Air curtain

clean and pleasant air protective

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Introduction:

In the modern era, with advancements and achievements accompanied by rapid population growth, energy, and its consumption have become crucial issues in industrial societies. One persistent problem in many industrial and commercial centers has been the operation of entrance doors for the passage and transportation of goods by employees. Traditional solutions such as tarpaulins and rubber bands have proven inadequate, leading to difficulties in movement, goods transport, and energy losses.

Since the 1960, when oil prices started to rise, energy conservation gained significant attention in Western countries, particularly the United States. As a result, the design and production of air curtain devices were gradually developed and implemented in industrial and commercial centers, medical facilities, administrative buildings, and food production facilities.

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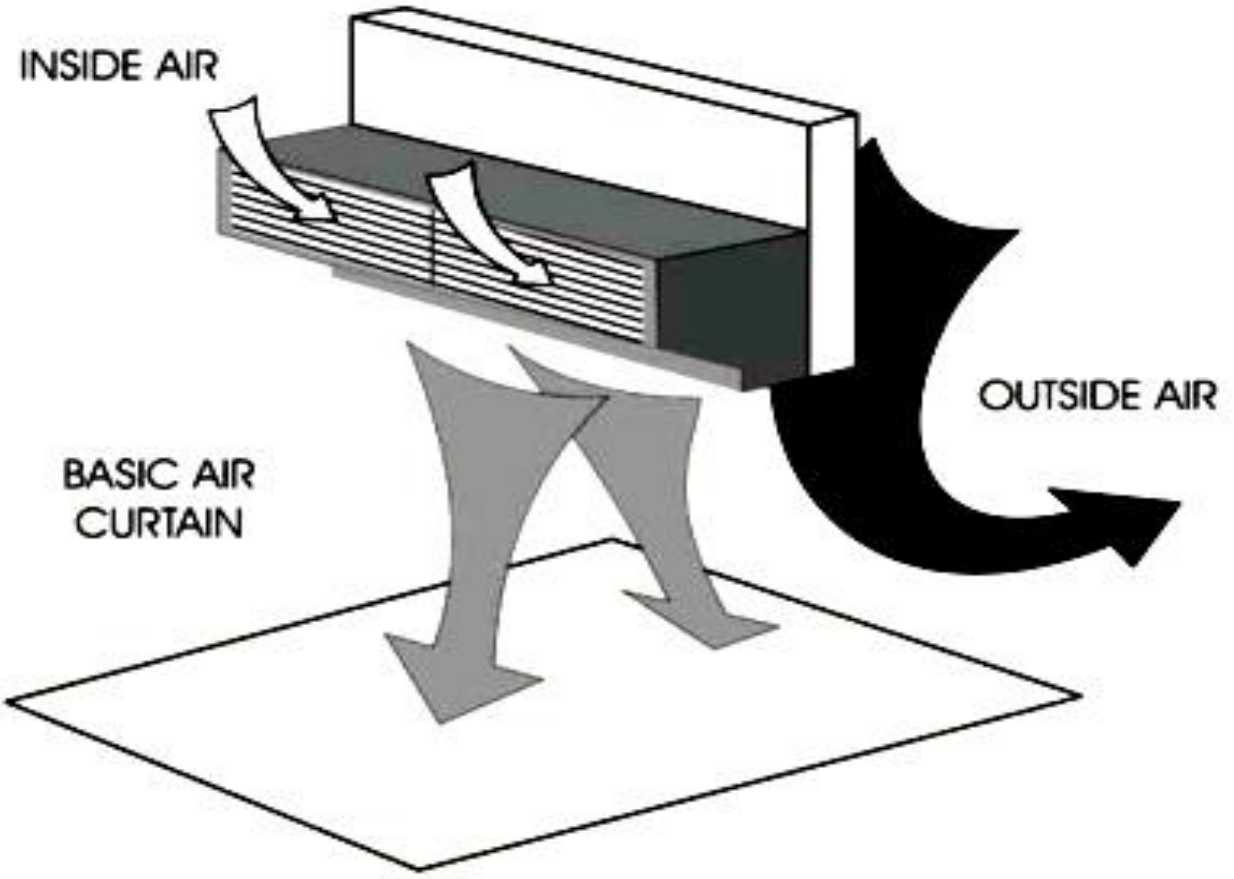
What is an Air Curtain device?

The Air Curtain device operates by drawing air from the surrounding installation environment and expelling it at a high velocity through a linear valve. This process effectively generates an invisible curtain of air at the entrance, separating the interior and exterior spaces.



