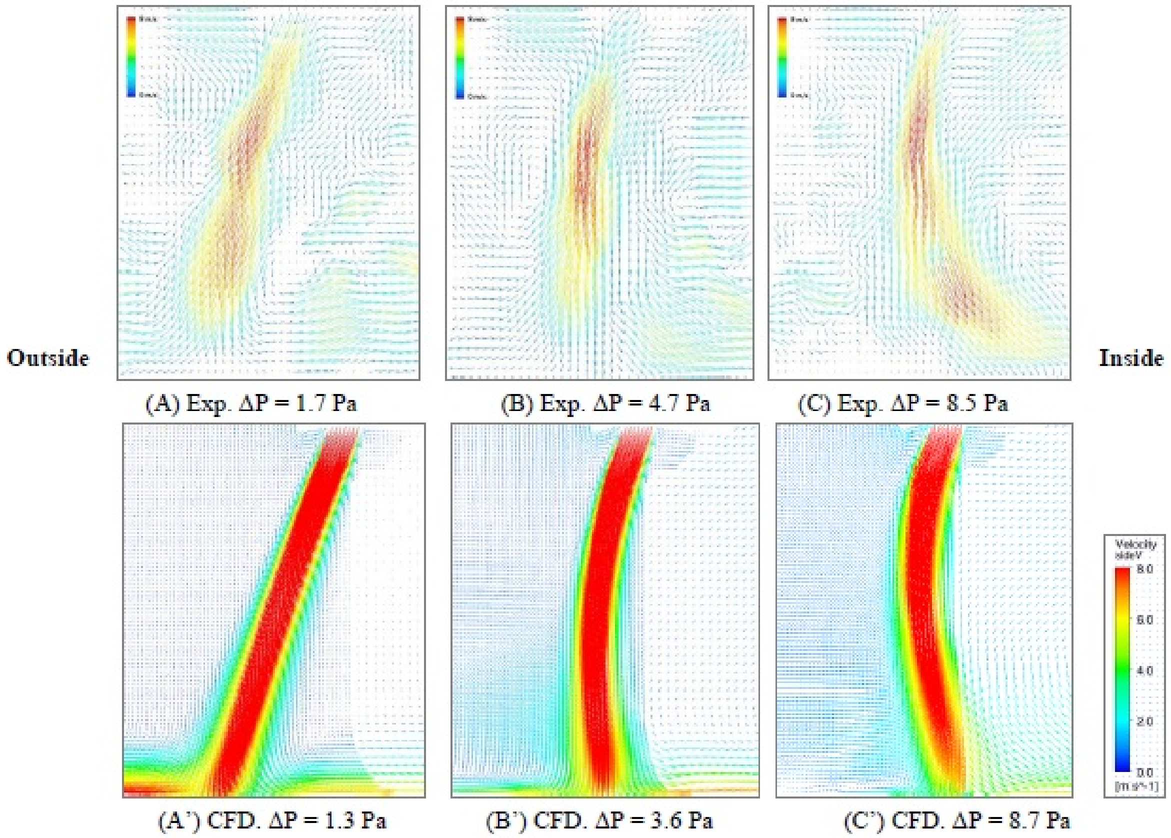
Second Study: CFD Simulation Validation

Results captured by PIV RMS data for airflows confirmed the three airflow conditions found in the previous study:

- Inflow breakthrough
- Outflow breakthrough
- Optimum conditions

Experimental infiltration rates measured through the chamber with an air curtain unit conformed well with the data obtained from numerical CFD simulations within the pressure difference range of -2 Pa to 20 Pa.

Data also confirmed the ability of the models developed in the first study to estimate air curtain performance in the inflow breakthrough and optimum conditions.



Comparison of experimental and CFD simulation flows, 1,791 fpm (9.1 m/s) at 20 degrees outward

Second Study: Methodology Validation

Based on infiltration/pressure measurements and visualized airflow data gathered at the doorway, the air curtain modeling method used in previous numerical studies (Wang & Zhong, 2013) was found to be valid and could accurately capture the performance of air curtain units in regard to air infiltration through double swing doors.

A correlation of the simulated and the experimental data is illustrated here.

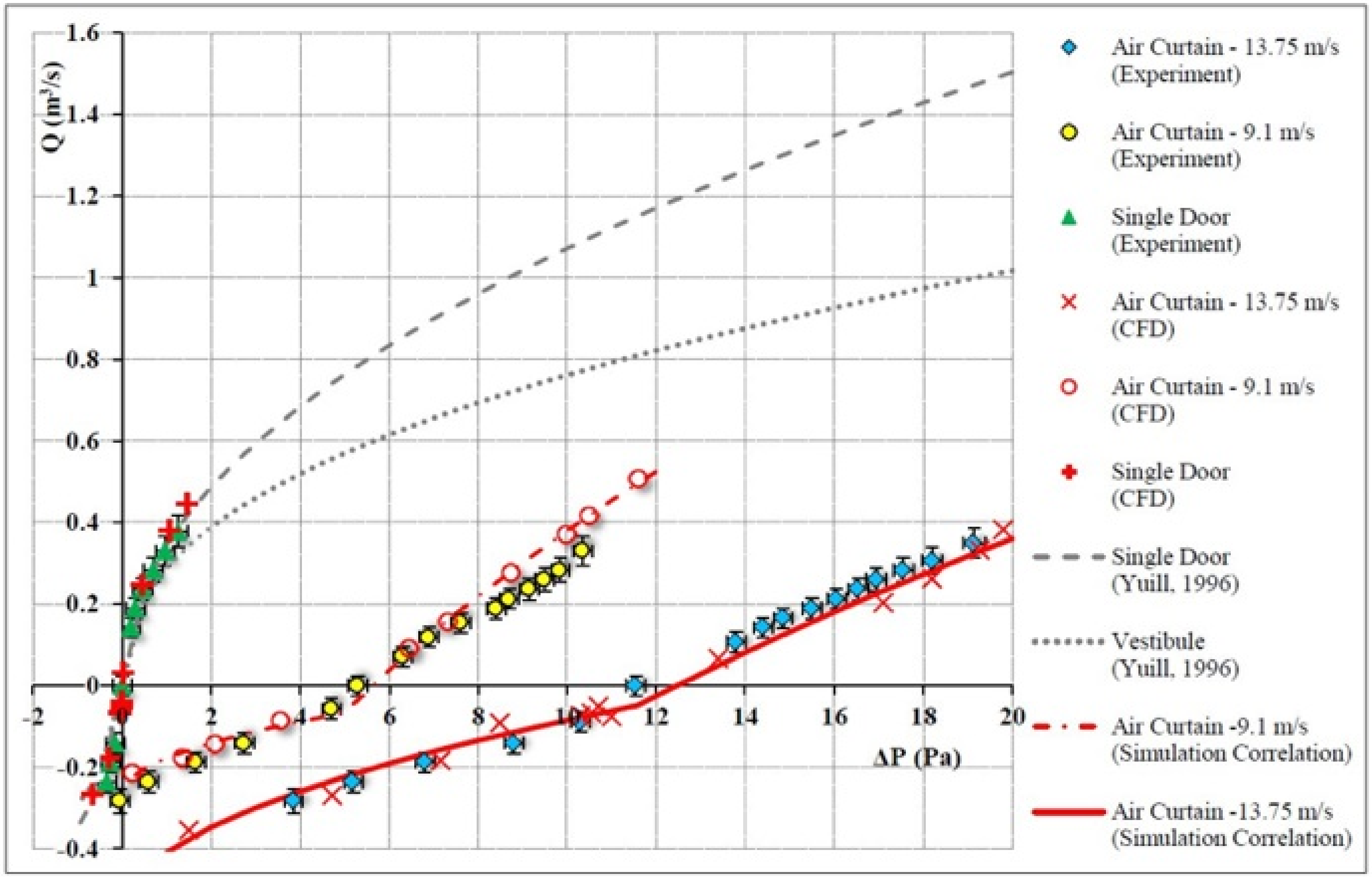


Figure 3. Comparison of experimental and CFD simulation data for air curtain and single door

