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Comparing Vestibule and Air Curtain Selection for Commercial Buildings

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INTRODUCTION

Determine the Best Entrance Solution for Your Space

Dialectic would like to provide retail and commercial building owners and designers a tool to help determine their need for either a vestibule or an air curtain entrance solution for their space. Building spaces vary by the type of business, but when code dictates that a vestibule is required due to its area, users need to be aware of their options. When we meet with clients to determine their needs, they typically ask questions such as: Should we install a vestibule or an air curtain? Will this discourage our customers from entering the space? How can we make it better? Vestibules and air curtains each have their positive attributes and having a designer that understands how to maximize the benefit of each will make for a better installation and user experience regardless of which option is chosen.

During the design phase of a space, the floor area comes into question as well as its impact to the design and function. Commercial building designers are required to install vestibules on the primary entrance doors leading to spaces that are equal to or greater than 3,000 square feet (ft^2), or 298 square meters (m^2), in all buildings. Many designers are unclear on what is included in determining the 3,000 ft^2 floor area that defines a space. Consider this example: does an entrance door leading from a lobby attached to a corridor with a total area of 3,000 ft^2 meet the vestibule requirement? When several doors leave a space greater than or equal to 3,000 ft^2, which doors require a vestibule?

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The International Energy Conservation Code (IECC), with multiple code years adopted by different states, requires that the primary entrance doors in spaces 3,000 ft² or greater have vestibules. This requirement typically applies to commercial spaces where the building entrance is connecting directly into the sales area or other occupancies with large lobbies, like a hotel or entertainment venue. We will cover spaces including commercial workplaces, stand-alone and strip-mall retail, schools, restaurants, outpatient health care facilities, hotels and multifamily housing. We will avoid in-depth analysis of each type but will list the requirements that are applicable to each occupancy type.

The American Society of Heating, Refrigeration and Air-conditioning Engineers (ASHRAE) established a US standard that provides minimum requirements for energy efficient designs for commercial buildings with ASHRAE Standard 90.1 (Energy Standard for Buildings Except Low-Rise Residential Buildings). New versions are updated and published every three years with the current version being ASHRAE Standard 90.1-2016. The IECC requirements are based on this standard. This standard requires vestibules for entrance doors accessing spaces 3,000 ft² or greater, but with some added requirements not present in the IECC. The first requirement is associated with vestibule envelope requirements. ASHRAE requires that the exterior envelope of a conditioned vestibule comply with the requirements for a conditioned space, while the interior and exterior of an unconditioned vestibule must comply with the envelope requirements for a semi-heated space. ASHRAE 90.1 also requires a minimum distance of 7 feet between closed interior and exterior vestibule doors. The differences between IECC and ASHRAE 90.1 are listed in the Code Citations section of this document.

Vestibule example

Photo: Dialectic

Air curtain example

Photo: Dialectic

What is a vestibule?

A **vestibule** is an anteroom (antechamber) or small foyer leading into a larger space, such as a lobby, entrance hall, or passage, for purposes like waiting, withholding the larger space view and reducing heat loss. In modern architecture, a vestibule typically refers to a small room with an outer door(s) and connected with the interior of the building. Architects and architectural designers employed by the building owner typically design vestibules.

A basic vestibule design consists of an outer glass door, an inner glass door, inset floor mats, and sometimes a waiting bench. This seems easy enough to design, but when vestibules are poorly designed issues can arise that are often related to thermal complaints (such as cold air reaching the reception desk or sales space), a lack of distance between doors, and timing between automatic outer doors closing and automatic inner doors opening. A good design requires understanding the function of the space and the habits of the customers and other users of that space.

Where does a vestibule apply?

Public entrances and high-traffic entrances are the intended doors where vestibules need to be included as part of the building design. Service doors or doors not used by the public are not the intended area for vestibules. Consider an example building with an entry space connected to corridors with a combined total area of 3,000 ft². 2,700 ft² for the entry space and 300 ft² for the connected corridors; only those areas that cannot be closed off from the entrance door are to be included in the area total when determining if a vestibule is required.

An example of an interior vestibule

Photo: B.J. Glass

An example of an exterior vestibule

What is an air curtain?

