Cold Store Air Curtain Guide

Air Curtain Industry Group

HEVAC

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AIR CURTAIN INDUSTRY GROUP

Introduction

Controlling the climate in and around cold stores is very complex because of the large temperature difference between inside and outside the cold store.

Within the food sector quality control and precise temperature regulation is critical, but every time the door of a cold store is opened the temperature fluctuates. Misting and icing-up around the door lead to poor visibility and accidents.

Logic dictates that if the doors can be left open, as is often the case in the retail sector, access back and forth becomes quicker and safer.

Plastic strips and fast acting doors are sometimes used to deal with these issues, but are acknowledged to be less than ideal.

A cold store air curtain is an air curtain adapted for use at the doorway of a cold store (freezing temperatures) or a chilled store (above freezing temperatures). They are normally mounted horizontally over the doorway but can also be mounted vertically at the side of the door.

Benefits

Profitability

- Allows higher traffic levels
- Increases available useable space
- Increased comfort and productivity
- Reduces product spoilage

Energy saving

- Limits energy loss from cold store, thereby reducing central plant capacity
- Increases efficiency of cooling plant
- Reduced carbon emissions
- Reduces the running cost of a building

Plant operating cost

- Longer life for cooling equipment
- Lower plant maintenance

Performance

- Helps maintain cold store environment
- Helps control dust, smoke and fume infiltration

Safety

- No physical obstruction
- Reduces misting and ice forming on floors at cold store entrances
- Higher visibility due to reduced condensation and unobstructed vision
- Helps to dry out floors adjacent to cold store entrances that could get wet

Hygiene

- Maintained temperatures offer the desired environment for stored products

Design Factors

The Opening

- The air curtain should be just wider than the full width of the door opening
- The design of the air curtain must be suitable to discharge air across the whole height of the opening
- The air curtain should be positioned as close to the opening as possible

Building Characteristics

- Building orientation
- Doorway locations
- Air leakage of the cold/chilled store (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

The Indoor Conditions

- 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 require special mounting (to clear fast acting doors)
- Other special requirements, e.g. humidity

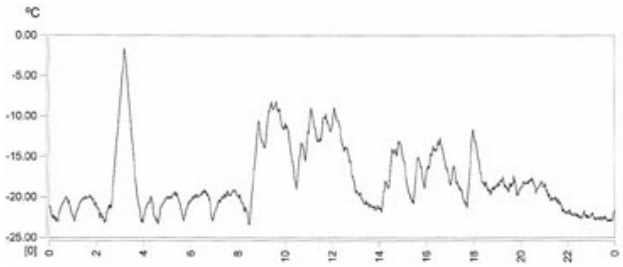
Applications

- Cold stores
- Chilled stores
- Ice stores
- Pubs, clubs, restaurants and catering trade
- Food manufacturers and processors
- Supermarkets
- Hotels
- Distribution centres
- Snow Domes
- Florists and flower markets
- Hospitals

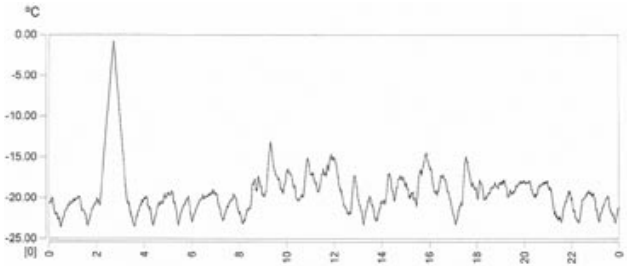
Case studies

Measurements were taken to show improvement in cold store operational efficiency when this food manufacturer replaced plastic strips with unheated air curtains. The air curtain proved to be much more efficient in keeping the cold air inside the cold storage and provided greater temperature stability. Installation of air curtains also reduced the risk of accidents because ice build up on the floor and visibility through the opening was improved.

Source Manuel Carvalho SA, Portugal



Before
(with plastic strips)



After
(with air curtain)

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Air curtains are an energy-saving solution to an effective separation of internal and external environments when doors must be kept open. They achieve this by delivering a powerful barrier of air - either ambient or heated - across the entire width of the doorway.

The open door not only causes discomfort but greatly increases energy loss and, therefore, the running costs of the building. Air curtain units offer a cost-effective, energy efficient solution to these problems by reducing heat loss by up to 80%.