Third Study

“Wind Effects on Air Curtain Aerodynamics Performance” (Wang & Stathopoulos, March 2018)

The previous study did preliminary investigation of the impact of wind by producing a representative pressure differential across the opening of the large-scale chamber. Although the impact of wind is commonly considered to be significant, prior to 2018, no studies existed on the effect of wind loading.

Consequently, in 2018, a more comprehensive AMCA-commissioned study was completed. A wind generator was built to create a 1,969 fpm (10 m/s) wind field directly in front of a large-scale chamber featuring an air curtain. The constraints of the lab space resulted in a limitation of uniformly distributed wind velocity to only 4 m/s.

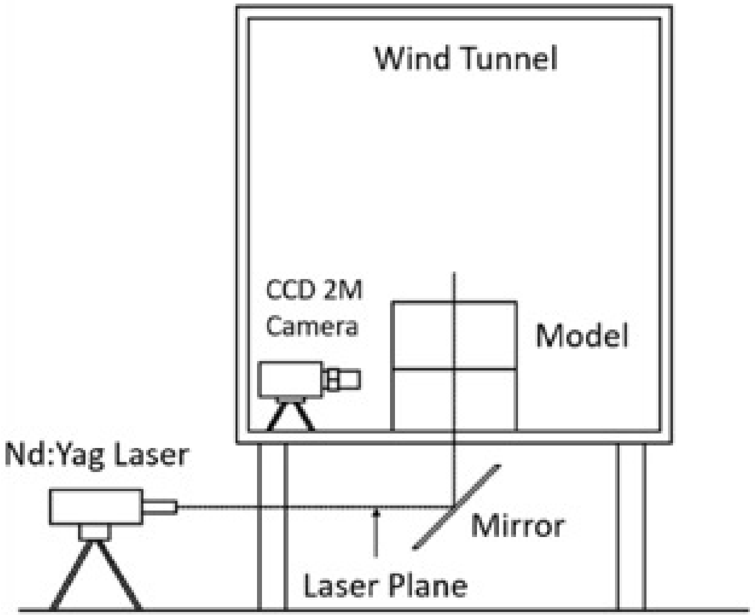
To supplement the wind generator tests, Concordia University’s boundary-layer wind tunnel was used for subscale testing of varying wind directions.

Large-Scale Test Chamber

Third Study

Two series of measurements were taken to evaluate the impact of wind on the performance of the air curtain.

1. Overall performance: variable discharge velocity and infiltration (building pressure) rates with constant wind speed
2. Comparative performance: constant discharge velocity and infiltration with variable wind speed

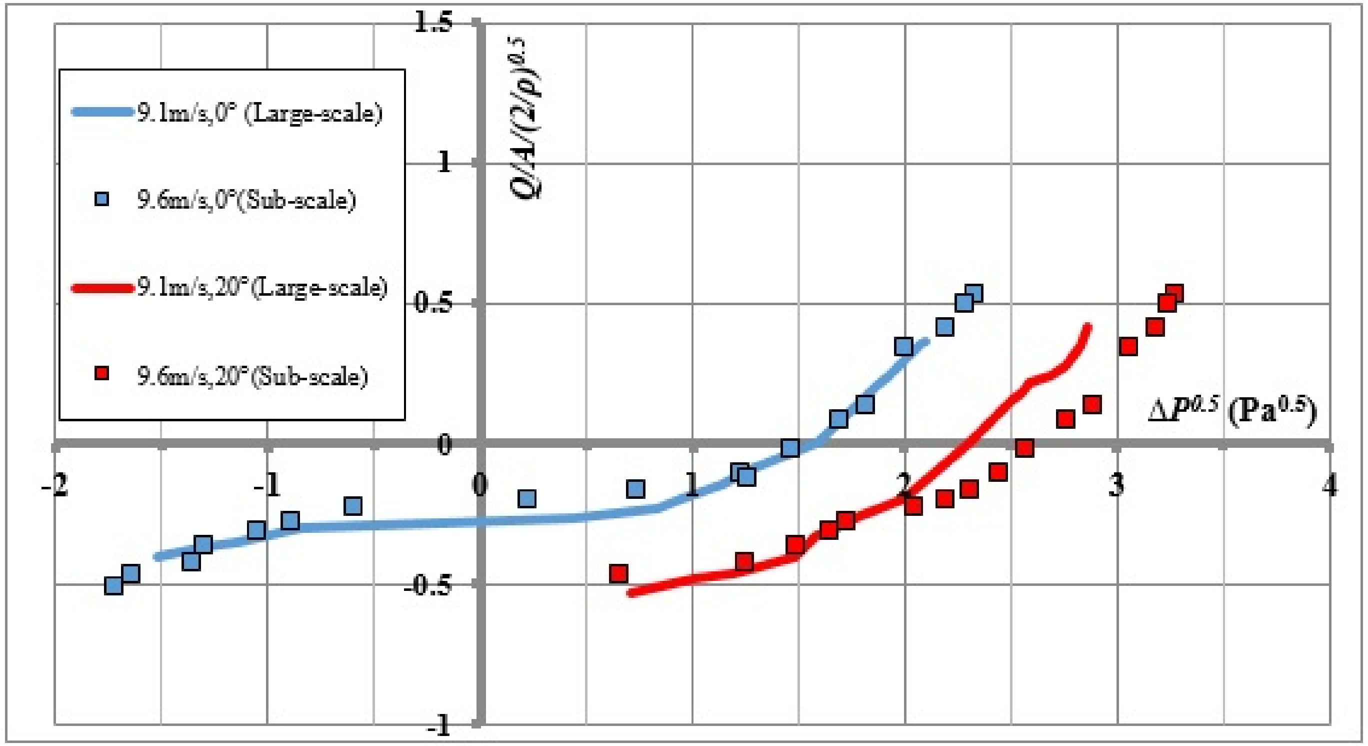


Third Study: Overall Performance

Overall Performance

Shown here, the test mapped the different flow rates versus the corresponding pressure differences across the door. The test results showed minimal impact to air curtain effectiveness until subjected to higher wind speeds, e.g., 3 to 4 m/s (6.71 mph to 8.95 mph). The impacts were minimal when the discharge velocity speeds and angles were set to ensure a good seal of the opening.

The results correlated the subscale model and large-scale chamber results; therefore, single-door and vestibule scaling is allowable.