An **air curtain** is a fan-powered device that creates an invisible air barrier (sheet of air) over the doorway to separate two different environments without limiting the access of people or vehicles. This sheet of air stabilizes when it splits at a surface, such as a floor, or meets a return grille. This stable sheet of air combined with the building's interior air pressure resists and reduces heat transfer over an opening in the building envelope. There are two major types of air curtains: non-recirculating (most common) and recirculating. They can be directly mounted on the wall or ceiling, exposed to view, or installed recessed into the ceiling, hidden from view (in-ceiling type). Heating, ventilation, and air conditioning (HVAC) mechanical engineers and mechanical designers typically select and design the air curtain systems employed by the building owner.

Non-recirculating air curtains

Non-recirculating air curtains are more widely used than the recirculating type because they are easier and less expensive to install and have lower maintenance costs. The height, width, and physical characteristics of the opening will indicate if the air curtain can be mounted horizontally above the door or vertically on one or both sides of the door. A horizontal mounting above the door minimizes the chances of damaging the air curtain. Use caution when mounting a unit vertically as it is accessible to the public and can be easily damaged.

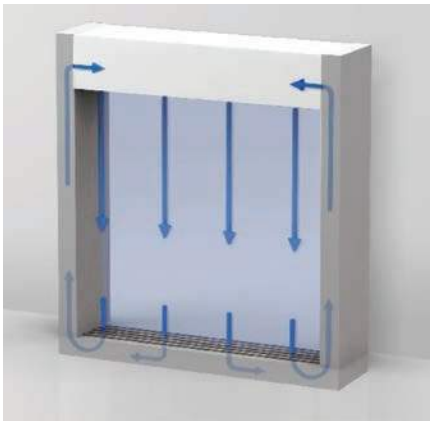
Recirculating air curtains

Recirculating air curtains are typically used in places with constant foot traffic such as supermarkets and store entrances. Recirculating air curtains are called air entrance systems as they are built into the entrance, usually during the original building construction.

They emit air from a discharge grille at the top of the opening and return it from the floor of the doorway. Air is returned through ductwork to the discharge grille. The non-obtrusive wide stream of low-velocity air created by recirculating air curtains is more desirable for large entrances separating two environments (indoors and outdoors).

An example of a non-recirculating air curtain

Example of a non-recirculating in-ceiling air curtain



An example of a recirculating air curtain

How do you decide whether to use a vestibule or an air curtain in the entrance to your space?

Here are some items to consider about using each.

Vestibule advantages

- It reduces heat loss and heat gain of a space. It creates a buffer zone between the exterior and the interior of a building for better indoor comfort of occupants.
- With proper door spacing it can reduce the infiltration of wind, wind-driven pollutants and insects.
- It provides security from the outside and a secure waiting area for visitors.
- It can be designed to be aesthetic and serve as an architectural feature at the entrance of a simple building exterior to draw people into the building.

Vestibule *disadvantages*

- They consume area the landlord may count as rentable space.
- Many vestibules are so small both doors are often open at same time when being used, significantly reducing the thermal energy savings.
- It can be difficult to determine if a space is required to have a vestibule.
- There is significant cost associated with the construction of a vestibule - much more than the cost of an air curtain.

Air curtain advantages

- Air curtains make emergency exits safer by not adding additional obstacles such as extra doors.
- Customer traffic may increase due to the "open door effect" where open doors are an invitation to explore.
- They can increase the available usable space compared to a vestibule.
- Air curtains can be equal to or better than vestibules in energy savings, depending on the climate zone, by reducing the energy lost from the conditioned space.
- They have lower construction costs compared to vestibules.
- An air curtain is effective at reducing the number of insects and pollutants that enter the building.
- They are easier to maintain with an average cost \$2-\$6 per ft^2 of floor area – much less than cost of a vestibule.
- There is no ductwork required to install an air curtain, electrical costs are lower, there are fewer doors, and they keep floors drier than vestibules during storms.

Air curtain *disadvantages*

- An air curtain is not a permanent barrier and is susceptible to strong winds, reducing protection for the occupants.
- They can annoy those passing through by mussing hair or clothes and may ruin an otherwise pleasurable shopping experience.
- Air curtains can be perceived as tacky by customers when noise and air flow exceed comfortable limits.
- They offer no security to entrances.

Once you've decided on the best entrance solution for your space, the next step is to design the entrance.

Here are some strategies to consider.

Functional strategies for vestibule design

Door placement: A revolving door for the outer door or staggering the door positions helps to prevent heat transfer from outside to inside or vice versa.