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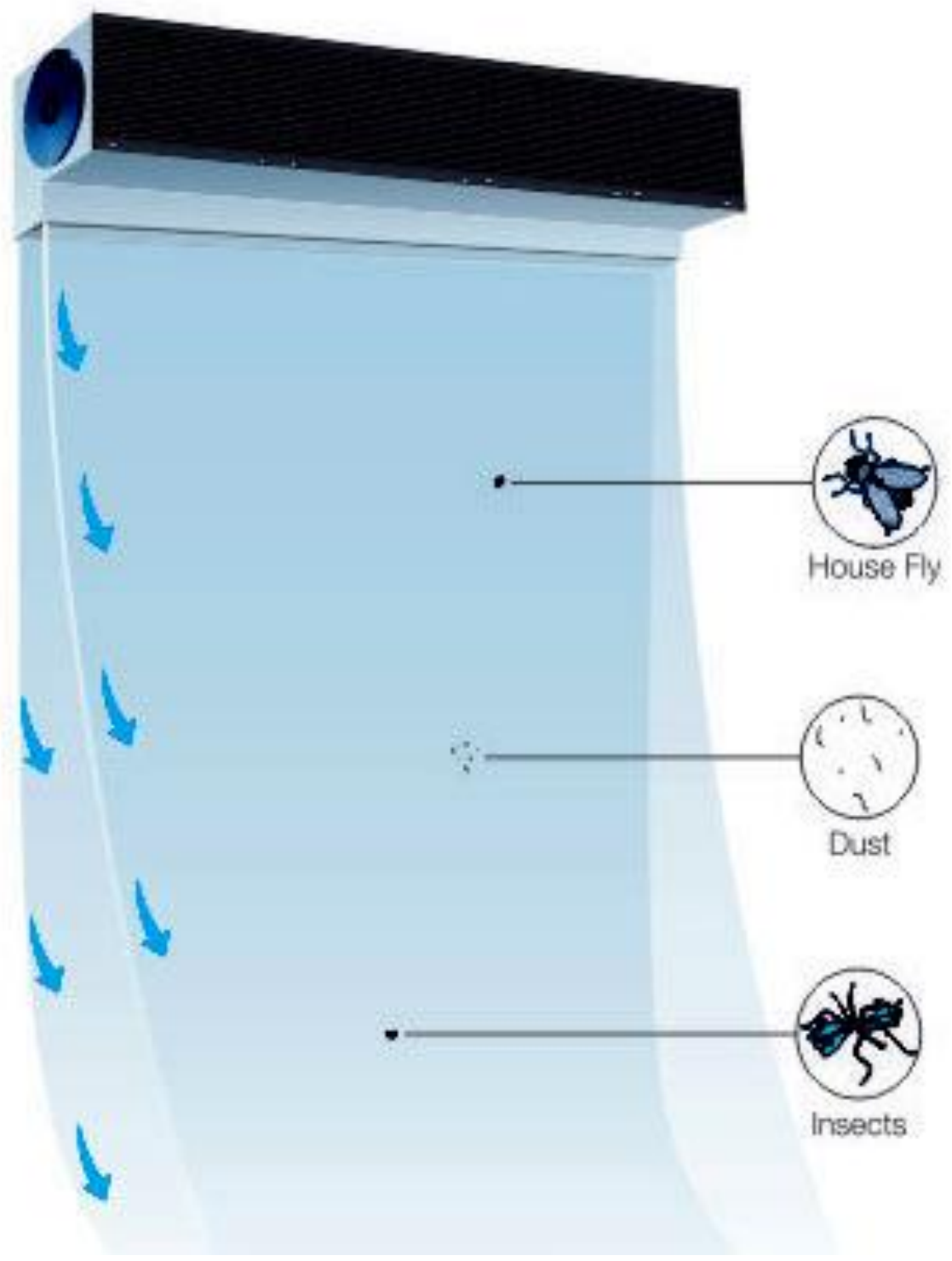

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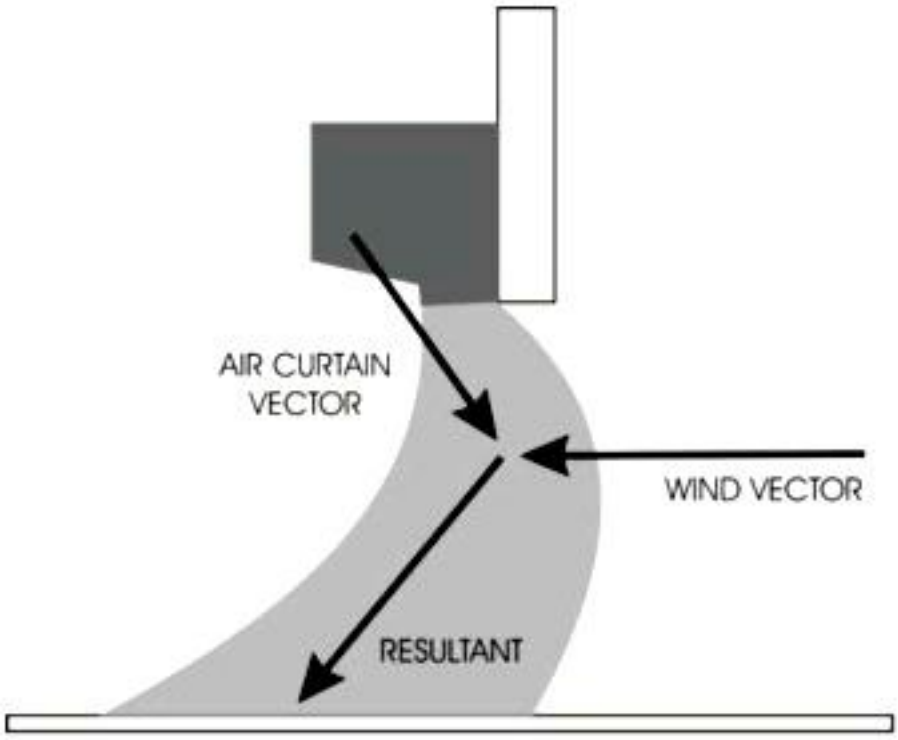
The basis of the Air Curtain device operation:

The figure below shows the operation of the Air Curtain device:



The air that is expelled from the Air Curtain device carries energy due to its high velocity and mass and is represented as a vector. Similarly, wind, which also possesses energy, is depicted as a vector at the doorway. The collision between these two vectors results in the formation of a third vector.

If the air curtain device's power exceeds the wind's strength, the third vector (airflow) inclines towards the exterior, whereas it moves inward when the wind prevails. Consequently, air curtain devices should be designed in a manner that enables them to establish balance against the entrance door opening.

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ENERGY SAVING:

The open doors in buildings result in a significant amount of energy wastage. The installation of air curtain systems can effectively mitigate up to 90% of these losses. By employing such systems, retail stores and large establishments can keep their doors open to attract a larger customer base during the winter season, all while preventing the ingress of cold air. Similarly, during the summer months, air curtains expel warm air outside without the requirement of any specific heating elements. These units find extensive usage in environments such as cold storage facilities and dairy factories. When implementing air curtains in chilled rooms, it is advisable to position the device at a slight angle of 15 degrees towards the warmer section to prevent the escape of cold air and safeguard the motor of the apparatus.

Before proceeding with the discussion on energy savings, it is necessary to examine the velocity profile and air infiltration in front of the entrance door:

According to the following figure, in the absence of wind flow, due to the temperature difference (air density) between the two environments, warm air escapes from the upper half of the door to the outside, while an equivalent amount of cold air enters from the lower half.

Now, in the presence of wind flow and negative pressure inside (such as when air-exhausting devices are present), the airflow infiltrates inward. The magnitude of this airflow is the product of the door's cross-sectional area and the wind speed, commonly expressed in units such as cubic feet per minute (c.f.m) or cubic meters per hour.