Comparison of large-scale and subscale chambers

Third Study: Comparative Performance

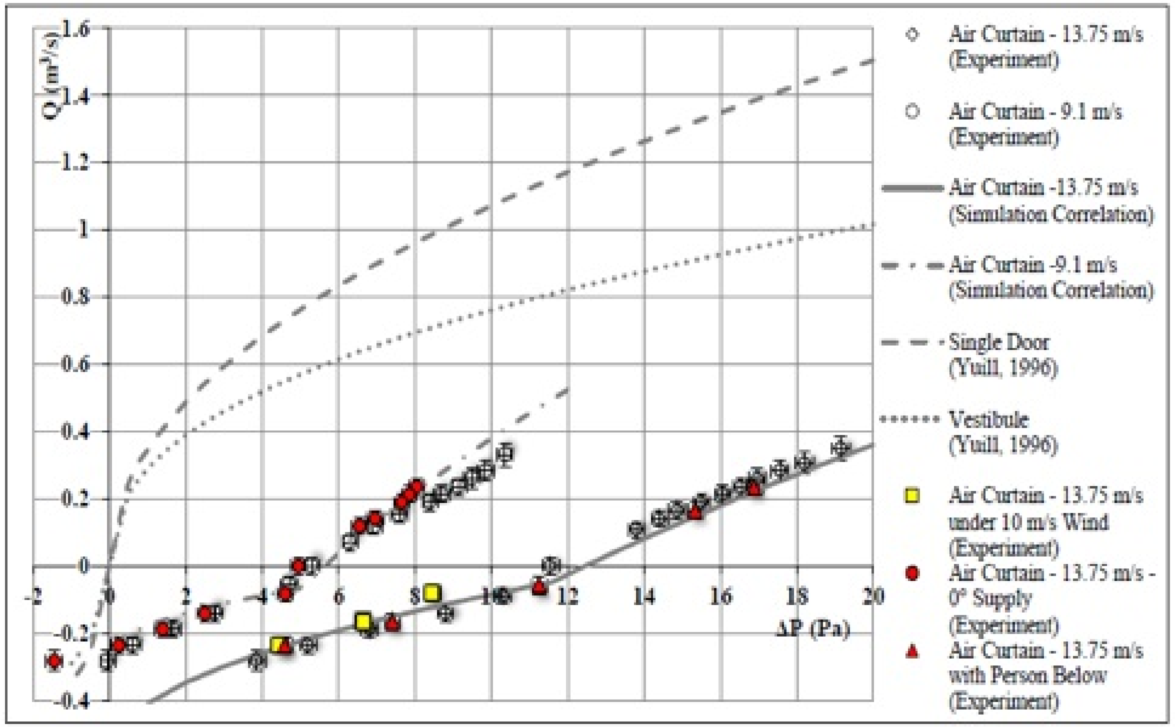


Figure 4. Comparison of measured air curtain performances under the conditions of a.) no wind and 10 m/s wind, b.) 0° and 20° supply jet angles and c.) without person and with a person below the air curtain

Comparative Performance

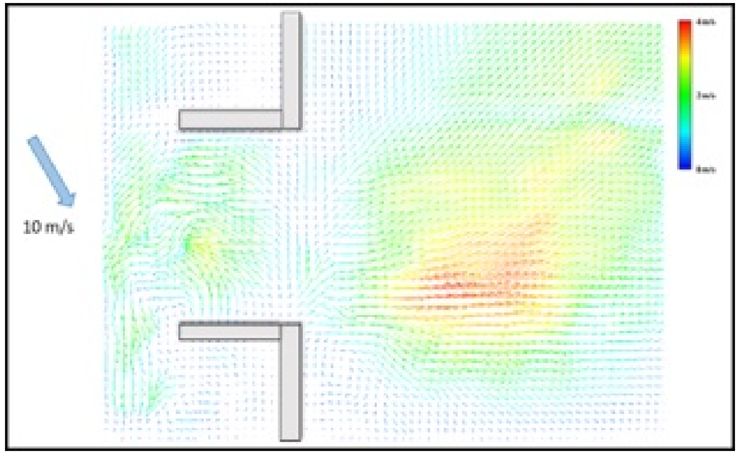
Generally, at high wind speeds (1,969 fpm [10 m/s]) air curtain performance was affected drastically, with infiltration breakthroughs starting earlier and at lower pressure differences than with no wind.

When the air curtain jet reached the floor, it provided a good seal. A mild wind (4 m/s [8.95 mph]) had almost zero impact on performance. The study found the worst wind attack angle to be 0 degrees (parallel to door). Increasing wind angle did not affect air curtain performance until an angle of 90 degrees (perpendicular to door) was reached.

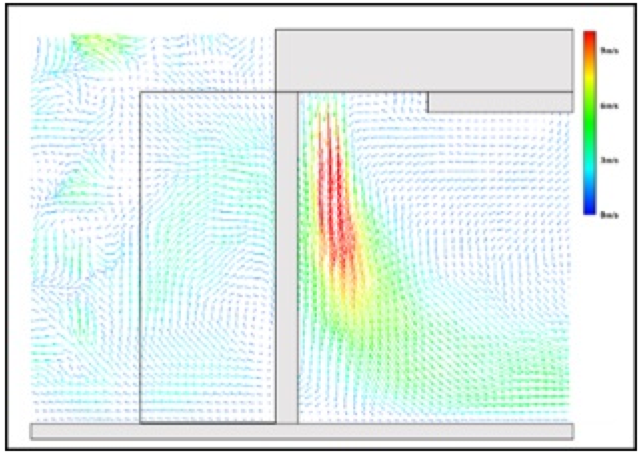
A person under or in front of the doorway improved air curtain performance since airflow is blocked from both directions.

Third Study: Comparative Performance

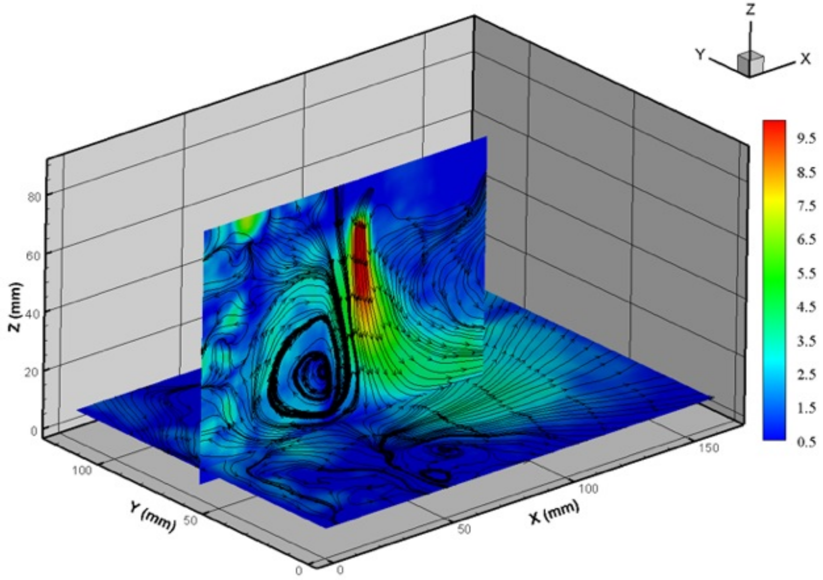
Shown below is an example of the comparative performance results of the two-dimensional numerical analysis and the 3D flow streamlines of PIV results of an air curtain unit with a double swing door.