Interior/exterior door spacing: Vestibules are typically squeezed down in size to reduce construction costs but doing so reduces their overall effectiveness. National codes require 7 feet between doors. In colder climates, however, 10 to 15 feet is recommended to provide a greater buffer distance between doors to increase effectiveness.

Configuration: Entry configuration and mechanical-system airflow are the main factors that affect comfort, not necessarily the distance from the front door to the main area (sales, cash wrap, front desk). A vestibule is part of a coordinated space plan, not an add-on, so all space adjacencies must be considered during design.

Security features: May be designed to provide additional lighting, cameras, and other electronic entry/exit features when waiting in or entering a vestibule.

Inviting: Vestibules are utilitarian, but they are an important part of the design and user experience while in a space. They should be designed to invite users in with thoughtful lighting, clean materials, clear signage, and coordinated in such a manner as to look like the rest of the building space.

Air curtain: Using a vestibule with one or more air curtains takes advantage of the strengths of both entrance solutions to achieve even greater energy efficiency. It can also buffer the building occupants from exterior elements much better than a vestibule alone.

A vestibule is often the first and last area visitors encounter in a space, so making sure it is properly designed is key to a positive experience.

Functional strategies for air curtain design

Air curtain positions: Depending on the type of air curtain (in-ceiling or exposed), performance and customer experience can be affected by how the air is directed across the door. Be sure to follow manufacturer recommendations for the best performance and overall customer experience.

Airflow velocity: Some manufacturers design air curtains for performance over comfort; this needs to be evaluated to the meet the need of the clientele as well as the space. Noise and airflow discomfort play a role in the overall experience in a retail environment where performance is less of a demand.

Air curtain type: The choice of exposed, in-ceiling, recess mounted, recirculating or non-recirculating can directly affect overall occupant experience. This must be taken into consideration during the initial building concept for the best results.

User traffic: Traffic type must be considered when selecting a vestibule and/or an air curtain. The use of certain occupancies typically determines the selection of either a vestibule or an air curtain. Sometimes cost concerns will determine the design solution. Without proper analysis, you can get the lowest-cost solution that may also be the poorest solution.

Air curtains can provide an effortless entry and exit without compromising the customer experience with mindful selection and placement.

Government and international requirements

ADA requirements

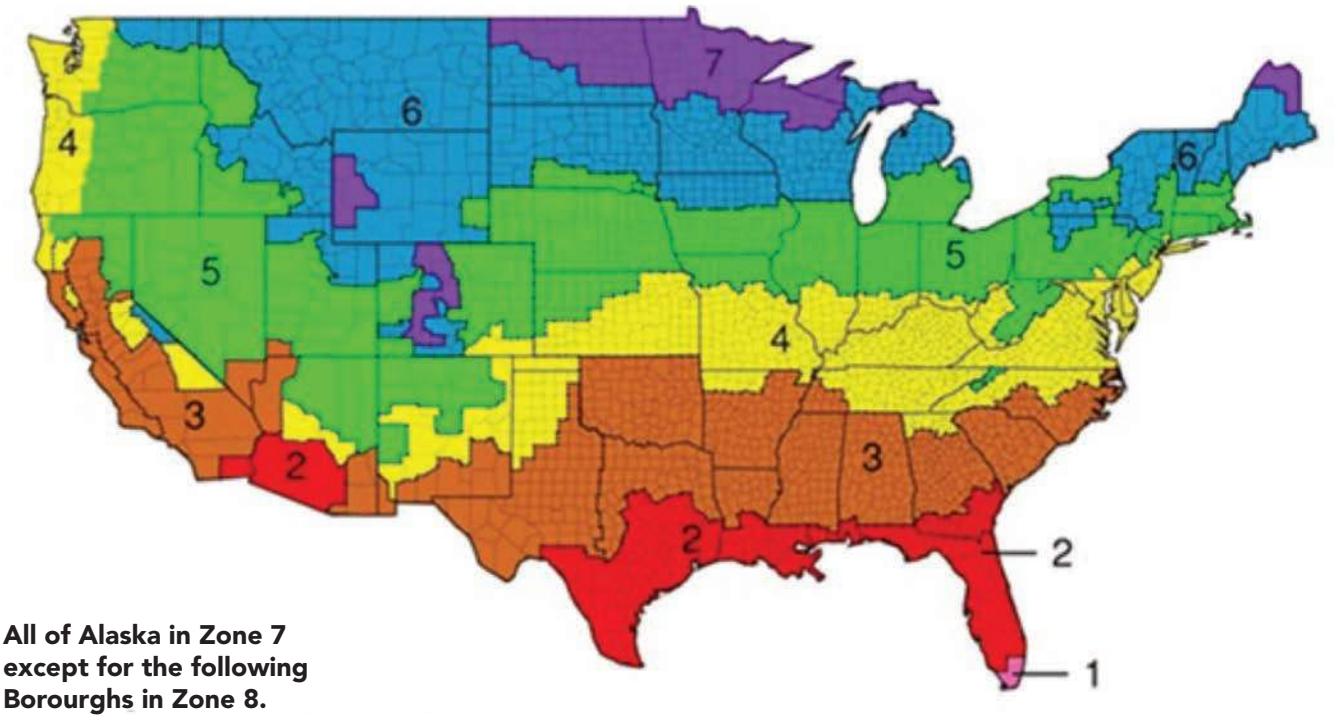
The Americans with Disabilities Act (ADA) provides guidance on door maneuvering clearances of those that will be encountered in a vestibule design. Care should be taken in implementing these clearances for entrances with and without vestibules. More detailed information is available through the United States Access Board (www.access-board.gov).