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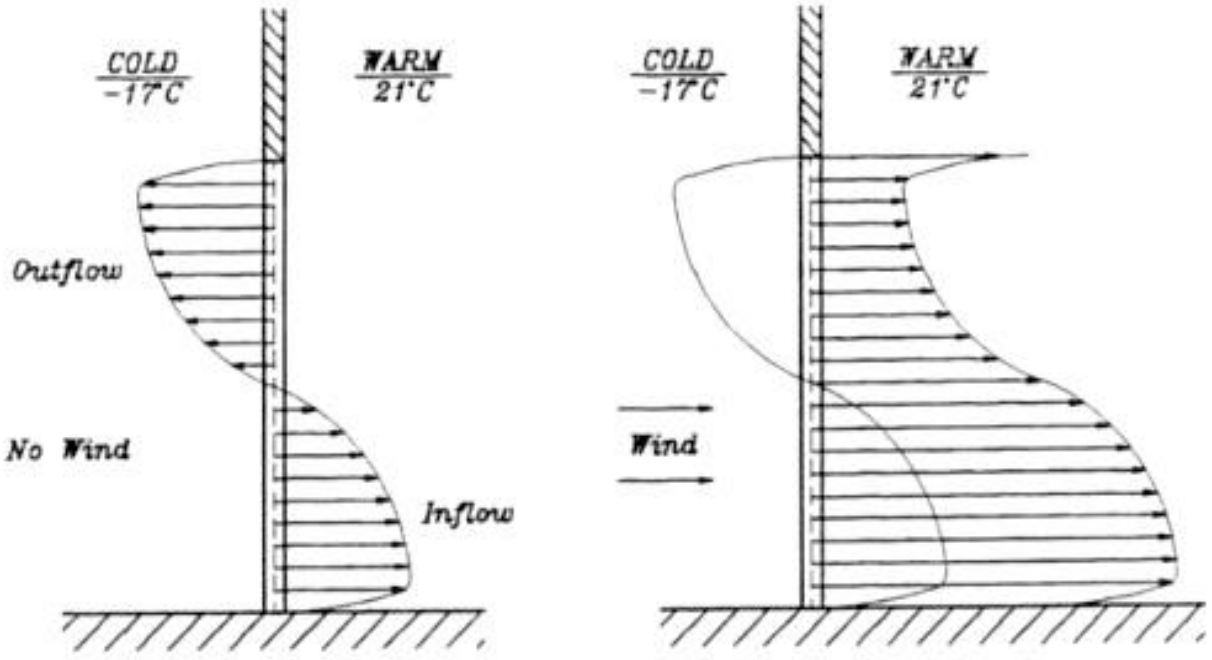
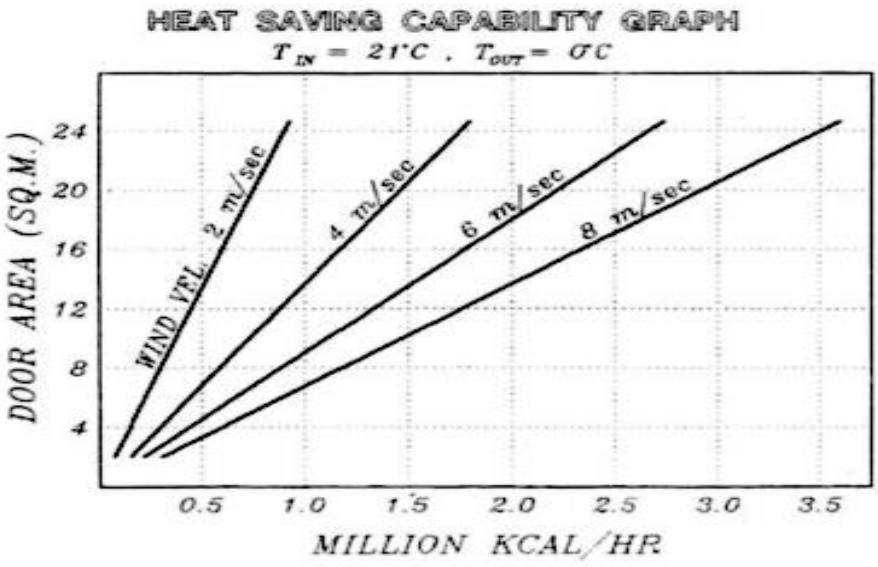


Based on this, the amount of wasted energy can be represented in the following graph:



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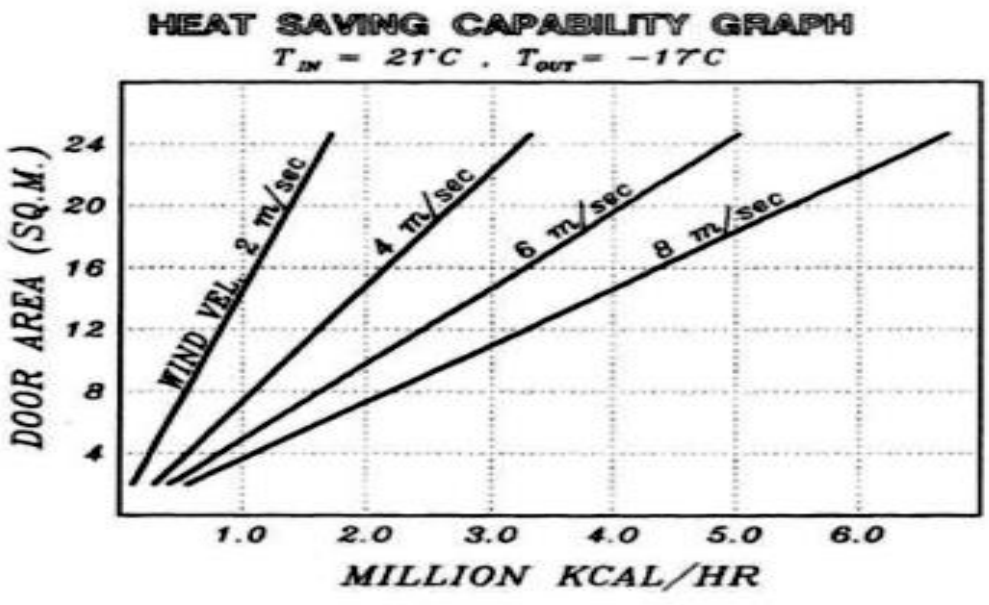
Fuel Consumption Value:

By quantifying the amount of energy wastage, it is possible to calculate the fuel consumption value for specific scenarios, such as the peak cold hour (Analysis 1), as well as for an entire year (Analysis 2), taking into account the presence of wind flow.

