THE IMPACT OF ENVIRONMENT CONDITIONS ON THE PERFORMANCE OF AN AIR CURTAIN UNIT.

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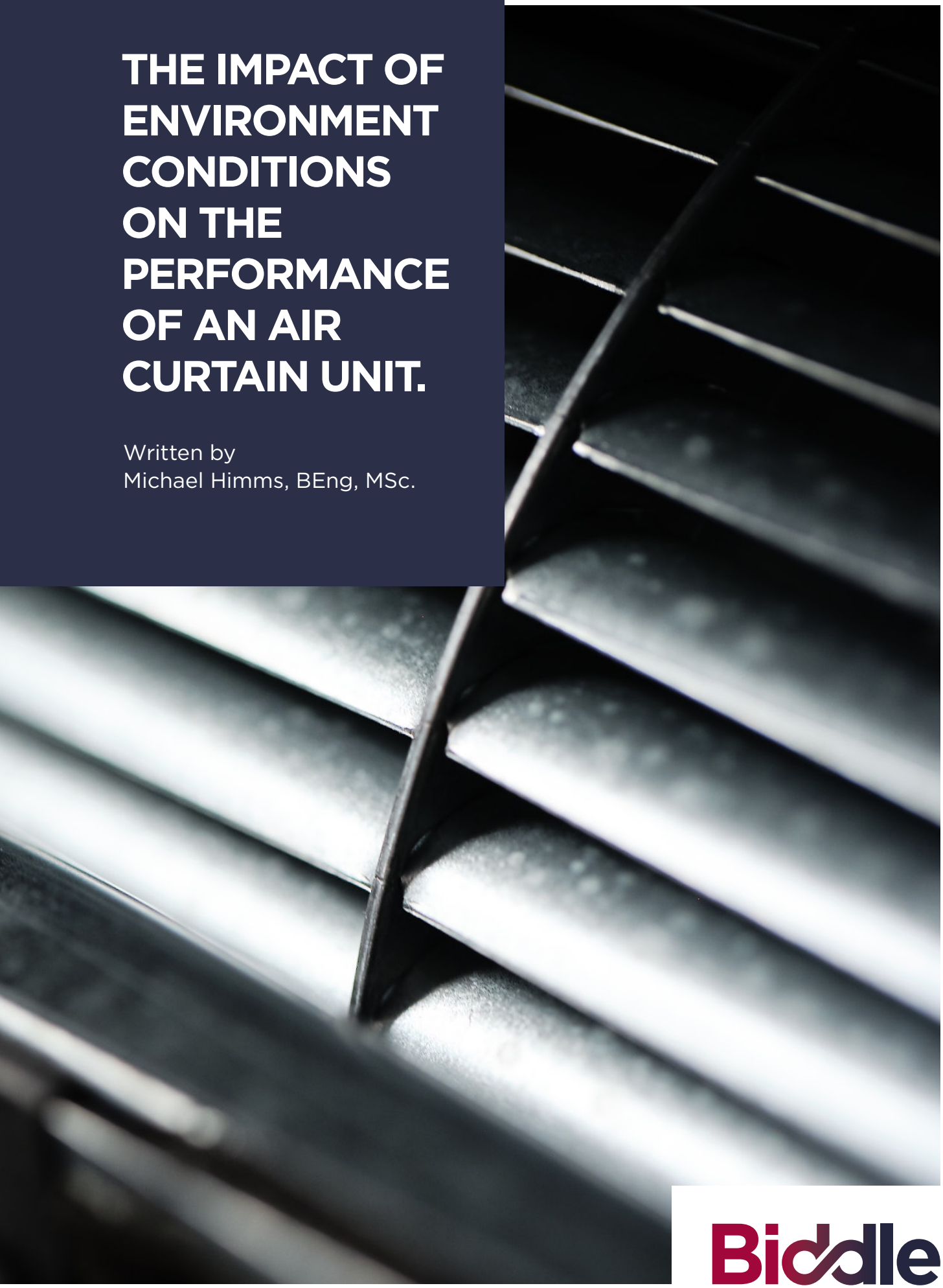


Biddle

INTRODUCTION

The application of air curtains over doorways is a well-documented and universally accepted practice supported with many CFD studies and laboratory tests. Where the research is lacking is how the effectiveness of an air curtain unit can be detrimentally impacted when the units are poorly selected, installed, commissioned or controlled over its product lifecycle.