Wind Direction: Top View



Wind Direction: Side View



Research & Study Results

To summarize the studies reviewed in this section:

- Air curtains with a minimum velocity projection of 400 fpm (2 m/s) at the floor were found to **significantly reduce total annual infiltration** through entrance doors when compared with vestibules and single doors.
- The studies found that in all the climate zones where ANSI/ASHRAE/IES 90.1 and the IECC required vestibules, an **air curtain was equally effective or better at saving energy**.
- Energy study results show a **reduction in total building energy use** by a factor of 0.3 to 2.2%.

ASHRAE Standard 90.1

These research studies have led to the addition of air curtain language in the:

- 2019 ASHRAE Standard 90.1
- 2015 *International Energy Conservation Code* (IECC), and
- 2015 *International Green Construction Code* (IgCC).

Effective in the fall of 2019, the ASHRAE Standard 90.1, "Energy Standard for Buildings Except Low-Rise Residential Buildings," allows AMCA-certified air curtains as exceptions to vestibules. The code provisions require that air curtains:

- be tested in accordance to ANSI/AMCA 220
- be installed according to the manufacturer's instructions, and
- have jet velocity of not less than 6.6 fps (2.0 m/s) at 6.0″ (15 cm) above the floor and direction not less than 20 degrees toward the opening.

Effective Fall of 2019,
***ASHRAE Standard 90.1,* Section 5.4.3.3 Vestibules and Revolving Doors**

Simply States: *Vestibules and revolving doors shall be installed in accordance with this section.*

New list of exceptions include air curtains complying with mandatory provisions of Section 10.4.5

"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 in (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."

NOTE: 2 m/s is equivalent to 400 ft/min

ASHRAE Standard 90.1

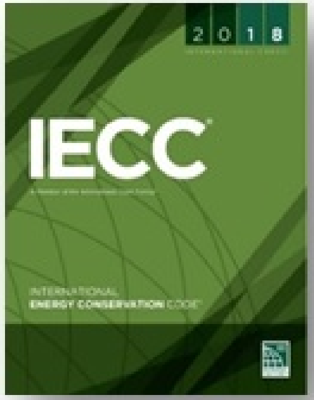
Note that many states and municipalities require ASHRAE 90.1 and/or at least one of the above building energy codes to be followed for commercial buildings. Also, ASHRAE 90.1 must be used to achieve the LEED® Energy & Atmosphere Minimum Energy Performance prerequisite.

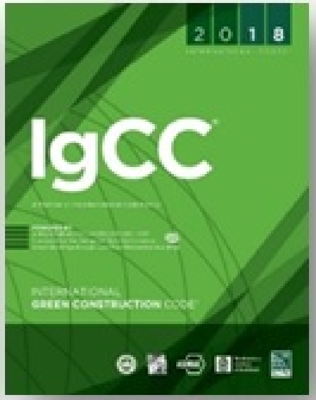
ASHRAE®

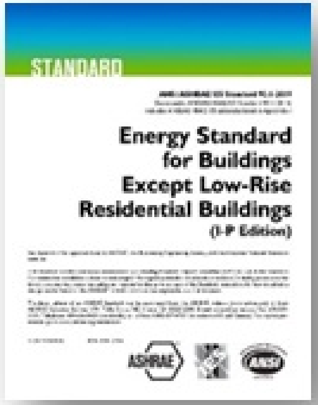
Air Curtain Energy Codes

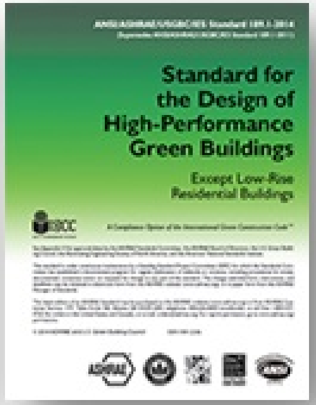
All the following energy codes and standards require 2 m/s (400 fpm) velocity at 6″ above the floor with a heavy emphasis on commissioning:

- **ANSI/ASHRAE/IES Standard 90.1**, Energy Standard for Buildings Except Low-Rise Residential Buildings
- **ANSI/ASHRAE/ICC/USGBC/IES Standard** 189.1-2017, Standard for the Design of High-Performance Green Buildings Except Low-Rise Residential Buildings
- **IECC 2018**, *International Energy Conservation Code*
- **IgCC 2018**, *International Green Construction Code*









Air Curtain Regulation

Shown below are various regulations pertaining to air curtains.

Federal: Department of Energy Fan Regulation

- Air curtains are currently in the exemptions list of the DOE's draft.

State: California Energy Commission Title 24 Energy Code

- Air curtains are currently in the exemptions list of the draft.
- 2022 California Building Energy Efficiency Standards (Title 24, Part 6) is considering air curtains as an alternative to vestibules based on ASHRAE 90.1.

Future Regulation, Codes, and Standards

- Types of ratings: energy or health based?
- Energy-based rating needed that measures effectiveness at resisting infiltration, not converting electrical power to air volume.
- An effectiveness rating would allow regulating and code bodies to establish a performance-based minimal allowable ranking.

Energy Code Compliance

To recap, here are the energy code compliance considerations related to air curtains:

- Codes require a minimum velocity of 2 m/s (400 fpm) at 6″ above the floor
- Requires test data acquired using ANSI/AMCA 220
- AMCA certification: third-party validation and access to velocity data
- Refer to the manufacturer's velocity projection table to determine compliance (see example below)

amca CERTIFIED RATINGS
AIR PERFORMANCE
AIR MOVEMENT AND CONTROL ASSOCIATION, INC.

VELOCITY PROJECTION: MODEL XYZ					
Distance from Nozzle (in)	40	80	120	160	200
Core Velocity (fpm)	1356	1011	978	856	794
Uniformity (%)	91	92	90	86	90

Overview: LEED® Certification

The U.S. Green Building Council (USGBC) developed the LEED (Leadership in Energy and Environmental Design) program. LEED® is the preeminent program for the design, construction, maintenance, and operations of high-performance green buildings.

LEED credit requirements cover the performance of materials in aggregate, not the performance of individual products or brands. Therefore, products that meet the LEED performance criteria can only contribute toward earning points needed for LEED certification; they cannot earn points individually toward LEED certification.

For detailed information about the council, their principles and programs, please visit www.usgbc.org.

LEED® is the preeminent program for the design, construction, maintenance, and operations of high-performance green buildings.

Air Curtains & LEED

The contributions of air curtains are not as easily captured for projects that require commissioning and energy modeling (i.e., new construction and major renovations). This is because commissioning and energy modeling are done with the building's doors and windows closed.

LEED v4 for Building Operations and Maintenance projects are where air curtains can contribute to earning LEED points, as the overall energy performance of the building is measured for a year.