The problem

Whenever the cold storage door is open, the large temperature difference between the inside cold air and outside warm air creates an exchange of air. Dense cold air spills out at low level and is replaced by warm moist air. This causes the following problems:

- Condensation icing at the entrance – frozen moisture on the floor creates a health and safety risk
- Poor temperature stability – temperature fluctuations in the cold store can reduce the quality and saleability of perishable goods,
- Energy wastage – cooling plant has to work harder to maintain internal temperature
- Contamination from dust, flying insects and other unwanted airborne particles, which will compromise hygiene and sanitation
- Icing on cooling plant and equipment mounted inside the cold store – reduction of efficiency and increased maintenance costs and reduced plant life
- Poor visibility and frequent replacement costs if traditional plastic strips are used

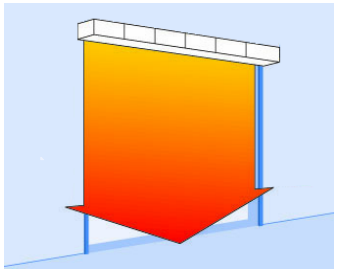
Cold store without air curtain

The Air Curtain Solution

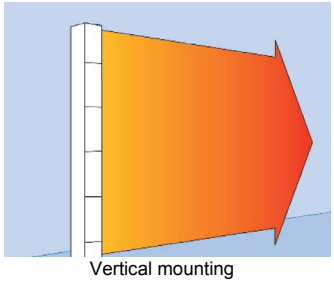
An air curtain installed at the ambient area above the open cold store separates temperature differential and helps prevent warm moist air entering the cold store and ice build up in and around doorways, therefore reducing energy use and increasing efficiency within cooling plants.

The air curtain can work in several ways, for example, by a high velocity air knife, multiple air stream, or single air stream mounted in either horizontal or vertical plane

To allow unimpeded access without high energy loss, the use of air curtains to maintain a stable temperature in cold storages is a sensible choice. Energy losses are reduced, delicate products are better protected whilst safety and accessibility are improved



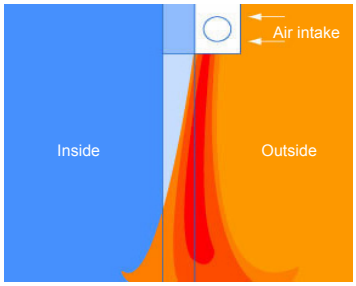
Horizontal mounting



Vertical mounting

The technology

The air stream of a cold store air curtain disrupts the natural convective heat transfer effect at a doorway where there is a temperature difference either side. This is where buoyant warm enters into the cold store at the top of the doorway and cold air from the store spills out at the bottom of the doorway. This convective flow is the primary heat loss infiltration mechanism and by minimising this flow with a cold store air curtain they can save energy compared with an open doorway without an air curtain.



Pattern of airflow

The width of the 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

Clockwise from top left:

Fig. 1 shows the effect on the conditioned space without an air curtain and illustrates convective heat losses
Fig. 2 shows the effect when an air curtain is used with too high an airflow velocity,
Fig. 3 shows the effect when an air curtain is used with incorrect outlet angle,
Fig. 4 shows the effectiveness of a correctly installed and selected air curtain,