Analysis 1: One-hour assessment:

The hall door has a rectangular opening with dimensions of approximately 5.3 meters in width and 4.2 meters in height, resulting in an approximate area of 22 square meters. The average wind speed is measured at 8 meters per second, while the indoor temperature is recorded at 21 degrees Celsius and the outdoor temperature at -17 degrees Celsius.



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The above graph clearly indicates that approximately 6 million calories of energy are lost per hour.

Considering the heating value of the fuel consumed, for diesel, we have 7,000 kilocalories per liter, and for gas, we have 9,400 kilocalories per cubic meter.

The amount of diesel fuel consumed (in liters per hour): 6000,000:7000=850

The amount of gas consumed (in cubic meters per hour): 6000,000:9400=640

Taking into account the fuel value for each liter of diesel at 1.21 Canadian dollars and each cubic meter at 163 cents (1.63 Canadian dollars), we have the following:

The cost of diesel fuel consumption (in dollars per hour): 850 × 1.21: 1,029

The cost of gas consumption (in dollars per hour): 640 × 1.63: 960

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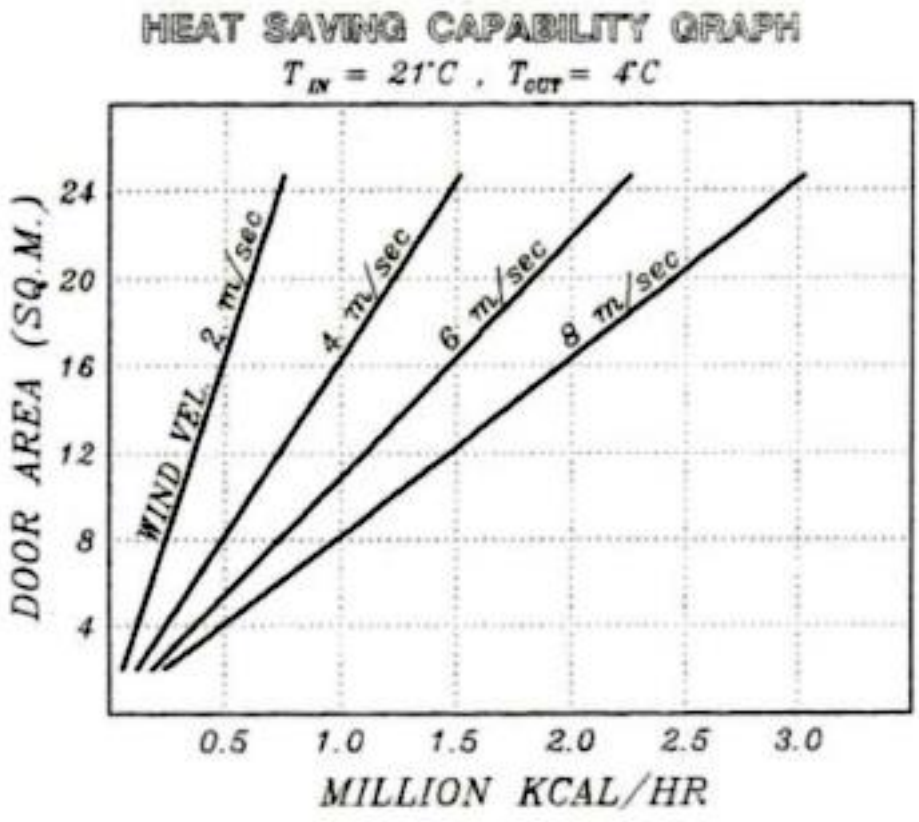
Analysis 2: For one year (four cold months):

The average wind speed is 4 meters per second and the temperature inside is 21 degrees Celsius and the average temperature outside is 4 degrees Celsius.



From the above graph, the amount of energy wasted is calculated as 1.35 million calories per hour for one year (four cold months).

Kilocalories	1,350,000 × 10 × 22 × 3= 891,000,000
Amount of diesel consumed (liters per year)	891,000 : 7,000 = 127,000
Amount of gas consumed (cubic meters per year)	891,000 : 9,400 = 95,000
Cost of diesel consumed (dollars per year)	127,000 × 1.2= 153,670
Cost of gas consumed (dollars per year)	95,000 × 1.50 = 142,500

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If the air curtain devices are designed, installed, and adjusted in accordance with the relevant standards, they will effectively prevent up to 90% of energy loss.

Electricity Cost of Air Curtain Devices for One Year (4 months): $15 \times 10 \times 22 \times 3 \times 8 = 792$ dollars

Savings Amount in Diesel Fuel Consumption (dollars per year): 153,670 – 792 = 152,870

Savings Amount in Gas Consumption (dollars per year): 142,500 – 792 = 141,708

Applications of the Air Curtain Device:

Generally, the applications of the Air Curtain device for protection against entrance doors include the following three cases:

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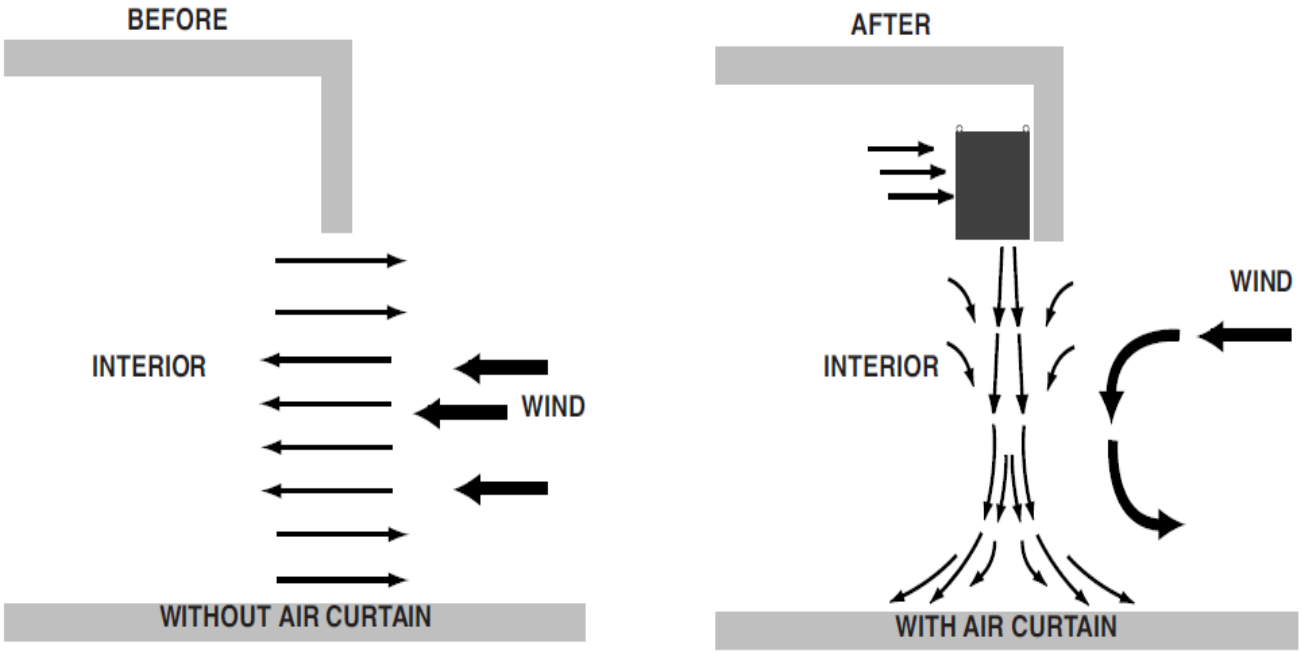
1-Wind stopping

The Air Curtain device is specifically engineered to inhibit the penetration of natural winds moving at an approximate speed of 8 meters per second.



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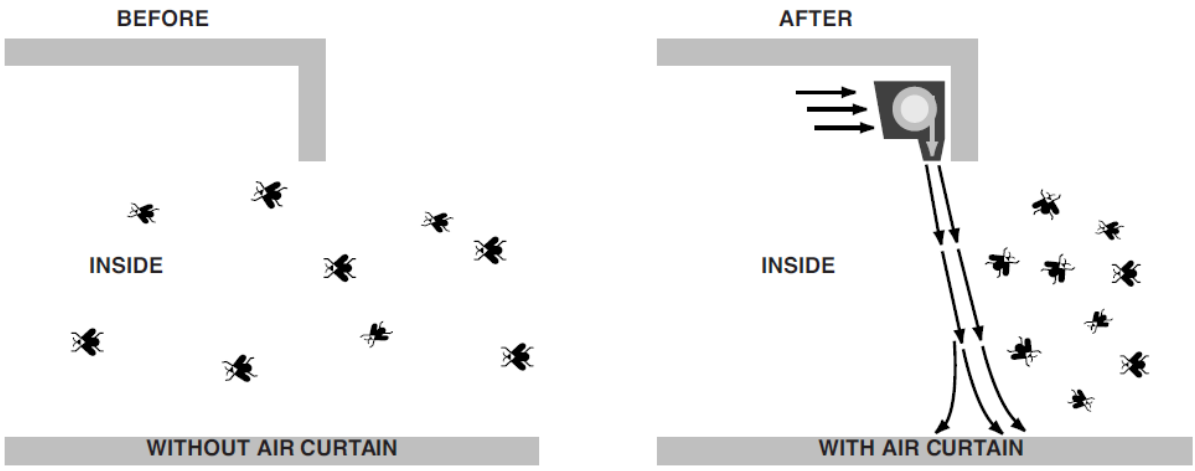
2-Insect control:

These devices are similar to the first row, but they work at maximum speed.



3-Separating environments:

Air curtain devices can be equipped with heating systems utilizing steam coils, hot water, and electric (heating element) methods. However, it should be noted that these devices are not designed to fully heat the entire space or indoor area. Nonetheless, they can create a temperature differential of approximately 15 degrees Celsius.

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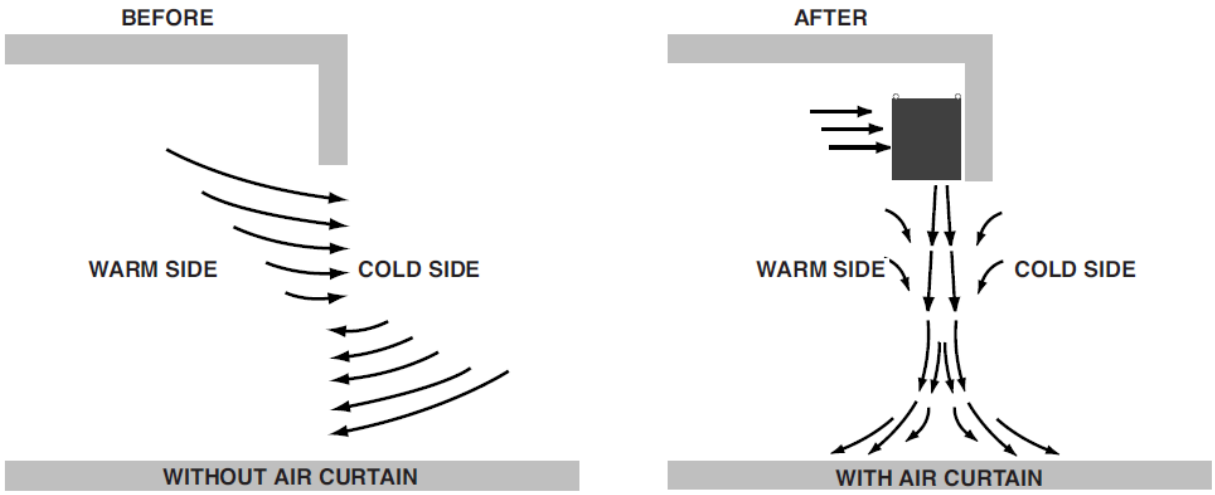

Heated air curtain

Air curtain devices are utilized for the separation of two spaces in terms of heat exchange, especially when the wind speed is not significant. The airflow velocity from the device should also be controllable.