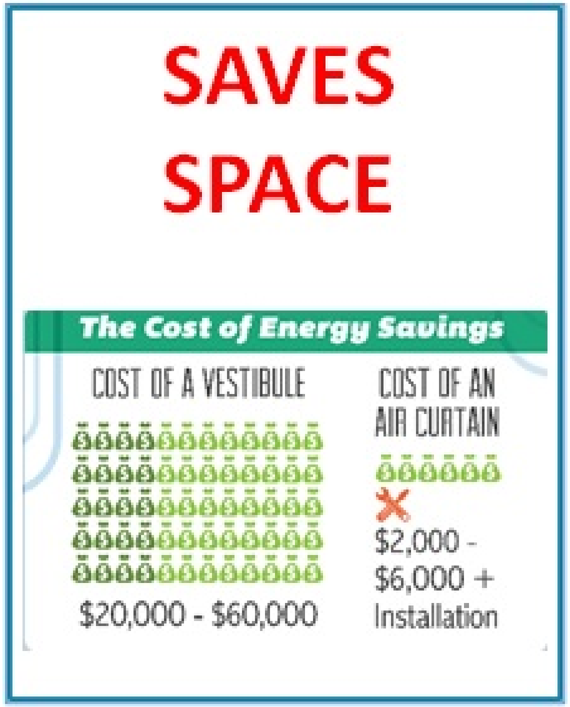
While no single product can earn a point or meet all the prerequisite requirements, air curtains can be part of an overall strategy for lowering energy consumption, protecting occupant comfort, and improving air quality, regardless of the LEED certification a project is aiming for.

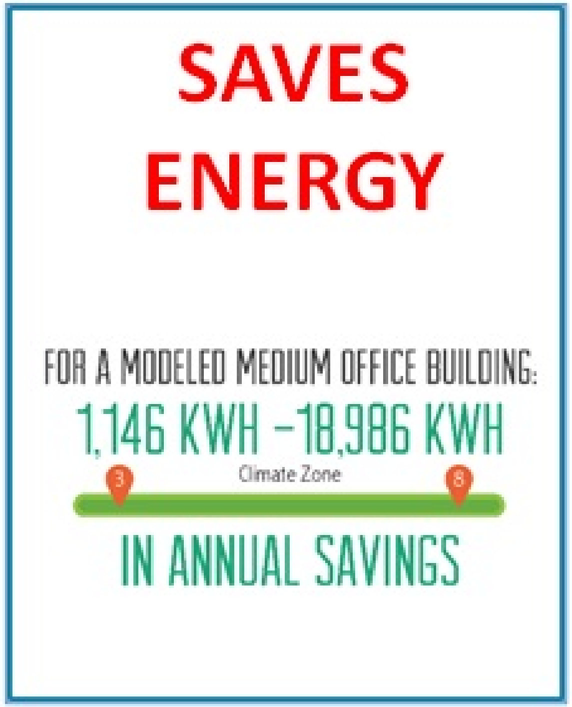
Air Curtains & LEED

LEED v4 for Building Operations and Maintenance Potential Applicable Prerequisite and Credits	Intent
Energy and Atmosphere Prerequisite: Minimum Energy Performance	To reduce the environmental and economic harms of excessive energy use by achieving a minimum level of energy efficiency for the building and its systems
Energy and Atmosphere EA Credit: Optimize Energy Performance	To achieve increasing levels of energy performance beyond the prerequisite standard to reduce environmental and economic harms associated with excessive energy use
Indoor Environmental Quality EQ Credit: Thermal Comfort	To promote occupants' productivity, comfort, and well-being by providing quality thermal comfort
Innovation IN Credit: Innovation	To encourage projects to achieve exceptional or innovative performance

Air Curtain: Vestibule Alternative

When contrasting the efficiency of air curtains versus vestibules, air curtains offer both first cost and operational savings, along with improved thermal comfort for the building occupants.





ROI Calculators & Selection Tools

Building professionals have a range of tools and resources at their disposal to aid in the specification process of an air curtain solution.

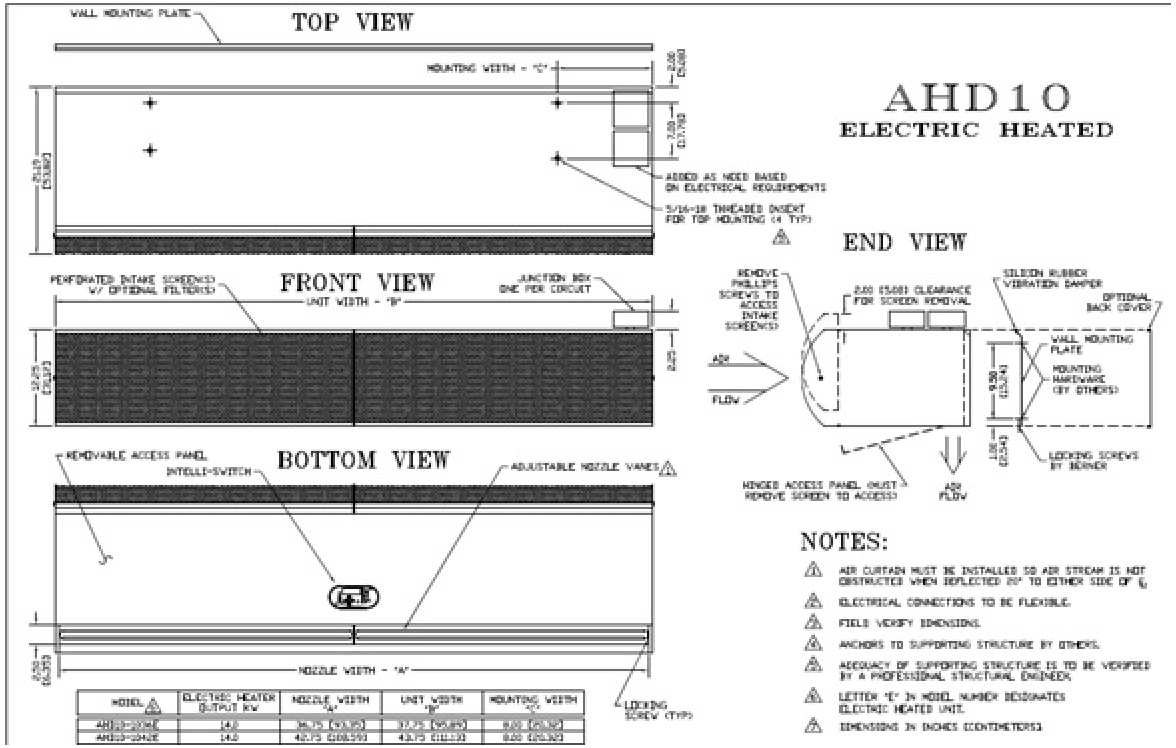
ROI (return on investment) calculator: Typically available from manufacturers, an ROI calculator can estimate the energy savings and payback periods of different types of air curtains.

Selection tools: Many manufacturer and engineering tools are available to use when designing an air curtain system:

- Air curtain selection guides (print and online) provide guidance on the options most appropriate for the application.
- Product catalogs (print and online) including data sheets offer performance information and power supply options.
- Submittals and Construction Specifications Institute (CSI) specifications assist architects and engineers in writing air curtain specifications.
- CAD (computer-aided design) and computer-aided design and drafting (CADD) technology proffers design and technical documentation (replaces manual drafting).
- Revit® is a software system that works with building information modeling (BIM) and provides detailed 3D models that can be inserted into the project design drawings.

Selection Tools

While selection tools exist, it is recommended to consult and verify with the manufacturer and/or their trained representative that the air curtain selection—including the power supply, controls, and mounting design—is the best option for the application.