Typically, air curtain units are selected by mounting height and door width in a particular weather scenario and for a majority of openings this is perfectly acceptable. However, if you shift the temperature down towards a colder winter temperature, or install the unit over an opening with a strong oncoming wind, then the performance and selection can be considerably different.

Weather conditions are continuously changing and it's important that the air curtain unit you're selecting can handle and react to these changing conditions. Eurovent's Air Curtain Guidebook estimates that a poorly selected and controlled air curtain can increase energy usage by 40% over not having one whilst a correctly maintained unit will reduce energy consumption by 60% and an optimised air curtain can reduce this further to 25% of the energy needed than without one.

PURPOSE OF TECHNICAL ARTICLE

This article will examine the impact of environment conditions on the air curtain unit performance, demonstrate what the cost is when it goes wrong and how intelligent and adaptive products like the Biddle SR comfort air curtain can ensure that energy isn't wasted and the SR does what you ask / require from it, to reduce energy consumption, reduce lifetime running costs and improve comfort for the building's users.

TECHNICAL TERMINOLOGY

EFFECTIVENESS

The NEU (National Education Union) reported that £5.4b has been cut from the schools budgets in England since 2015.

$$E = \frac{Qb - Qa}{Qb}$$

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

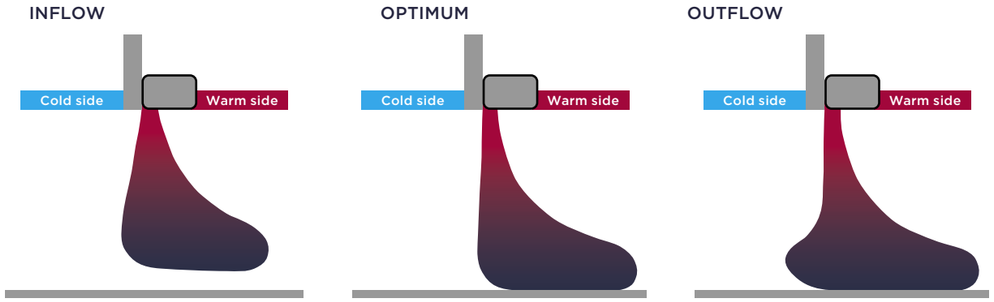
Qb is the energy exchange through an open doorway WITHOUT an air curtain unit fitted

SECOND, EFFICIENCY

Efficiency tends to be incorrectly detailed by some air curtain unit manufacturers – efficiency is a function of energy input and energy outputted from a given system. So, when functionality such as heated air streams come into play it can significantly distort any technical meanings of efficiency. Instead, effectiveness is focused on quantifying the thermal improvements an air curtain unit can make, more in keeping with typical customer's expectations.

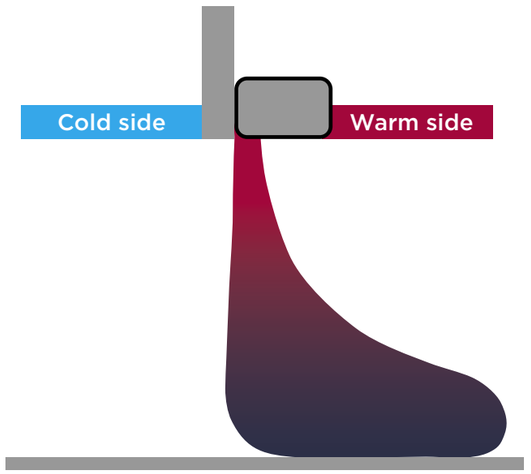
Importantly, when establishing air curtain unit performance, there are three states an air curtain can operating in:

- Inflow condition
- Optimum
- Outflow condition



OPTIMUM PERFORMANCE

Optimum is clearly the desire state, but it's important to stress that the conditions that achieve this state is a function of multiple environment variables that all change continuously. For example if you change the outdoor temperature by just 3 degrees, then the product can quickly change from optimum to inflow:



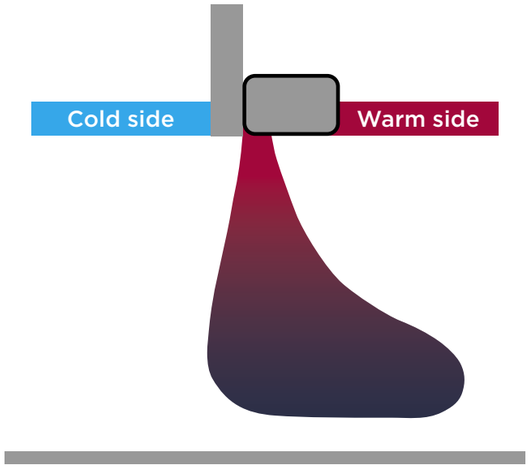
The example above shows an example air curtains performance examined using the Biddle VACP doorloss calculation tool.

SR - The following needs to be placed alongside the image, highlighted maybe within a Biddle red or blue box

Test situations specifics:

- Standard door height and width
- 20c Inside temperature
- 0c outside temperature
- 39c air curtain discharge temperature
- 1m (100cm) discharge length
- 1,000 m3/h flow rate"

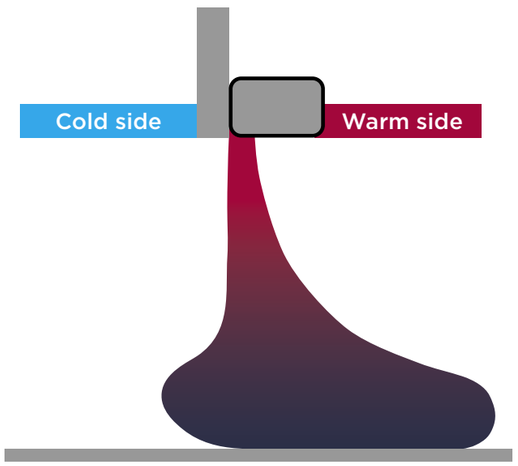
The air curtain is performing at optimum levels and producing a sufficient air curtain.



Now, we have changed over the outside air temperature to -3c, keeping all other variable exactly the same. You will notice that the unit is no longer providing a sufficient air curtain, as the air stream no longer reaches the floor and is now at inflow state.

OUTFLOW

Alternatively, if the air curtain is set to the known optimal settings and begins to run at the start of the day, as the day warms up, the unit can create an 'outflow' state as seen below. This is with a simple change in outside temperature of just 5oC:



All these situations emphasise how significant external factors can be to an air curtain's performance and support the need to select a product with an intelligent control system that can respond to these changes. However, a control system is only as good as it's inputs.

TEMPERATURE SENSORS AND SWITCHES

So, to operate an effective air curtain what sensors are needed?

As a minimum, a good air curtain should use data from the following sensors:

- Door switch – to allow the air curtain unit to detect when the door is open or closed as required in conformance to ASHRAE 90.1.
- Inside temperature sensor – particularly important if the unit is designed with heating to avoid any overheating of the conditioned space.
- Outside temperature sensor – combined with inside temperature, the air curtain can then understand the temperature difference and as such, how strong the convective forces are across the doorway.

INSTALLATION OF SENSORS

The challenge with fitting these sensors then lies with the installer. Some manufacturers opt for remote sensors, or even wireless sensors and both of these present challenges for the installer.