Pressure negative

In general, buildings that, for any reason, are vented and have less replacement of the exhausted air become subjected to negative pressure. Now, if their doors or valves are opened, air enters with great intensity, and under such circumstances, the efficiency of air curtain devices decreases. It should be noted that this problem exists in most factories.

To solve this issue and for the entry of replacement air (fresh air), you can rectify the problem by installing a shutter damper equipped with a mesh (to prevent the entry of insects), at the highest height of the hall and near the air curtain device.

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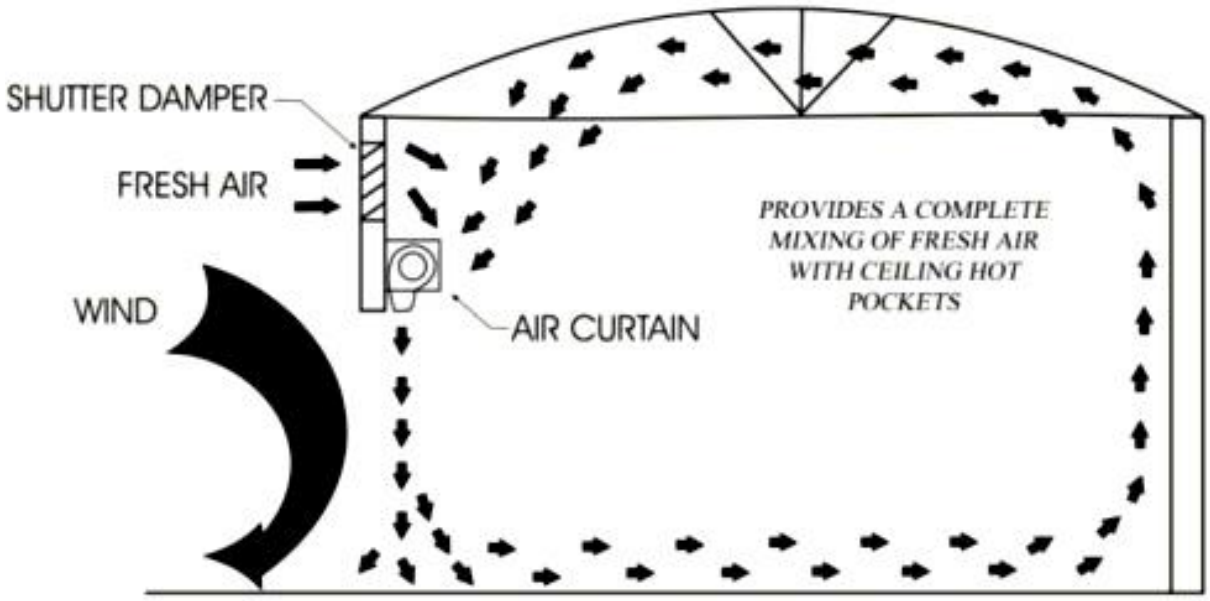

Fresh air enters through this damper and mixes with the stagnant air at the top of the building or hall, creating a state of equilibrium within the space. Naturally, under such conditions, the efficiency of the air curtain device will be enhanced.

Installation of Air Curtain Devices:

Air Curtain devices are usually installed horizontally above the doors in most cases, and in special cases (air projection from bottom to top), they are installed inversely. In circumstances where there is no space for the installation of an air curtain at the top of the doors, the devices can be installed vertically in three possible configurations:

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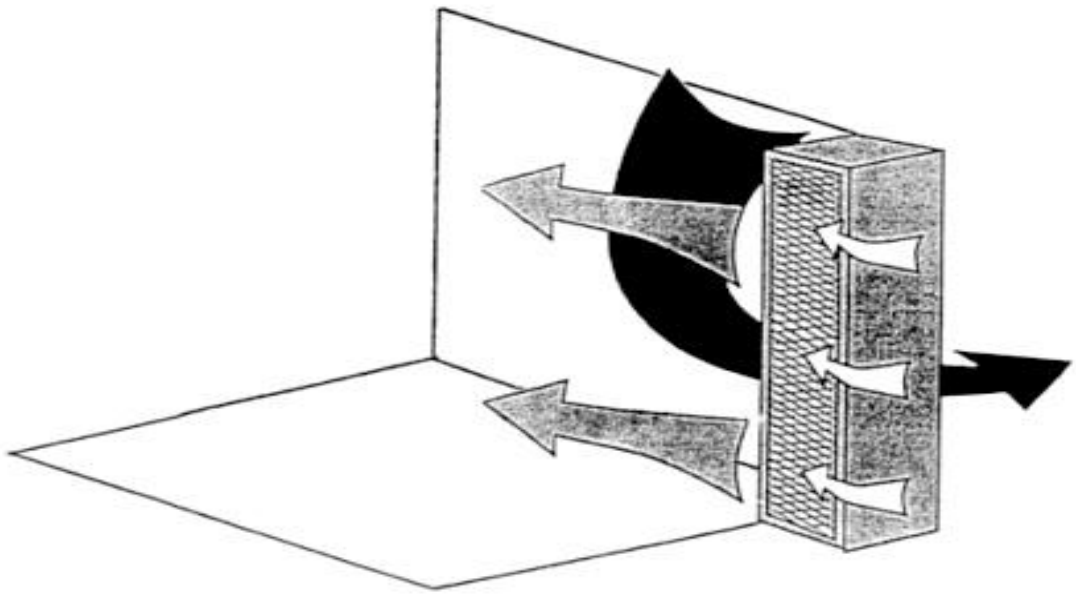
1. Simple Vertical:

In this case, the device is installed vertically on one side of the door, causing the air current to accelerate into a part of the interior space.



