AIR CURTAIN GUIDE








HEVAC

AIR CURTAIN INDUSTRY GROUP

AIR CURTAIN GUIDE

WHAT IS AN AIR CURTAIN ?

In its simplest form, an air curtain is a continuous broad stream of air circulated across a doorway serving a conditioned space. Air curtains 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 CURTAINS WORK ? (1)

For winter operation air curtains 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 an open doorway without an air curtain.

Wind and building stack effects can also cause airflow in at the doorway and whilst air curtains 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 curtains in doorways:

- Fig. 1 shows the effect on the conditioned space without an Air Curtain and illustrates convective heat losses,
- Fig. 2 shows the effect on the conditioned space when an inadequately selected Air Curtain is used,
- Fig. 3 shows the effectiveness of a correctly installed and selected Air Curtain,

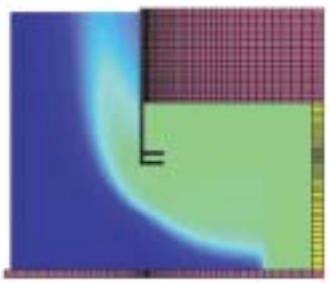


Fig. 1

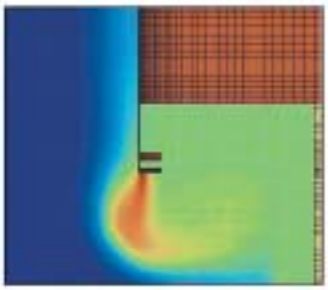


Fig. 2

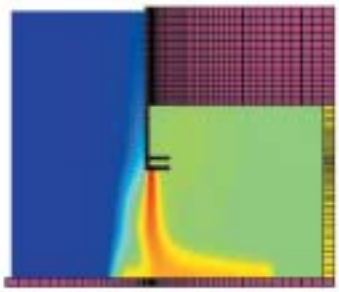


Fig. 3

The heat output of an air curtain must be sufficient to temper the volume of air coming in at the entrance. An air curtain 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 with a non-heated air stream (Ambient Air Curtain) 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 discharge grille should be just wider than the doorway opening; an air curtain 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 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.

WHERE AIR CURTAINS ARE USED

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 curtains are exterior doors to factories and warehouses and interior doors between factory areas of different temperatures.


Vertical Air curtains at Factory Doorway

Cold Stores Used to reduce the loss of refrigerated air, minimise temperature variations, misting and the build-up of ice on the floor of a cold store each time the entrance is opened.

Clean Rooms Air curtains can be installed on the 'clean' side of a space to control the transfer of dust and humidity through the doorway.

Other Uses Air curtains are also used for diverse applications such as in the mining industry, insect control in food processing plants, dairies, restaurants and supermarkets, and across the openings of industrial ovens and refrigerated display cabinets. They may also be used to separate smoking from non-smoking areas, helping to maintain an agreeable internal environment.

Buildings where Air Curtains are likely to be used

- Supermarkets
- Factories
- Warehouses
- Cold Stores
- Showrooms
- High Street Stores
- Pubs & Clubs
- Restaurants
- Atria
- Retail Outlets
- Hotels
- Airports
- Leisure Complexes
- Municipal Buildings
- Railway & Bus Stations
- Hospitals
- Cinemas
- Reception Areas
- Any frequently used entrance

BENEFITS OF AIR CURTAINS

Profitability

- Allows 'open door trading' invitation to customers
- Increases customer comfort
- Increases available useable space
- Increases employee comfort and productivity
- Reduces employee absenteeism
- Reduces product spoilage

Energy

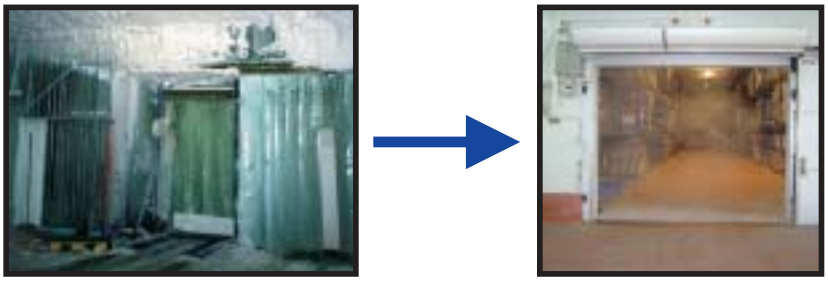
- Limits energy loss from a conditioned space, thereby reducing central plant capacity
- Reduces the carbon emissions from a building by reducing its energy losses
- Reduces the running cost of a building
- Recovers stratified warm air from high level

Performance

- Helps maintain heated or air conditioned environment
- Helps control airborne insect ingress
- Helps control dust infiltration
- Helps control smoke and fumes from penetrating the space

Safety

- Increases doorway safety as the air curtain is not a physical obstruction
- Reduces misting and ice forming on floors at cold store entrances



- Helps to dry out floors adjacent to cold store entrances.