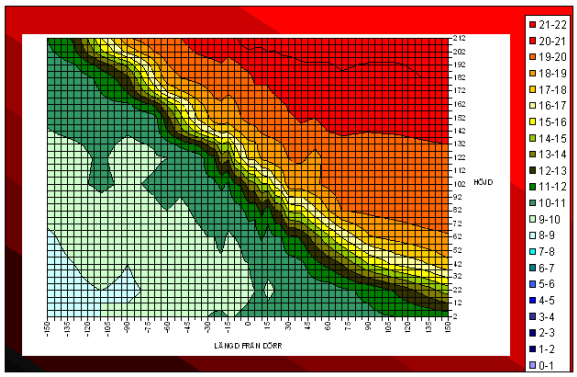


Fig. 1

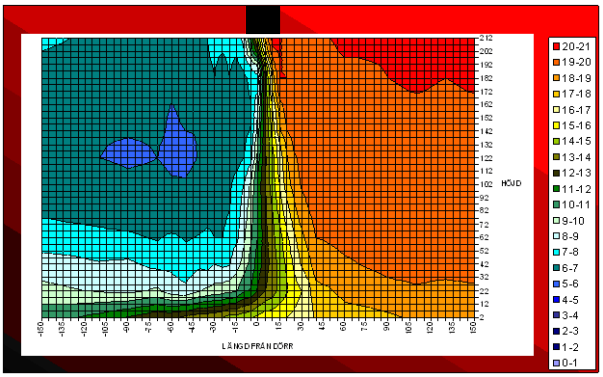


Fig. 2

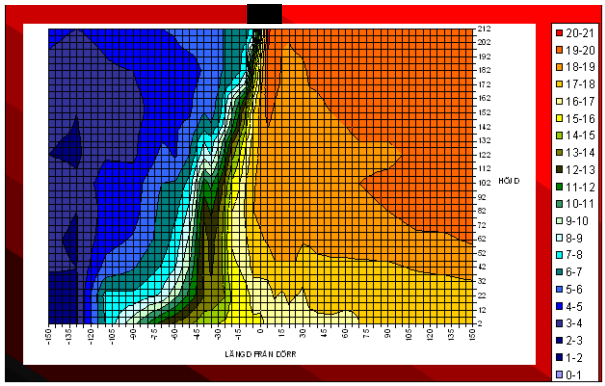


Fig. 3

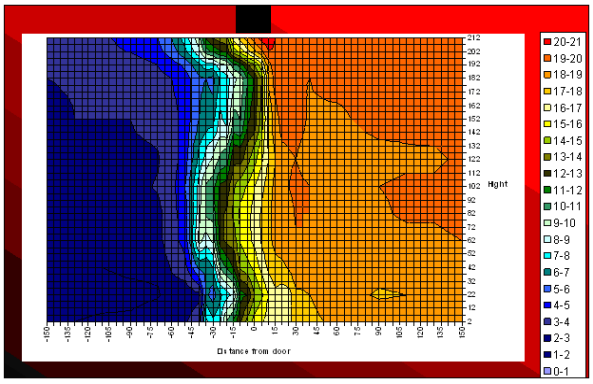


Fig. 4

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Technical aspects of a cold store air curtain

A lot of research work has been done by HEVAC members, BSRIA in the UK and by TNO in the Netherlands into understanding how an air curtain operates and the energy savings associated when compared to an open doorway left unprotected. From this research it has been determined that the cooling power loss (Q) kW from an open cold/chilled store doorway, because of infiltration of air, can be calculated using the following expression by Mann/Hofer.

$$Q = (0.48 + 0.004\Delta T)A(h_w - h_c)\sqrt{H}\rho_c\sqrt{1 - \frac{\rho_w}{\rho_c}}$$

where, ΔT = temperature differential across doorway (°C)
A = area of doorway (m^2)
h_w = enthalpy of air on warm side of doorway (kJ/kg)
h_c = enthalpy of air on cold side of doorway (kJ/kg)
ρ_c = density of air on cold side of doorway (kg/m^3)
ρ_w = density of air on warm side of doorway (kg/m^3)
H = height of doorway (m)

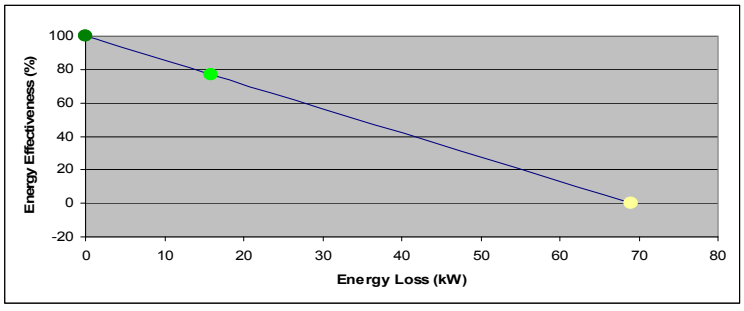
As an example a cold store with a 2.35m high x 1.8m wide doorway has a cold store temperature of minus 22°C with 70% relative humidity. The loading bay area adjacent to the cold store is typically at +7°C, 70% Rh. This equates to a cooling load of 69kW which has to be made up by the cold store refrigeration equipment.

Research has been carried out with FRPERC, University of Bristol, where tests were carried out with a cold store air curtain fitted over the doorway of a cold store. The infiltration of air into the cold store was measured using a CO_2 tracer gas method for different door opening times with and without the air curtain operating. From these tests the effectiveness of the air curtain in preventing infiltration of air was as high as 76.9%, where effectiveness E 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 $Q_a = 1$)



In this case example the cooling load of 69kW would be reduced to 15.9kW (i.e. 69kW x 0.231) with a decrease in electricity costs and a reduction in health and safety hazards from ice formation and fog in the doorway.