WIRELESS SENSORS

The alternative is to use wireless sensors. Experience shows that these are often a nuisance – constantly replacing batteries and interference in the communication leads to a frustrated end user with a dysfunctional inefficient product with a high level of upkeep. Also, where you NEED to place the sensors and where you CAN place thesensors is different article.

I-SENSE

To address these challenges, the SR features the 'I-Sense' - a passively reading eye continuously scanning the floor, monitoring temperatures both inside and outside, with the ability to detect an open door. Built in to the product, it is factory fitted and factory tested to reduce any time setting up or commissioning on site.

REMOTE SENSORS

Remote sensors need to be hardwired between the unit and the door. If the units are installed close to the doorway such as pictured below , then it is relatively simple, but it's typically hard to hide the cable in a discreet fashion.

Install the units just in inside a high fronted glass building and the problem becomes even more challenging. With a more complicated path for the cables to be routed through, installation and maintenance is more difficult and it can lead to interference.

Occasionally the sensors aren't expected to be wholly accurate due to local disturbances. However, to solve this, the SR unit has a built in averaging feature. Here the data from multiple sensors is averaged and the basis of that is used to derive the unit's functionality.

When sensors like the I-Sense aren't suitable, for example underfloor heated spaces, or vertically mounted applications, in these cases the installer still has the option to go back to more conventional wired sensors, or they can use the built in country specific climatic data. When an SR unit is commissioned the user will enter some specifics such as country the unit is installed in. Whilst this is typically used for language selection in other products, for the Biddle SR comfort air curtain, it allows the unit to load typical climate data models and the unit can then control using that.

Whilst not as accurate as having sensors fitted, it's another tool that Biddle is equipping the installer with to overcome challenges on site and promote an energy efficient product.

CLIMATE SEPARATION – MOMENTUM AND VELOCITY

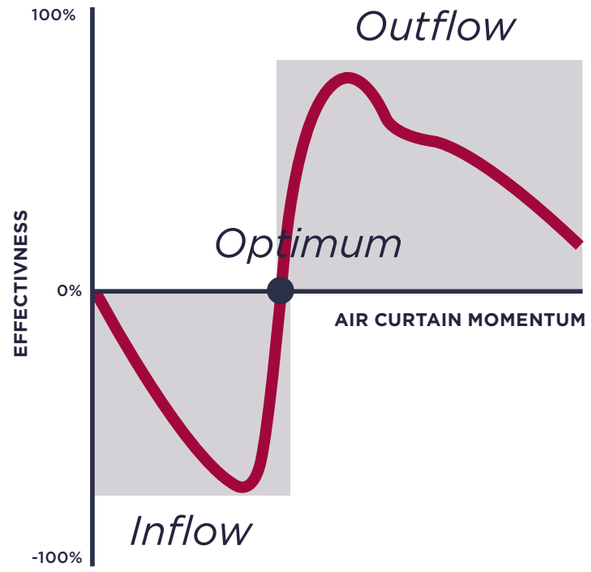
Once the data about the local environment has been collected, the air curtain needs to then use that to achieve the climate separation and associated energy savings.

The principle of air curtains is all about momentum and show clearly in the graph below.

When we examine the graph, what we see is that there is a critical point, the breakthrough point, that up until that point we're actually wasting energy. This outflow condition is the area where underspecified systems, overdoor heaters or even incorrectly controlled air curtain units reside. Increase the power of the unit a little further and suddenly we're climbing the steep curve to maximising the air curtain unit's effectiveness.

If we keep going, then that's where we're now moving into outflow condition. Here, there is so much momentum that it's just hitting the floor and causing turbulence and that conditioned air is start to 'leak' outside.

