Air Curtain Units Guide

HEVAC

Air Curtain Industry Group

Introduction

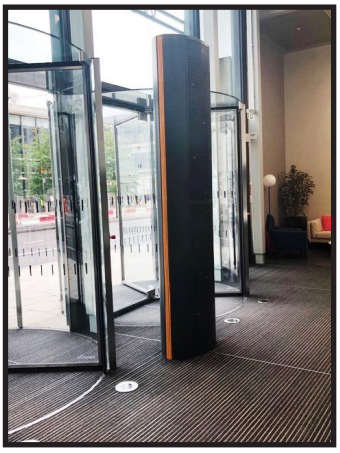
An air curtain unit provides a continuous broad stream of air across a doorway.
Air curtain units are normally mounted horizontally over the doorway or vertically at the side of the doorway.

Type of air curtain

Surface mounted

Recessed

Vertical



Benefits

Profitability

- Allows ‘open door trading’ invitation to customers
- Increases comfort for customers and staff
- Increases available useable space
- Increased productivity
- Reduces employee absenteeism
- Reduces product spoilage

Energy saving

- Limits energy loss from conditioned space thereby reducing central plant capacity
- Increases efficiency of cooling plant
- Reduced carbon emissions
- Reduces the running cost of a building
- Recovers stratified air from high level

Performance

- Helps maintain heated or air conditioned environment
- Helps control airborne insect ingress
- Helps control dust, smoke and fume infiltration

Design factors

The opening

- The air curtain unit supply air should be wider than the full width of the door opening
- Suitable to discharge air across the whole height of the opening at a supply air temperature which is acceptable for the comfort of people passing through the doorway
- The heat output of the air curtain unit must be sufficient to temper the volume of air coming in at the entrance
- The air curtain unit supply air should be positioned as close to the opening as possible

Building characteristics

- Height of the building and its ability to create a stack (or chimney) effect
- Building orientation
- Doorway locations
- Air leakage which creates a pressure difference across the doorway leading to draughts should be effectively zero. A tight building envelope also reduces heat losses

The outdoor climate conditions

- Temperature
- Humidity
- Prevailing wind conditions

The indoor conditions

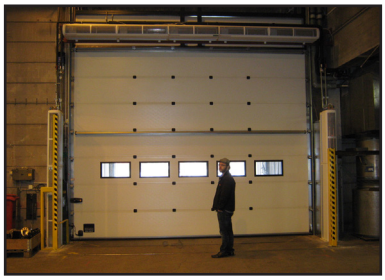
- Does the surrounding area need to be heated?
- What special conditions need to be met (e.g. work areas in proximity to the door)?
- Are there obstacles on or around the door that need to be removed?
- Will the air curtain units require special mounting (to clear fast acting doors)?
- Other special requirements e.g. humidity, acoustic

Heating sources

- Direct electric heating
- Low, medium or high pressure hot water
- Refrigerant condensers
- Direct & indirect gas fired
- Steam
- Renewable energy sources (wind power electric, heat pump low pressure hot water, heat pump refrigeration)

Applications

Airports
Atria
Care homes
Cinemas
Cold stores
Distribution centres
Educational establishments
Factories
Galleries
High street stores
Hospitals
Hotels
Industrial processes
Leisure complexes
Loading bays
Municipal buildings
Museums
Pubs & clubs
Railways & bus stations
Reception areas
Restaurants
Retail outlets
Shopping centres
Showrooms
Supermarkets
Warehouses



Application guide

Air conditioned areas	Typical locations are at the entrances to retail stores to condition the ingress of outdoor air into the conditioned space.
Industrial climate control	Normal locations for air curtain units are exterior doors to factories and warehouses as well as interior openings between areas of different temperatures.
Cold stores	Used to reduce the loss of refrigerated air, minimise temperature variations and misting of a cold store each time the entrance is opened.
Clean rooms	Air curtain units can be installed on the 'clean' side of a space to control the transfer of dust and humidity through the doorway.
Other uses	Air curtain units are also used for diverse applications such as in the mining industry, insect control in food processing plants, dairies, restaurants, supermarkets and across the openings of industrial ovens and refrigerated display cabinets.

What is an air curtain unit?

In its simplest form, an air curtain unit is a device that provides a continuous broad stream of air circulated across a doorway serving a conditioned space. Air curtain units are normally mounted horizontally over the door. They can also be mounted vertically at the side of the door or under the floor directed upwards.