International requirements

The provinces of Canada abide by either ASHRAE 90.1 - (Various years depending on province) or the National Energy Code of Canada for Buildings 2015/2017 (NECB).

US climate zones

Climate zones defined by IECC and ASHRAE are used to determine the need for vestibules and exceptions to their use such as air curtains. Climate zones 1 and 2 do not require the use of a vestibule under these codes.



All of Alaska in Zone 7 except for the following Borourghs in Zone 8.

Bethel
Dellingham
Fairbanks N. Star
Nome
North Slope
Northwest Artic
Southeast Fairbanks
Wade Hampton
Yukon–Koyukuk

Zone 1 includes Hawaii, Guam, Puerto Rico, and the Virgin Islands

US climate zones as referenced in IECC and ASHRAE 90.1

State code requirements*

Each state has adopted differing years of the IECC code and ASHRAE 90.1. Below is a list of those states and their current adopted code. Some states have created their own tailored version of the IECC and are included below. Some populous municipalities have also created their own specific version of code to better address their local issues. Visit the municipality website in question for the latest updates to their code.

State code requirements

2015 IECC	2012 IECC	2009 IECC	ASHRAE 90.1
Alabama	Alaska	Arkansas	Mississippi - 2010
Hawaii	Connecticut	Georgia	West Virginia - 2007
Illinois	Delaware	Maine	
Maryland	Idaho	New Hampshire	
Massachusetts	Iowa	New Mexico	
Michigan	Kentucky	Pennsylvania	
New Jersey	Montana	South Carolina	
New York	Nevada		
Texas	Rhode Island		
Utah	Tennessee		
Wisconsin			
State-specific codes			
California - 2016 California Building Energy Efficiency Standards			
Florida - 2017 Florida Building Code			
Indiana - 2010 Indiana Energy Conservation Code			
Minnesota - 2015 Minnesota Energy Code			
North Carolina - 2012 North Carolina Energy Code			
Ohio - 2017 Ohio Energy Code			
Oregon - 2014 Oregon Energy Efficiency Specialty Code			
Vermont - 2015 Vermont Commercial Building Energy Standards			
Virginia – 2012 Virginia Energy Conservation Code			
Washington - 2015 Washington State Energy Code			
Washington D.C. - 2013 District of Columbia Energy Conservation Code			
States with no mandated codes			
Arizona			
Colorado			
Kansas			
Louisiana			
Missouri			
North Dakota			
Oklahoma			
South Dakota			

State codes are subject to change. Municipalities may have additional or city/county specific requirements.

Code citations

Only recent versions of the IECC (2018 and 2015) include the exception of using air curtains to replace vestibules. While this is a recent development in terms of the documentation, authorities having jurisdiction (AHJs) can approve of air curtains on a case by case basis if documentation and proof of an engineered solution is provided. Given the new code exceptions many jurisdictions may be inclined to approve air curtain installation without the additional effort even if their state has not yet adopted the newer codes. The designer must be mindful to verify all of the exceptions for a vestibule requirement in both IECC and ASHRAE 90.1 before proceeding with a vestibule or air curtain design. The following lists the most recent codes to the oldest codes used by the states including ASHRAE 90.1-2013 as a reference. State specific codes are largely based on IECC tri-annual versions.