It's important to note that this article has so far looked at air stream momentum. The equation, familiar to nearly all Engineers is shown below:



$$p = mv$$

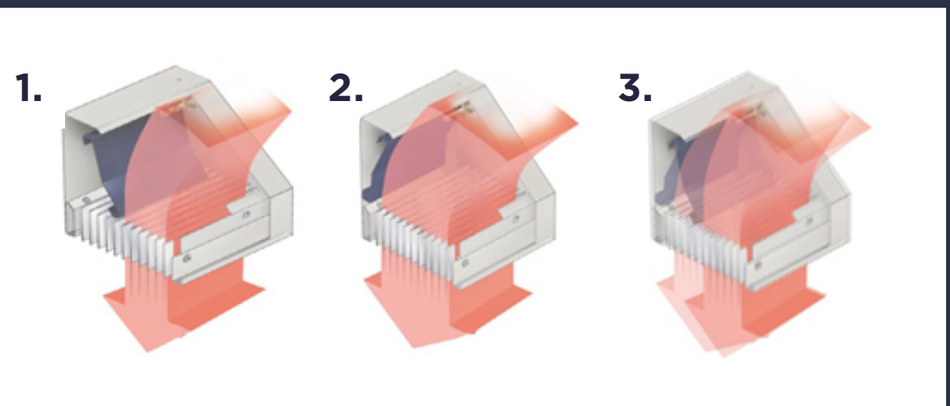
Where: **p – momentum (kg.m/s)**
m – mass (kg)
v – velocity (m/s)

Most people will look at this equation and think to increase the fan speed to achieve increased momentum and they wouldn't be wrong. Increased fan speed will give both higher mass and velocity terms as there is both more air particles and the airflow moves quicker respectively. However, velocity is both a blessing and a curse when applied to air curtains.

Air curtains used for insect control tend to need velocities exceeding 6m/s to sufficient disrupt their flight. For thermal applications however this figure should be relaxed to 2m/s as measured at floor level.

Air curtain manufacturers fall into two categories, those who position their product offer around reaching the momentum required with higher velocities and those who don't. Under laboratory conditions, both work and each method will let you create an air curtain that will become effective at those conditions. The difference though is that you start to factor in changing environments then air curtains with higher velocities are more sensitive to becoming ineffective.

The challenge then is how to change the air curtain's momentum without changing velocity. This is where Biddle's patented damper technology comes into its own in reducing the lifetime operating costs of the unit. As the fan speed increases, the damper moves back increasing the cross sectional area of the grille, allowing more mass through at the same velocity.