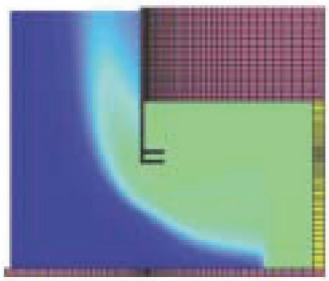
How do air curtain units work?

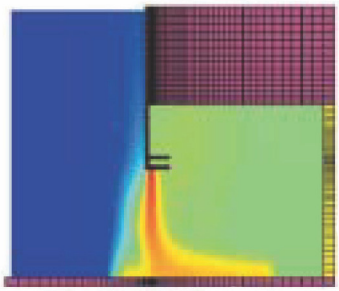
For winter operation air curtain units disrupt the natural convection (buoyant flow) effect of warm air spilling out of the top of an open doorway and being replaced by cold air coming in at the bottom. This convective flow is the primary heat loss infiltration mechanism and by minimising this flow they can save energy compared with a doorway without an air curtain unit.

Wind and building stack effects can cause air to flow into the doorway and whilst air curtain units do not necessarily act as a barrier to prevent the entry of this outside air, when used in air conditioned or industrial climate control areas (HVACR applications), they will condition the incoming air at the entrance and minimise cold draughts.

The Computational Fluid Dynamics (CFD) temperature profiles below indicate the effect of air curtain units in doorways:

Fig. 1 shows the effect on the conditioned space without an air curtain unit and illustrates convective heat losses
Fig. 2 shows the effectiveness of a correctly installed and selected air curtain unit

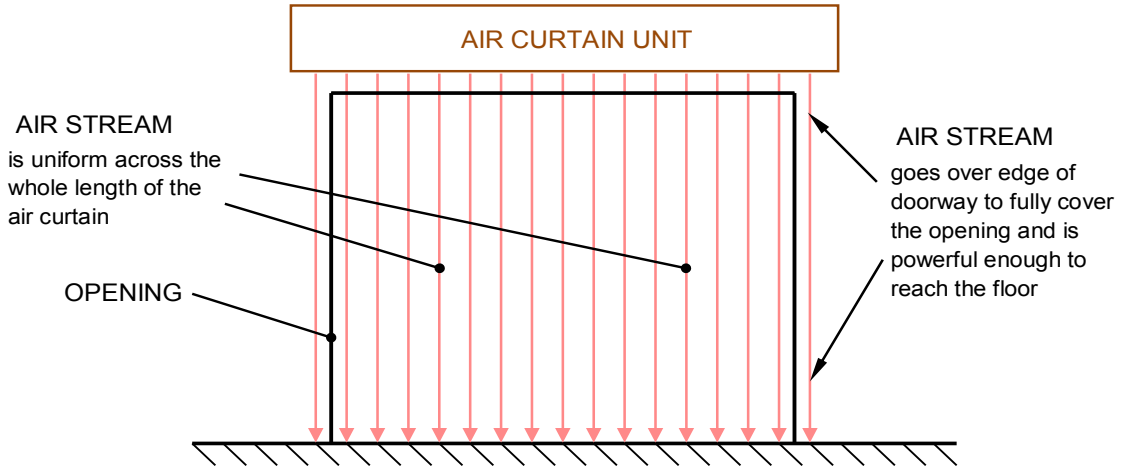




The heat output of an air curtain unit must be sufficient to temper the volume of air coming into the entrance. An air curtain unit will become less effective if the velocity of the incoming air is excessive. This can occur as a result of under-pressure within the building from extract systems, stack effect with leaky or tall buildings, or wind effects on an exposed site.

If conditions are not extreme, an air curtain unit with a non-heated air stream (Ambient Air Curtain units) can also be effective in reducing energy losses from an air conditioned entrance by disrupting the natural convective heat transfer at the doorway.

The width of an air curtain unit's discharge grille should be wider than the doorway opening; an air curtain unit that is narrower than the doorway is ineffective. Opening and closing of doors can disturb the air stream, which may take some time to re-establish. The heating capacity of an air curtain unit can have an effect on the space temperature within the building entrance and suitable controls need to be fitted to adjust the heat output and air stream characteristics if necessary.



Design procedure for new build

An authoritative engineering design procedure for calculating the supply air flow and thermal capacity of an air curtain unit for an HVACR application is explained in the BSRIA Application Guide 2/97, Air Curtains – Commercial Applications (4). The procedure for a 'Building with an Air Tightness Specification' should be followed, i.e. a practical building with some air leakage. Within the BSRIA Application Guide, Section 4.2 explains the design procedure, and Section 5.2 gives worked examples for buildings with a range of air tightness specifications.

$$E = \frac{Q_b - Q_a}{Q_b}$$

This allows the engineer to calculate the supply air flow rate and thermal capacity of the required air curtain units for a particular application. Additionally it is possible to provide detailed site analyses of specific customer projects using Computational Fluid Dynamics (CFD) techniques. A simulation of the building plans with the air curtain units at the door opening is generated using a previously validated computer model. A range of weather, pressure and temperature scenarios are then introduced to see the predicted effect that the air curtain units will have on the internal environment. Energy transfer and energy effectiveness can also then be determined.