Nozzle Width (in)	Max Vel. at Nozzle (fpm)	Avg. Outlet Vel. (fpm)	Air Volume (cfm)	Outlet Vel. Uniformity	Power Rating (kW)	Motor(s) @ hp
36.75	6,611	2,171	1,385	86%	0.52	1 @ ½
42.75	7,591	1,948	1,446	75%	0.55	1 @ ½
48.75	6,700	1,772	1,500	54%	0.55	1 @ ½
60.75	6,907	2,106	2,221	59%	0.86	2 @ ½
74.50	6,611	2,142	2,770	86%	1.04	2 @ ½
86.50	7,591	1,926	2,892	75%	1.10	2 @ ½
98.50	6,700	1,754	3,000	54%	1.10	2 @ ½
112.25	6,611	2,132	4,155	86%	1.56	3 @ ½
118.25	6,611	2,054	4,216	75%	1.59	3 @ ½

Case Study: Fork 'n' Pint Restaurant, Lake Orion, Michigan

Air curtains protect both kitchen and dining environments when the doors are open. They can help maintain a more comfortable and quality environment that keeps outside temperatures, odors, and flying insects out, improving food safety while reducing energy costs.

Problem: The customers and employees of this restaurant complained they were often uncomfortable due to the cold Michigan winter weather infiltrating the space every time the front door opened, especially during peak times. As a result, no one wanted to sit near the door. Additionally, the loss of valuable heating energy led to high energy bills.

Solution: A low-profile air curtain (suitable for mounting heights to 8′) was installed over the main entrance to help maintain a comfortable interior.

Outcome: This solution resulted in annual energy savings of $500+ and happy customers and employees. It also eliminated the need for a $15,000+ vestibule construction.

Case Study: Charleston Fun Park, Charleston, South Carolina

Problem: The indoor facilities of this amusement park in South Carolina had high air conditioning energy bills and uncomfortable indoor temperatures due to the high foot traffic that travelled through the entrance doors during the hot, humid summers.

Solution: Four low-profile air curtains were installed over each customer entrance that were far less expensive to install than a vestibule.

Outcome: The air curtain solution improved indoor air comfort for the park patrons and helped increase sales 20% in the first year. The air curtains provide continuous protection of the air-conditioned space when the doors are open, which during high traffic times is nonstop. Furthermore, the park cut their annual utility bills by $20,000 by installing air curtains over the park's entrances.

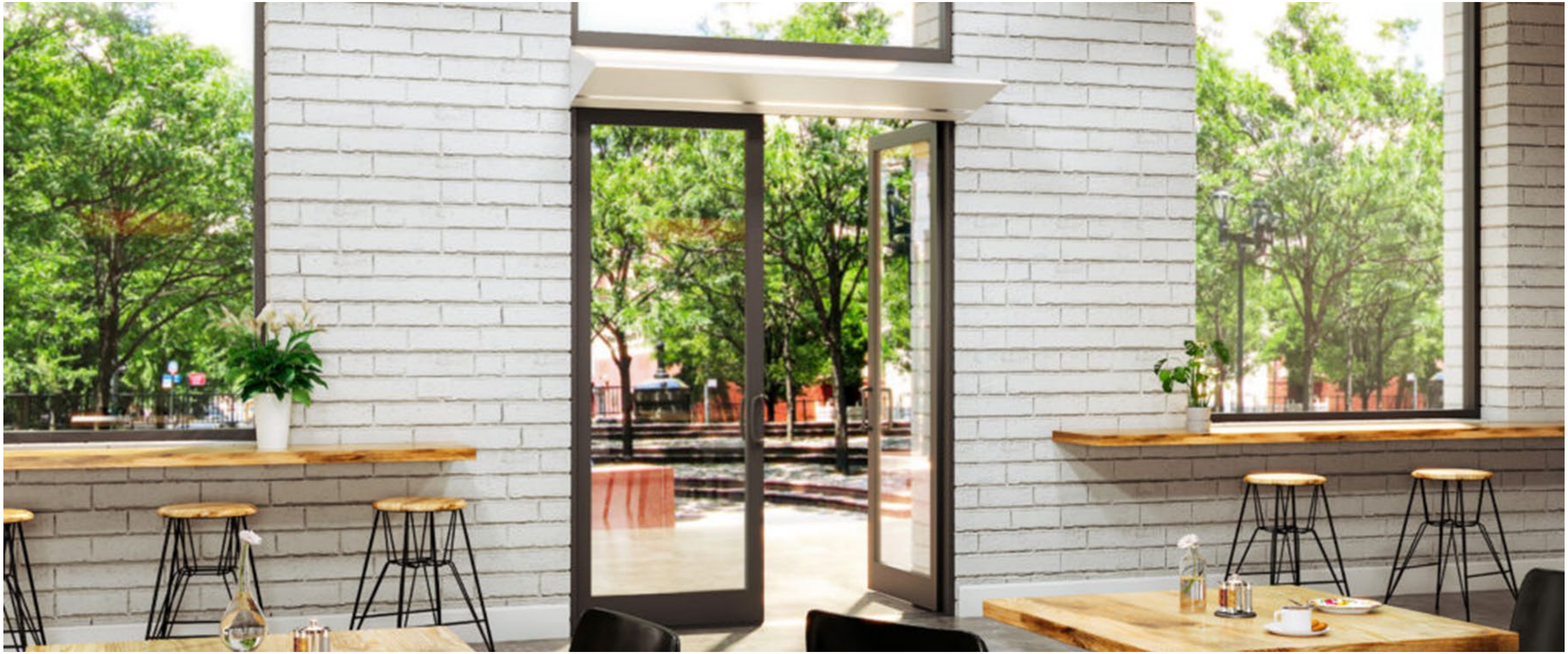
Case Study: Hearth Pizzeria, Needham, Massachusetts

Problem: The extreme winter temperatures caused the area by the entrance of this pizzeria to be too cold to seat patrons and for employees to be comfortable.

Solution: An air curtain (suitable for mounting height up to 10′) was installed over the main entrance.

Outcome: The air curtain reduced costly heating/cooling losses through the doorway while allowing natural, unobstructed sunlight into the store front. It made the entire restaurant floor space comfortable and usable during the chilly winter months, negating the need for an expensive vestibule that would reduce usable space for customers. Temperature complaints from the staff and customers are now a thing of the past.

Air Curtains & Public Health



Air Curtains & Public Health: Introduction

Having a safe, comfortable space with well-circulated air is not a luxury; it is a necessity. An air curtain can help to create a safe environment needed to keep the building occupants healthy.

In this section of the course, we explore how air curtains can support a safe indoor environment, good indoor air quality, and thermal comfort.

Open Doors / Closed Doors

When the door is **open**, air curtains:

- maintain thermal comfort and protect against humidity
- reduce entry of health hazards (carbon monoxide, tobacco smoke, vehicle exhaust, and other pollutants), and
- provide chemical-free flying insect control.

When the door is **open** or **closed**, air curtains:

- destratify room air
- reduce airflow “dead zones”
- aid fresh air distribution from the air handler, and
- reduce energy loss.