IECC 2015 / 2018, Section C402.5.7 Vestibules

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 where vestibules are not required:

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 ft^2 (298 m^2) in area.
5. Revolving doors.
6. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.
7. Doors that have an air curtain with a velocity of not less than 6.56 feet per second (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.

IECC 2012, Section C402.4.7 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.

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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 ft^2 (298 m^2) in area.
5. Revolving doors.
6. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

IECC 2009, Section 502.4.7 Vestibules

A door that separates 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.

Exceptions where vestibules are not required:

1. Buildings in Climate Zones 1 and 2.
2. Doors not intended to be used as a building entrance door, such as doors to mechanical or electrical equipment rooms.
3. Doors opening directly from a sleeping unit or dwelling unit.
4. Doors that open directly from a space less than 3,000 ft^2 (298 m^2) in area.
5. Revolving doors.
6. Doors used primarily to facilitate vehicular movement or material handling and adjacent personnel doors.

ASHRAE 90.1-2013, Section 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 semi-heated space.

Exceptions where vestibules are not required:

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 located in Climate Zone 3 or 4 that are less than four stories above grade and less than 10,000 ft^2 in area.
6. Building entrances in buildings located in Climate Zone 5, 6, 7, or 8 that are less than 1,000 ft^2 in 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.

Selecting the right entry system for your commercial space is an important decision, impacting the cost, user comfort and design aspects of your project.

The following studies can give you more extensive information on the energy savings of vestibules and the use of vestibules and air curtains in specific climate zones. These studies build upon other studies that have been performed over the years to produce the most complete picture of what using each system means for a building owner. The studies can inform the building owner about how using one system versus the other translates into a particular level of energy savings.

Energy Saving Impact of ASHRAE 90.1 Vestibule Requirements

A Pacific Northwest National Laboratory (PNNL) paper titled "Energy Saving Impact of ASHRAE 90.1 Vestibule Requirements: Modeling of Air Infiltration through Door Openings" evaluated the energy saving potential for vestibules using whole building energy simulation tools. This can be used by clients and owners as a guide to determining where a vestibule is required.

The prototype model building table below illustrates the typically encountered entrance zone areas where a vestibule would be mandated based on the area. Architects are mindful of this and try to avoid being locked into a vestibule if that is not part of their design intent.

The table below lists the vestibule requirement for each building prototype under ASHRAE 90.1 – 2013. The exceptions to each prototype are identified with a number next to the building prototype name when it corresponds to all climate zones and a number next to yes or no confirmation when it corresponds to a particular climate zone. The exceptions are slightly different for the IECC versions of the code and should be verified before proceeding with design.

ASHRAE 90.1 - 2013 vestibule requirement for all prototypes in each zone

Building Prototype	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8
Large Office	No (1)	No (1)	Yes	Yes	Yes	Yes	Yes	Yes
Medium Office (2),(5)	No (1)	No (1)	No	No	No	No	No	No
Small Office (2), (5)	No (1)	No (1)	No	No	No	No	No	No
Warehouse (2),(5)	No (1)	No (1)	No	No	No	No	No	No
Quick Service Restaurant (2),(5)	No (1)	No (1)	No	No	No	No	No	No
Sit-down Restaurant (2)	No (1)	No (1)	No	No	No	No	No	No
Strip Mall (2)	No (1)	No (1)	No	No	No	No	No	No
Standalone Retail (2)	No (1)	No (1)	No	No	No	No	No	No
Primary School (2),(5)	No (1)	No (1)	No	No	No	No	No	No
Secondary School (2),(5)	No (1)	No (1)	No	No	No	No	No	No
Small Hotel (5)	No (1)	No (1)	No	No	No	No	No	No
Large Hotel	No (1)	No (1)	Yes	Yes	Yes	Yes	Yes	Yes
Hospital	No (1)	No (1)	Yes	Yes	Yes	Yes	Yes	Yes
Outpatient Health Care (2)	No (1)	No (1)	No	No	No	No	No	No
High-rise Apartment (5)	No (1)	No (1)	Yes	Yes	Yes	Yes	Yes	Yes
Mid-rise Apartment (5)	No (1)	No (1)	No	No	No	No	No	No

Note: 90.1 exceptions, which are used in determining that no vestibule requirement exists for a building in a particular climate zone, are shown in parenthesis.