HEATING SOURCES

The warm air from an air curtain can be derived from one of the following sources:

- Direct electric heating
- Low, medium or high pressure hot water
- Refrigerant condensers
- Direct gas fired
- Indirect gas fired
- Steam
- Energy derived from renewable energy sources (e.g. wind power electric, ground source heat pump low pressure hot water, heat pump refrigeration, etc.)

DESIGN FACTORS TO CONSIDER WHEN SELECTING AN AIR CURTAIN

There are a number of factors to consider when selecting the most suitable air curtain for an HVACR application:

Type of Air Curtain

- Surface Mounted or Recessed

The Opening

- The air curtain should ideally be just wider than the full width, or taller than the height of the opening
- The design of the air curtain must be suitable to discharge air across the whole height and width 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 must be sufficient to temper the volume of air coming in at the entrance
- The air curtain 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 ideally be less than 5 $m^3/h/m^2$ at 50Pa test pressure [(2) (3)]. A tight building envelope also reduces heat losses. The diagrams below show the likely points of air leakage from buildings including the obvious open doorways.

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 ?
- Other special requirements, e.g. humidity
- Are there acoustic considerations ?

Where Air Curtain Performance may be Compromised

- When external wind factors are too severe
- Leaky buildings with high infiltration rates
- Poorly located entrances
- When indoor/outdoor temperature difference is extreme
- High entrances and tall buildings creating high stack effect
- Where manufacturers O&M requirements are not followed
- Where there is poor control strategy

DESIGN PROCEDURE FOR NEW BUILD

An authoritative engineering design procedure for calculating the supply air flow and thermal capacity of an air curtain 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. This allows the engineer to calculate the supply air flow rate and thermal capacity of the required air curtain for a particular application.

Additionally several manufacturers are able 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 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 will have on the internal environment. Energy transfer and energy effectiveness can also then be determined.

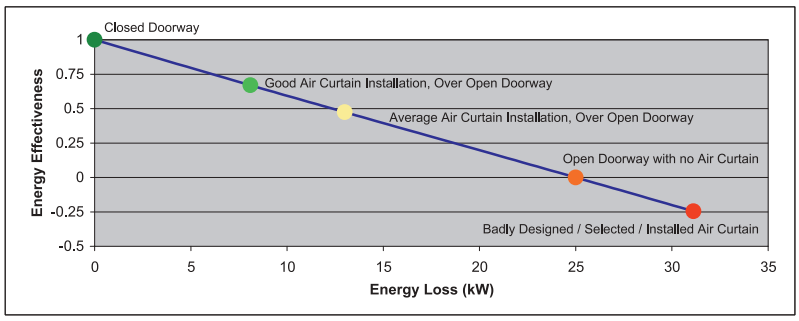
Energy Effectiveness of an Air Curtain (HVACR Application)

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

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

where, E is the Energy Effectiveness,
Q_a is the Energy Exchange through an Open Doorway WITH an Air Curtain fitted plus the power consumed by the Air Curtain,
Q_b is the Energy Exchange through an Open Doorway WITHOUT an Air Curtain 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 $Q_a = 0$)
0 = Bad (equivalent to an open doorway with no air curtain, if $Q_a = 1$)
NB. The energy effectiveness could also become a negative figure, if $Q_a > 1$
e.g. -0.25, in the case of a badly designed, badly selected or badly installed air curtain, 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 curtains fitted and CFD techniques can also be used to predict this. Notwithstanding this, a good air curtain installation could be up to 70% effective at controlling the original energy exchange loss through a doorway without an air curtain. 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 and the energy effectiveness then calculated.

CONTROLS

Controls with the air curtain are essential to prevent unnecessary energy usage, to provide the correct temperature air stream and to prevent overheating within the building entrance. 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 normally remotely mounted and configured to satisfy the needs of the building occupants. At the simplest control level only manual operation of the fan(s), the fan speed and the heat output 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

The air curtain should not be seen as a space heater for warming up internal areas, especially if it is electrically heated. Heat output is first and foremost to allow the unit to operate as an air curtain.

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This guide provides just the basic information on Air Curtains and should not be used as a comprehensive design document.
Further information is available from the manufacturers and they will also be able to provide you with the most suitable product to suit your application.

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Produced by the Air Curtain Industry Group of HEVAC

Biddle Air Curtains
Envirotec Ltd
Frenger Systems Ltd
Glen Dimplex UK Ltd
JS Air Curtains
S&P Coil Products Ltd
Frico Ltd
Thermoscreens Ltd
Vent Axia Ltd

Full contact details can be found at www.feta.co.uk

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References in text:
(1) CIBSE Guide B2, Section 3, page 22 (annotated)
(2) CIBSE TM23, Testing Buildings for Air Leakage
(3) BSRIA Technical Note 19/2001, Air Tightness Testing
(4) BSRIA Application Guide 2/97, Air Curtains – Commercial Applications

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