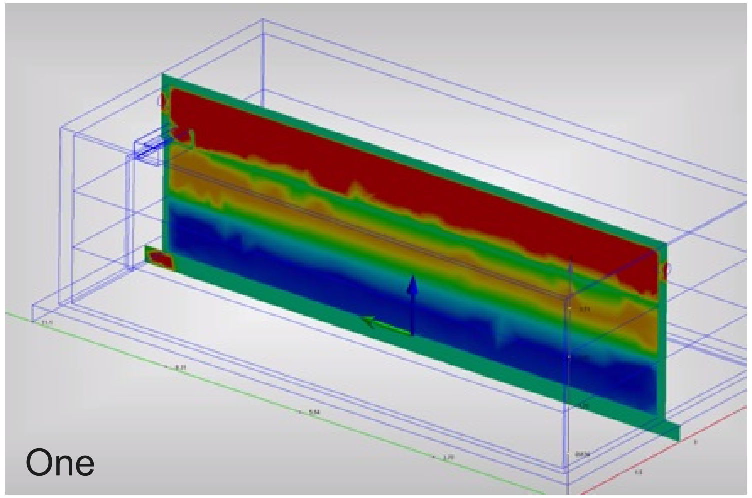
Destratification & Dead Zones

As a result of their functions, air curtains support good indoor air quality (IAQ):

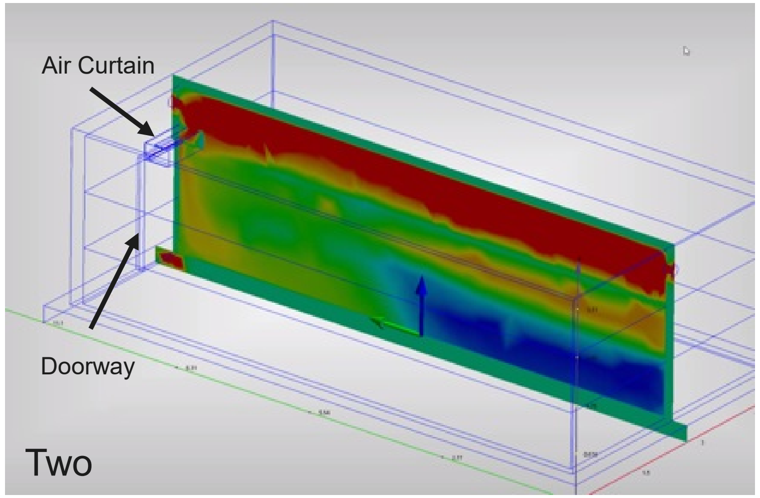
- Mix room air and reduce buildup of thermal layers
- Help to remove airflow dead zones
- Reduce “hot” and “cold” spots in the space to maintain comfortable temperatures
- Reduce overall energy consumption

Destratification & Dead Zones

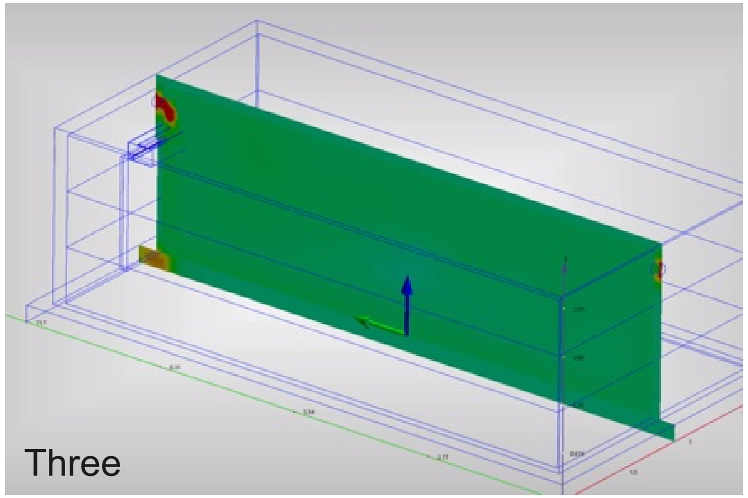
The illustrations below show a cut plane of a CFD 3D modeling of how the air curtain mixes the air in the space. In this example, the door is closed.



Colder air along floor; warmer air along ceiling



Air curtain activates, drawing in warm ceiling air and sending it across the floor



Room air is mixed

Air Curtains & Air Purification: HEPA Filters

Next, we look at the relationship between air curtains and air purification technologies, beginning with high-efficiency particulate air (HEPA) filters.

A HEPA filter is a type of mechanical air filter that works by forcing air through a fine mesh designed to trap harmful particles (pollen, pet dander, dust mites, etc.) as small as 0.3 microns. HEPA filters require a low face velocity in order to properly work. In other words, the air needs to move slowly through the filter in order for the filter to capture the particles. The slower the air passes, the more effective the HEPA filter is at capturing particles. If the air is moving too quickly, it will pull particles through the filter as opposed to removing them.

A HEPA filter creates a lot of static pressure, resulting in minimal performance of an air curtain. However, research into translating residential HEPA filter system technology to air curtains looks promising.

Air Curtains & Air Purification

Due to their placement over entrances combined with their ability to mix the room air, air curtains are uniquely positioned to incorporate air purification technologies into their systems.

Two popular technologies that allow air curtains to operate as air curtains while also helping to kill germs and mold spores in the air are:

1. ultraviolet-C (UV-C) light, and
2. needlepoint bipolar ionization (NPBI®).

These air purification technologies support safe indoor environments and complement other best practices in preventing the transmission of pathogens, such as increased ventilation, the use of face masks, social distancing, hand hygiene, cough etiquette, and surface cleaning.

Air Curtains & Air Purification: UV-C Light

UV-C light provides passive disinfection of the air.

One type of UV-C light is GUV or UVGI. According to the Centers for Disease Control and Prevention, “Germicidal Ultraviolet (GUV), or Ultraviolet Germicidal Irradiation (UVGI), is a disinfection tool used in many different settings, such as residential, commercial, educational, and healthcare. The technology uses ultraviolet (UV) energy to inactivate (kill) microorganisms, including viruses, when designed and installed correctly.”

The speed with which the air flows past UVGI light inside a nonrecirculating air curtain is too fast to provide the dosage required for the ultraviolet light to properly kill germs and thus requires multiple passes.

However, using upper room distribution of UVGI light at safe, low-intensity levels allows slow-moving air outside of the air curtain to be treated before it is drawn into the air curtain, decreasing the number of passes required. It is when the air is pulled through the air curtain that the air velocity increases significantly.