Energy Saving Impact of ASHRAE 90.1 Vestibule Requirements: Modeling of Air Infiltration through Door Openings, Table 2, page 8.
Pacific Northwest National Laboratory – U.S. Department of Energy

Door traffic is a good indicator of whether a vestibule or air curtain will impact the energy savings or the user's experience. High traffic entrances will benefit from not having a vestibule that might impede users trying to enter the space. Ease of entry into the space is also dependent on the vesibule design. In addition, a poorly designed vestibule ceases to save energy as the doors are held open for extended periods while people make their way through the entry. The table below illustrates both the peak and off-peak door-opening frequency for each building type. Door-opening frequency due to traffic directly translates into energy loss of a space.

Door-opening frequency estimation for each building type*

Building Type	Peak Occupancy [Persons]	Door-opening frequency [number of door openings per hour]	
		Peak	Off-peak
Small Office	9	9	1
Medium Office	105	105	10
Warehouse	23	23	2
Standalone Retail	77	153	15
Strip Mall	17/8	34/16	3/2
Primary School	580	580	58
Secondary School	1041	1041	104
Quick Service Restaurant	90	90	9
Sit-down Restaurant	57	57	6
Outpatient Health Care	123	123	12
Small Hotel	90	90	9
Mid-rise Apartment	46	46	5

**The door-opening frequency for peak hour can be estimated based on the number of occupants in a building. For retail and strip-mall stores, it is assumed that customers would use entrance door two times within 1 hour (i.e., once they enter and once they leave the store). However, for other building types it can be safely assumed that people stay longer than 1 hour in the building and use the entrance door once within 1 hour when they enter or leave. Therefore, the door-opening frequency for peak hour can be estimated to be equal to the number of occupants in all prototypical buildings except retail and strip-mall stores.*

Energy Saving Impact of ASHRAE 90.1 Vestibule Requirements: Modeling of Air Infiltration through Door Openings, Table 5, page 11. Pacific Northwest National Laboratory – U.S. Department of Energy

The results for vestibule energy savings is provided below in a national weighted-average savings for each building prototype. The results provide general observations that can be used by the designer in choosing to use a vestibule even where it is not required by code.

National weighted-average site energy savings for each building prototype*

Building Type	Energy End Use Savings [kBtu/ft^2]	Savings [%]
Small Office	0.13	0.63
Medium Office	0.09	0.23
Warehouse	0.09	0.36
Standalone Retail	1.49	2.38
Strip Mall	3.56	5.61
Primary School	0.16	0.29
Secondary School	0.04	0.06
Quick Service Restaurant	13.3	4.16
Sit-down Restaurant	4.56	1.89
Outpatient Health Care	0.04	0.03
Small Hotel	0.34	0.57
Mid-rise Apartment	0.11	0.30

**The weighting factors used to calculate national average savings are different for each building and each climate zone. The weighting factors, as well as the method to estimate the weighting factors and their values can be found in PNNL reports [10,*

Energy Saving Impact of ASHRAE 90.1 Vestibule Requirements: Modeling of Air Infiltration through Door Openings, Table 8, page 17. Pacific Northwest National Laboratory – U.S. Department of Energy

Results summary

- Smaller buildings such as strip malls, small offices, stand-alone retail, quick-service and sit-down restaurants with higher door-opening frequency tend to have a larger percentage of energy savings from the use of vestibules. They have a smaller peak infiltration rate through door openings compared to other building types, but yield greater savings because of the smaller floor area of the building and the higher door opening frequency.
- Larger buildings including primary and secondary schools that experience frequent door openings and therefore large amounts of infiltration at peak hours have smaller percentage levels of energy savings because of the larger floor area and higher baseline energy use. The net savings is much smaller compared to the overall building energy use.
- Generally, the energy savings from the use of a vestibule is most pronounced in the colder climate zones. The results also highlight the higher potential for energy savings for smaller buildings (i.e. strip malls, small offices, stand-alone retail, quick-service and sit-down restaurants). The results can also be used to guide the designer in the application of an air curtain for the same type of buildings.

Investigation of the Impact of Building Entrance Air Curtain on Whole Building Energy Use

An Air Movement and Control Association International, Inc. (AMCA) study, "Investigation of the Impact of Building Entrance Air Curtain on Whole Building Energy Use," evaluated the effectiveness of air curtains compared to vestibules and determined that air curtains had the potential to consistently meet or outperform vestibules in terms of energy savings. The study took other real-world factors into consideration to determine air curtain performance that included the building entrance orientation, frequency of use, the balance of the building HVAC system (pressure) affecting air infiltration/exfiltration, and the overall energy performance of the air curtain. These additional factors were shown to be as important as door-opening frequency.