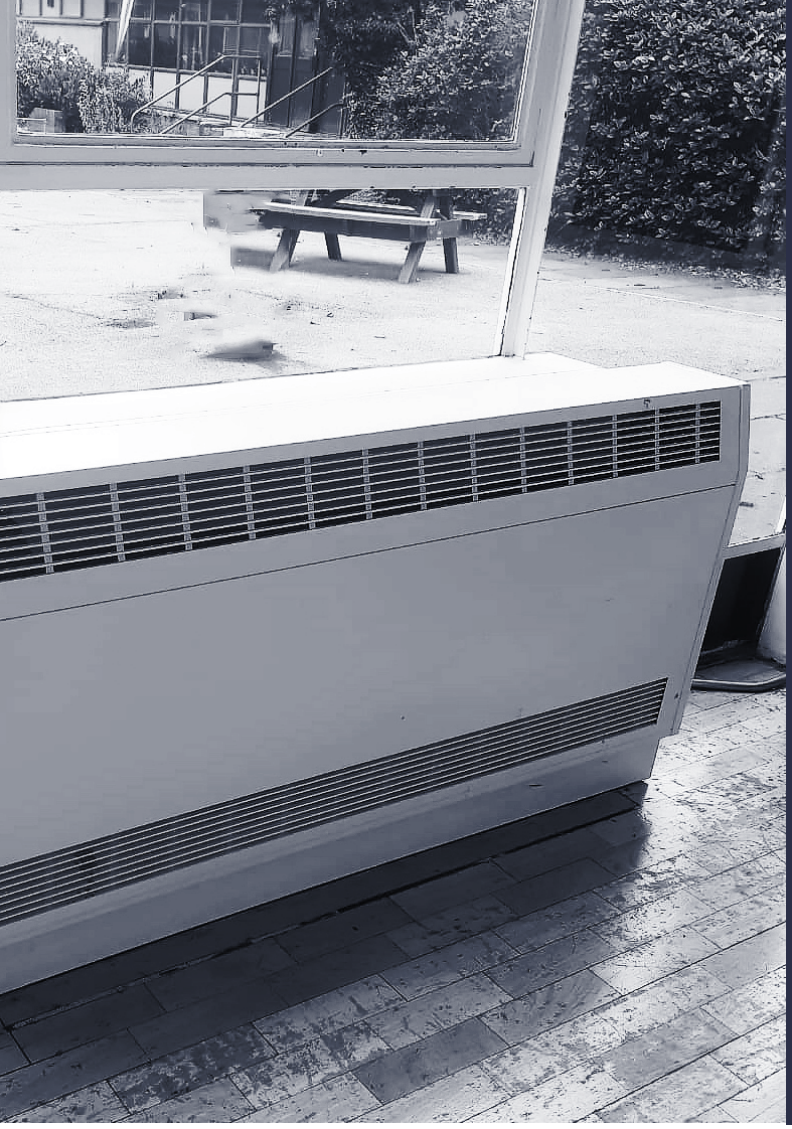
The benefit of these to the end user is four fold:

The first, is that, is that the draught risk is minimised to the building occupants in the immediate vicinity of the unit. All too often do we hear stories of competitor products installed in small premises like coffee shops or small shops that the air curtain unit is causing a draught and to compensate for this they either switch off the unit or switch it to maximum heat all day, both options costing the buildings owner more in building utilities and comfort.

The second benefit is that to generate a higher velocity you have to spin the fans significantly quicker creating noise. The fan affinity laws show us that rpm and pressure is a square law so double the pressure and the rpm of the fan has to increase four times! When you look at the power/rpm law it gets even worse, for the same increase, you'll need nearly eight times the amount of fan power to achieve the same result.

Thirdly, and linked to the previous benefit is that some units use a built in plenum to converge the air stream. This is a design that also creates additional pressure on the fans, and again increases wear.

The final benefit is about wind chill. As explored at the start of this article, the conditions under which the unit works is a constantly moving challenge. It's quite reasonable that in mild external conditions, when the sun hits the front of that shop window and warms up the store sufficiently, it is almost expected that the unit will work as an ambient unit, just offering that protective shield from external odours or smoke particulates. In this case, that higher velocity air curtain is going to have a significantly lower level of thermal comfort for those underneath it than a Biddle SR unit with it's constant velocity air curtain. At 6m/s, the average velocity of the Biddle SR unit, the effects will be substantially more welcoming to that space that a draught gust of high velocity air hitting that prospective customer in the face from other products.



BRINGING IT ALL TOGETHER

We've now looked at how the inputs and outputs of the Biddle SR can be adapted to promote and drive energy efficiency and thermal comfort up in the buildings you're working with and so the final part is to combine these with the unit's built in intelligence. Called CHIPS (Correct Heating and Impulse Predictive System) the SR unit combines all this information and outputs to give effective climatic control under different weather conditions throughout the year.

CONCLUSION

To conclude, air curtains are typically heated units and so therefore can be a large consumer of energy from the building's systems. As such the controls and technologies of the product are of vital importance to ensuring low running costs. You wouldn't just accept a basic on/off heating thermostat, you want one with a timer or maybe adaptive start to realise greater comfort, and the same is true of air curtains. You want an level of automatic control that can react to the environment for both your wallet's sake and those that are using the space. This is whee the SR is a different product proposal to the competitors as that level of automatic control is built in, tested and approved by the experts.

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