2. Vertical with Energy Absorber:

In this configuration, an energy-absorbing plenum is installed opposite the air curtain device to reduce the high speed of the outgoing air.

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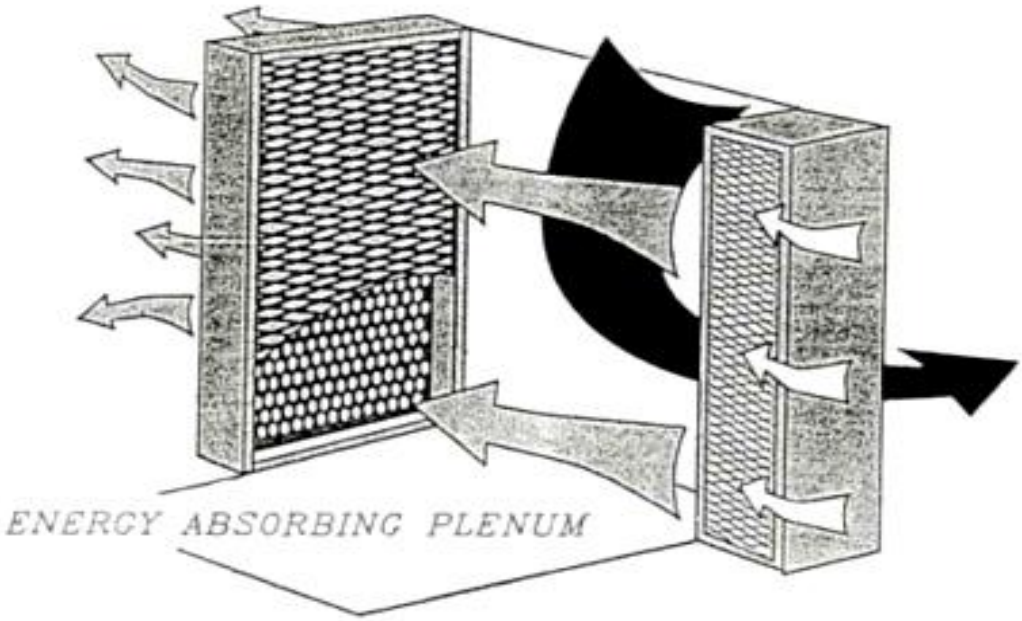

3. Vertical with Suction and Drive:

In larger halls with wider entrance doors, it is advisable to install the air curtain devices in a two-way (to and fro) configuration, as depicted in the figure below:

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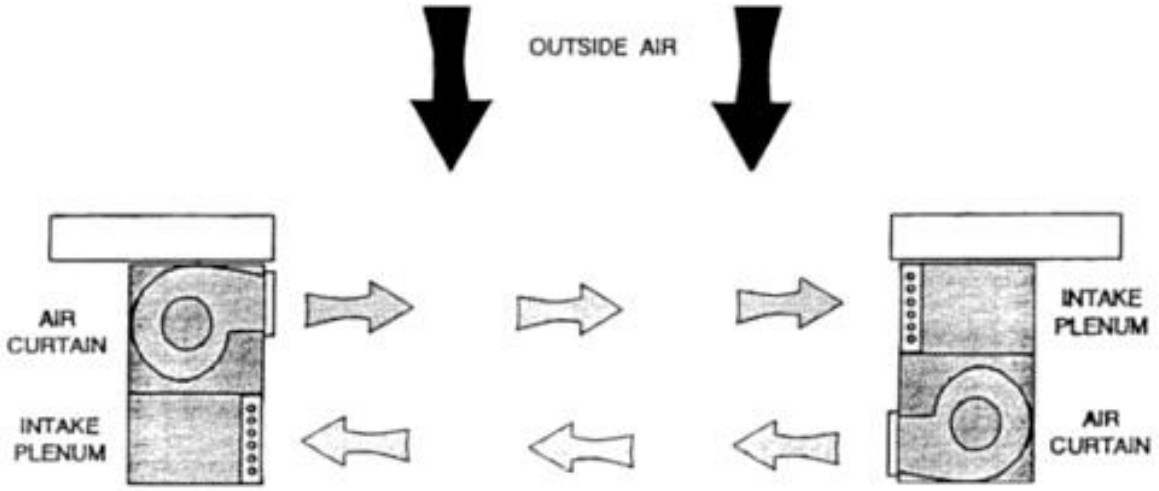

Based on the above figure, each air curtain device has an air inlet enclosure, which is precisely located opposite the linear valve of the opposing air curtain device. The functionality of this model is to create a thicker air curtain against the door. The velocity of the air emanating from this device will be lower compared to devices that are installed above the door. This model of the air curtain also has the capability to be fitted with a heating coil and a filter.

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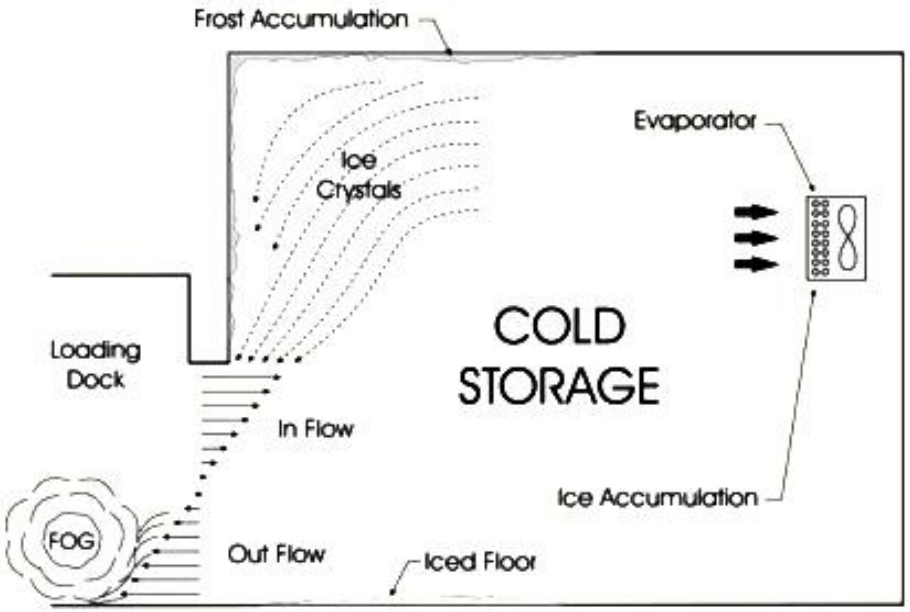
Advantages of Air Curtains:

1. Separation of warm indoor air from cold outdoor air, resulting in reduced heating costs (warm air curtain).
2. Separation of cold indoor air from warm outdoor air, resulting in reduced cooling costs (cool air curtain).
3. Prevention of microbial and microorganism infiltration, thereby ensuring an appropriate hygienic environment.
4. Prevention of the intrusion of dust, smoke, and polluting gases.
5. Mitigation of heat loss in heating facilities.
6. Prevention of cooling loss in cold storage facilities, as well as preventing frost in their interiors (Cold storage air curtain).



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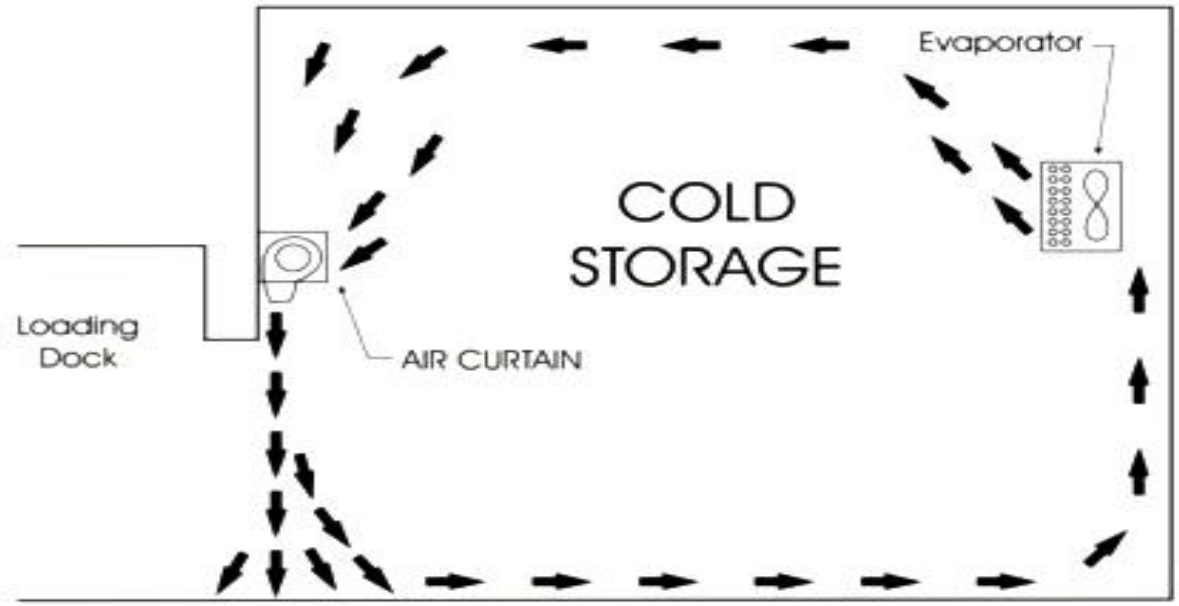
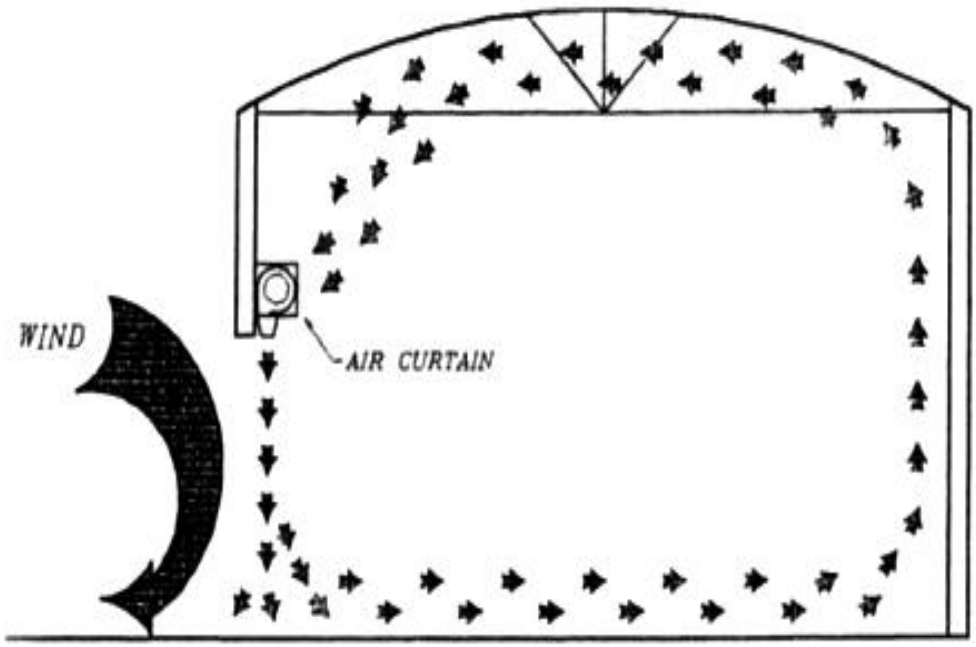


AFTER

7. Facilitates the circulation of stagnant warm air residing at the top of halls, resulting in reduced heating generation costs.



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8. By isolating parts of the hall using an air curtain device, the spread of any pollution from the production process, dust, and pollutants can be controlled. In essence, air curtain devices will complement hoods and polluted air exhaust systems.
9. Enhances the performance and efficiency of workers, which will lead to an improvement in both quality and quantity.
10. In addition to all the benefits mentioned above, an air curtain device creates an invisible door at entrances. This does not interfere with the movement of the employees and contributes to their comfort and ease while also facilitating the easy movement of goods. In today's world, air curtains are suggested as the ultimate solution for controlling the issues mentioned above.

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