Based on the results of the modeled building and the air curtain in this study, considering its lower initial cost and space saving benefit, an air curtain should be a good alternative to the vestibule for the climate zones of 3-8. The modeled air curtain door reduced energy consumption by 0.3% to 2.2% in the study. The results from this study are based on a specific building type, specific parameters, and a specific modeling method of the air curtains. While this shows a good result for air curtains, generalization of the conclusions may need further analysis based on the changes to the modeling scenario. This includes expanding the opening to multiple doors rather than a single door and varying the real-world factors for the case actually being considered by the building owner and/or designer.

Impact of climate zones on the annual heating/cooling saving and total energy savings of air curtain compared to the single door and/or the vestibule door.

Climate Zone	City	Heating/ Cooling	Air Curtain Fan Energy kWh	Air Curtain Annual Performance					
				Basis for Comparison: Single Door			Basis for Comparison: Vestibule		
				Heating/Cooling Saving, kWh (%)	Total Saving		Heating/Cooling Saving, kWh (%)	Total Saving	
					E_{saving}	P_{saving}		E_{saving}	P_{saving}
1	Miami	Cooling	94	175 (0.0)	81	0.0	-		
2	Austin	Cooling	158	290 (0.1)	132	0.0			
3	Atlanta	Heating	200	2003 (2.9)	1757	0.4	1172 (1.7)	1146	0.3
		Cooling		-46 (-0.0)			174 (0.1)		
4	Baltimore	Heating	331				2425 (1.6)	2217	0.5
		Cooling					123 (0.1)		
5	Chicago	Heating	371				4383 (1.7)	4169	0.9
		Cooling		-			157 (0.1)		
6	Minneapolis	Heating	372				7379 (2.0)	7007	1.2
7	Fargo	Heating	415				9152 (2.0)	8737	1.4
8	Fairbanks	Heating	529				19515 (2.5)	18986	2.2
For selected zones, when the operation of air curtain is not controlled by outdoor temperature									
3	Atlanta	Heating	786	2161 (3.2)	911	0.2	1330 (2.0)	300	0.0
		Cooling		-464 (-0.1)			-244 (-0.1)		
4	Baltimore	Heating	786				2695 (1.7)	1620	0.4
		Cooling					-289 (-0.1)		
5	Chicago	Heating	786	-			4694 (1.9)	3721	0.8
		Cooling					-187 (-0.1)		

If the air curtain is equipped with temperature control, i.e. "on" when the door is opened and at the same time the outdoor temperature is over 30 °C or under 10 °C, and "off" in other cases during the business hours.

Investigation of the Impact of Building Entrance Air Curtain on Whole Building Energy Use, Table 6, page 9.

The PNNL study and the AMCA study are to be taken at face value as they are models rather than real-world testing results, but they are a good indicator of what would be encountered by using either a vestibule or an air curtain. They inform a building owner of what to expect from either system so that a designer (architect or HVAC mechanical) can make adjustments to improve the final design and benefit the end user. There are real-world test results from air curtain manufacturers, but those results vary from each manufacturer and the models tested.

CONCLUSION

While some may argue that a vestibule is better than an air curtain or vice versa, much of the decision to install one over the other comes down to installed cost, the function of the space, the traffic level and overall experience the owner wants the occupants to have when entering the space.

The overall effectiveness of an air curtain or vestibule is dependent on the design and application. The designer has the responsibility of informing both the architect and the building owner about what each option is capable of and the many factors that come into play in making a choice. Misapplication of either entrance system can work against what the building owner is trying to accomplish for the space. The designer must be aware of all local code requirements and experienced enough to properly design the system. Air curtain designs and performance vary from manufacturer to manufacturer, so research by the designer is necessary for an effective installation. Vestibule designs can be even more varied and need input from multiple disciplines for an effective design. Informing building owners about the requirements and choices available can have lasting benefits for both the owners and the building users.

Dialectic works in all 50 states and the District of Columbia. We have the experience in your climate area, knowledge of local codes and design expertise to help you decide on and design your ideal entrance solution. We can work with you and your project partners and provide sustainable solutions for your industry.

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