Controls

Controls with the air curtain 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.

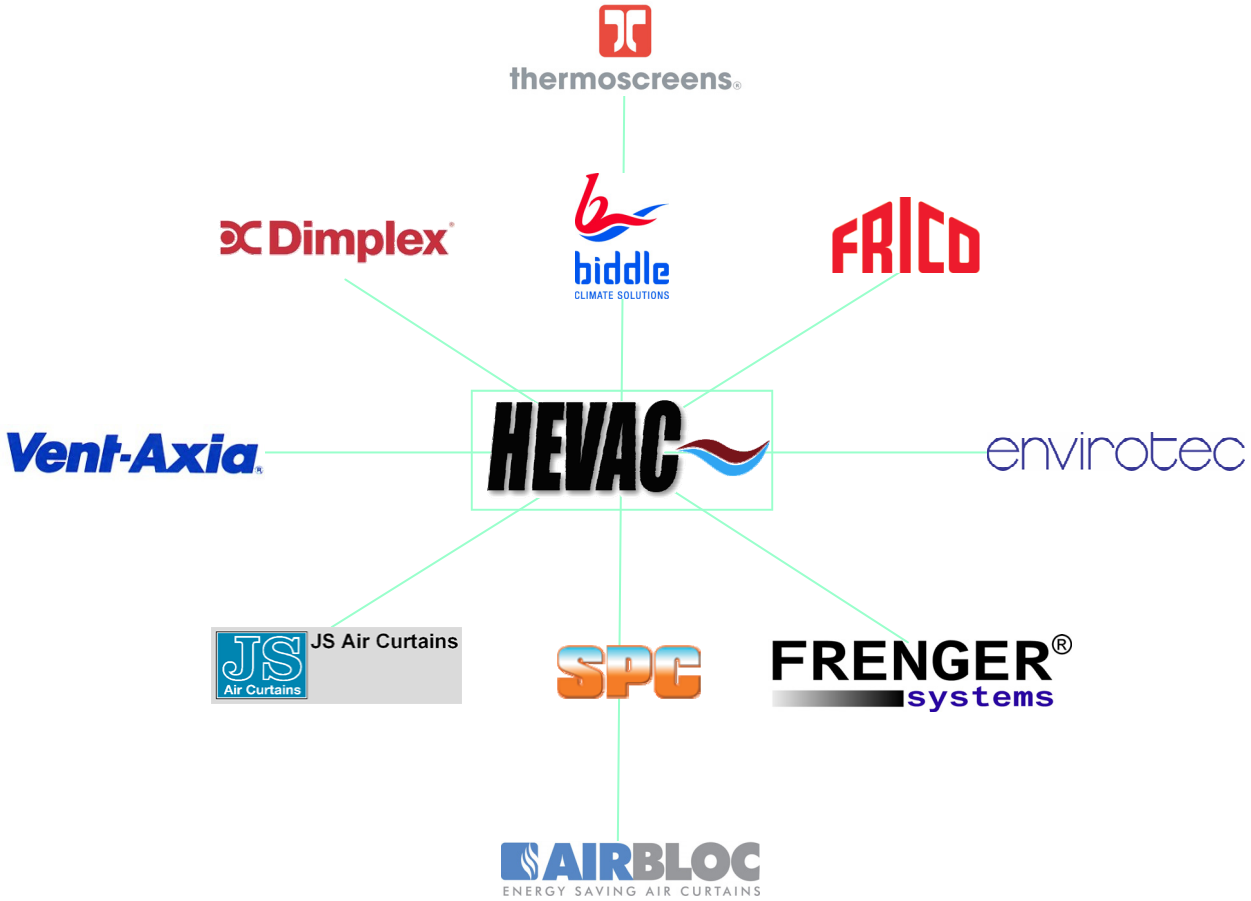
For convenience, user operated controls are normally remotely mounted and configured to satisfy the needs of the building occupants. At the simplest control level only manual operation of the fan(s) and fan speed may be required, however more advanced control options may be included such as:

- Timer On/Off control
- BMS control interface
- Automatic door activation

This guide provides just the basic information on cold store air curtains 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 Air Curtain Industry Group of HEVAC.



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