Energy effectiveness of an air curtain unit (HVACR application)

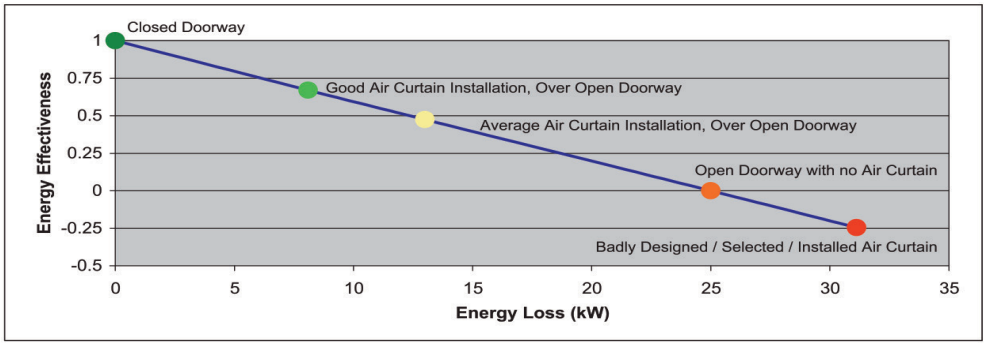
The energy effectiveness of an air curtain unit installation over an open doorway can be described by the following equation:

where,
- E is the energy effectiveness
- Qa is the energy exchange through an open doorway WITH an air curtain unit fitted plus the power consumed by the air curtain units
- Qb is the energy exchange through an open doorway WITHOUT an air curtain unit fitted

The closer the energy effectiveness is to 1 (unity) the better the energy effectiveness with,

1 = Ultimate Barrier (equivalent to a closed door, if Qa = 0)
0 = Bad (equivalent to an open doorway with no air curtain units, if Qa = 1)

NB. The energy effectiveness could also become a negative figure, if Qa >1 e.g. -0.25, in the case of a badly designed, badly selected or badly installed air curtain unit, which could make the energy situation even worse than just having an open doorway. See chart below for example doorway situation.



The Air Curtain Industry Group of HEVAC is developing equations for measuring the energy exchange through open doorways with and without air curtain units fitted and CFD techniques can also be used to predict this. Notwithstanding this, a good air curtain unit installation could be up to 70% effective at controlling the original energy exchange loss through a doorway without an air curtain unit. To a significant extent it does this by disrupting the natural convection (buoyant flow) effect of warm air spilling out of the top of the open doorway and being replaced by cold air in at the bottom. The new "lower" energy exchange (30% of the original) is added to the power consumed by the air curtain unit and the energy effectiveness then calculated.

Controls

Controls with the air curtain unit are essential to prevent unnecessary energy usage. They can, if necessary, also be used to adjust the air stream characteristics and to optimise penetration across the doorway.

For convenience, user operated controls are mounted remotely and configured to satisfy the needs of the building occupants. At the simplest control level only manual operation of the fan(s) and fan speed may be required, however more advanced control options may be included such as:

- Thermostatic control
- Timer On/Off control
- Step or modulating control of electric or water heating
- BMS control interface
- Energy management
- Automatic door activation
- Optimisation controls for on/off and temperature adjustment

Where air curtain unit performance may be compromised

- When external wind factors are too severe
- Leaky buildings with high infiltration rates
- Where entrances are subject to unusual wind conditions such as tunnel effects
- When indoor/outdoor temperature difference is extreme
- High entrances and tall buildings creating high stack effect
- Where manufactures O&M requirements are not followed
- Where there is poor control strategy
- Poor maintenance regime
- When the air curtain unit is underspecified

The air curtain unit should not necessarily be seen as a space heater for warming up internal areas, especially if it is electrically heated. An air curtain unit is most effective as an air barrier when utilising ambient air, although a heated air stream will result in a more comfortable local environment by reducing cold draughts.

This guide provides the basic information on cold store air curtain units and should not be used as a comprehensive design document.

Further information is available from the manufacturers who will be able to provide the most suitable product to suit for your individual applications.

This brochure has been produced by the following members of the Air Curtain Industry Group of HEVAC.

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