Air Curtains & Air Purification: NPBI

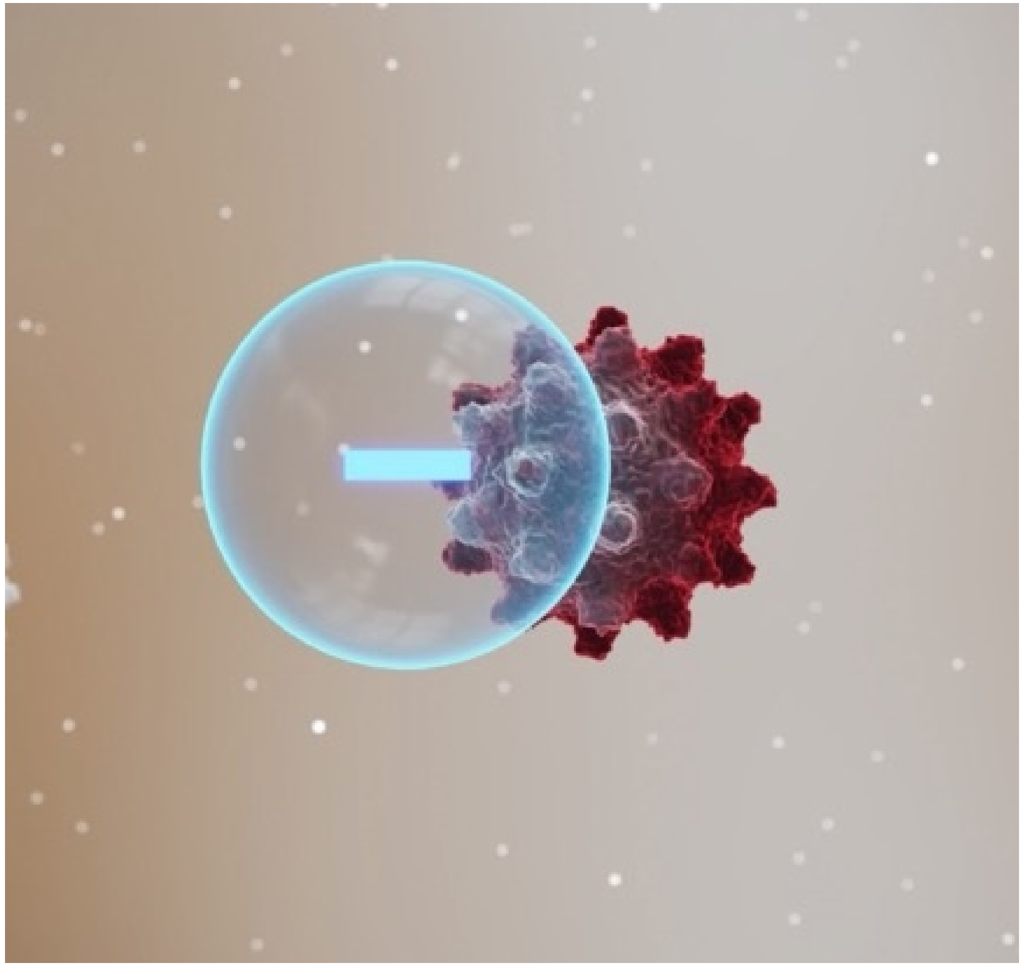
Also known as cold plasma, NPBI technology uses a low voltage to ionize air molecules, preventing the formation of ozone. The positively charged ions preclude a charge from building up in the space.

By stripping the hydrogen required for survival from pathogens, the negatively charged ions:

- deactivate/kill viruses and germs
- kill mold spores and bacteria, and
- neutralize odors and VOCs.

NPBI causes particle agglomeration, where airborne particles, such as dust and pollen, begin to cluster together, making it easier to capture the particles in a filtration system.

NPBI is a known technology used by hospitals, schools, military bases, and more.



Air Curtains & Air Purification: NPBI

Through third-party pathogen testing and research, NPBI has proven to reduce airborne pathogens.

- SARS virus reduced by 73.4%
- H1N1 human influenza virus reduced by 99.7%
- Mold spore kill rate of 99.5% over 24 hours

NPBI is UL 867 and UL 2998 validated as an ozone and by-products-free technology.

Air Curtain Systems with NPBI Air Purification: Advantages

When combined with an air curtain system, needlepoint bipolar ionization provides **active** pathogen disinfection of the space to quickly and continuously clean the air—not just what passes through the air curtain, but the space around the entrance, as well.

When a door is opened, an airstream filled with carcinogen-free ionized air molecules disinfects and purifies the air. When the door closes, it is recommended to continue operation of the air curtain to keep cycling ions out into the space.

Advantages include these:

- High velocity of distribution
- High ion density within the space
- A more uniform and continuous distribution of ions
- Stratified layers of air eliminated, and air circulation increased

Review Question

Explain how air curtains support good indoor air quality.

Answer

Air curtains support good indoor air quality (IAQ) by:

- aiding in fresh air distribution from the air handler
- mixing room air and reducing buildup of thermal layers
- helping to remove airflow dead zones, and
- reducing “hot” and “cold” spots in the space to maintain comfortable temperatures.

Air Curtain Systems with NPBI Air Purification: Applications

Air curtains with air purification systems are an ideal solution to assist with the disinfection of the air for the following applications:

- Lobbies and waiting rooms
- Dining areas
- Reception areas
- Gyms
- Salons
- Boutiques and more

Chemical-Free Flying Insect Control

Air curtains support integrated pest management (IPM) programs and are an ideal solution to the ongoing requests for fewer chemicals and more environmentally sensitive methods of controlling flying insects in occupied spaces.

Both the Food and Drug Administration (FDA) and the U.S. Department of Agriculture (USDA) recommend air curtains as a method to protect openings of food service and preparation establishments against the entry of flying insects.

The high velocity of the airstream creates conditions that make it difficult, if not impossible, for flying insects to pass through the opening.

Chemical-Free Flying Insect Control: Kitchen Delivery Entrances

While not considered a “main entrance,” restaurant kitchen delivery entrances are often required by local health codes to use air curtains that have been tested to NSF 37 to help protect these entrances from flying insect infiltration.

NSF 37 Requirements:

- Service Entry: Requires velocity of 8.15 m/s (1,600 fpm) at 0.9 m (3 ft) above floor over a grid 75 mm (3 in) deep.
- Service Window: Requires velocity of 3.05 m/s (600 fpm), one-third the distance of the vertical opening above a service window countertop.

People, Planet, Profit: Sustainability Goals

In conclusion, air curtains used over main entrances contribute to the in-space experience and support sustainability goals around energy conservation, public health, and indoor air quality.

- **People**: contribute to comfort, IAQ, and good health
- **Planet**: provide energy conservation and chemical-free insect control
- **Profit**: provide energy savings and increased customer satisfaction and employee productivity

Summary

Key Takeaways

- Main entrance air curtains are used by architects and engineers to improve energy efficiency and protect occupant comfort, the in-space experience, and well-being.
- Effective fall of 2019, air curtains tested in accordance with ANSI/AMCA 220 are allowed as an exception to a vestibule under ASHRAE 90.1, ASHRAE 189.1, and IECC 2018.
- When contrasting the efficiency of air curtains versus vestibules, air curtains offer both first cost and operational savings, along with improved thermal comfort for the building occupants.
- A noncirculating air curtain unit blows a controlled stream of air across an opening to the other side to create an air seal. The high-velocity airstream works by entraining air into a barrier to counteract thermal exchange and wind loading.
- A properly installed air curtain unit provides the following benefits:
  - Reduces the load on heating and cooling equipment, resulting in energy savings
  - Protects thermal comfort of the building occupants
  - Destratifies and mixes room air
  - Provides chemical-free flying insect control
  - Protects a building's interior environment from windborne dust, contaminants, and fumes
  - Increases safety by providing a clear, unobtrusive view through the opening
- When combined with an air curtain system, needlepoint bipolar ionization (NPBI) provides active pathogen disinfection of the space to quickly and continuously clean the air.

Resources & References

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Conclusion