

# Catalogue

[www.breathingbuildings.com](http://www.breathingbuildings.com)

# Breathing Buildings is the UK's leading natural and hybrid ventilation company - home of the E-Stack and NVHR mixing ventilation systems that are changing the world

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When we started the company back in 2006 you had a choice between cold draughts and wasteful pre-heating of air. Our patented **E-Stack mixing ventilation** products and strategy, allied to **smart controls and superb engineering** has changed that forever. The benefits of mixing ventilation are now so clear that they have been written into regulations, a testimony to the **evidence we can show you** of making it work.

Our catalogue is intended to make it easier for you to choose the right ventilation system, we hope it helps. Please get in touch with us so that **we can show you our systems at work delivering superb indoor environments**. It is something we are incredibly proud of and we want your building project to be just as successful. At Breathing Buildings that means supporting you from initial design right through to making sure it works as you expect.

**Let us prove it to you.** Come and visit one of our buildings and allow us to help you with yours.

# Contents

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## Introduction

- 06** Breathing Buildings
  - 08** What Is Natural Ventilation?
  - 09** Why Use Natural Ventilation?
- 

## Control Strategy and Options

- 10** Control Strategies
  - 11** Ventilation Systems
  - 12** Our Product Solutions
- 

## E-Stack® Mixing Ventilation Systems

### R Series

- 15** Product Information
- 17** Performance & Installation
- 17** System Schematic & Wiring

### S Series

- 19** Product Information
- 23** Performance & Installation
- 23** System Schematic & Wiring

### A Series

- 25** Product Information
- 27** Installation
- 27** System Schematic & Wiring

### F Series

- 29** Product Information
  - 31** Performance & Installation
  - 31** System Schematic & Wiring
- 

## Passive Ventilation

- 33** Product Information
  - 36** Roof Terminals
  - 41** Dampers
  - 42** Passive Stack Ventilation
- 

## Case Studies and Thought Leadership

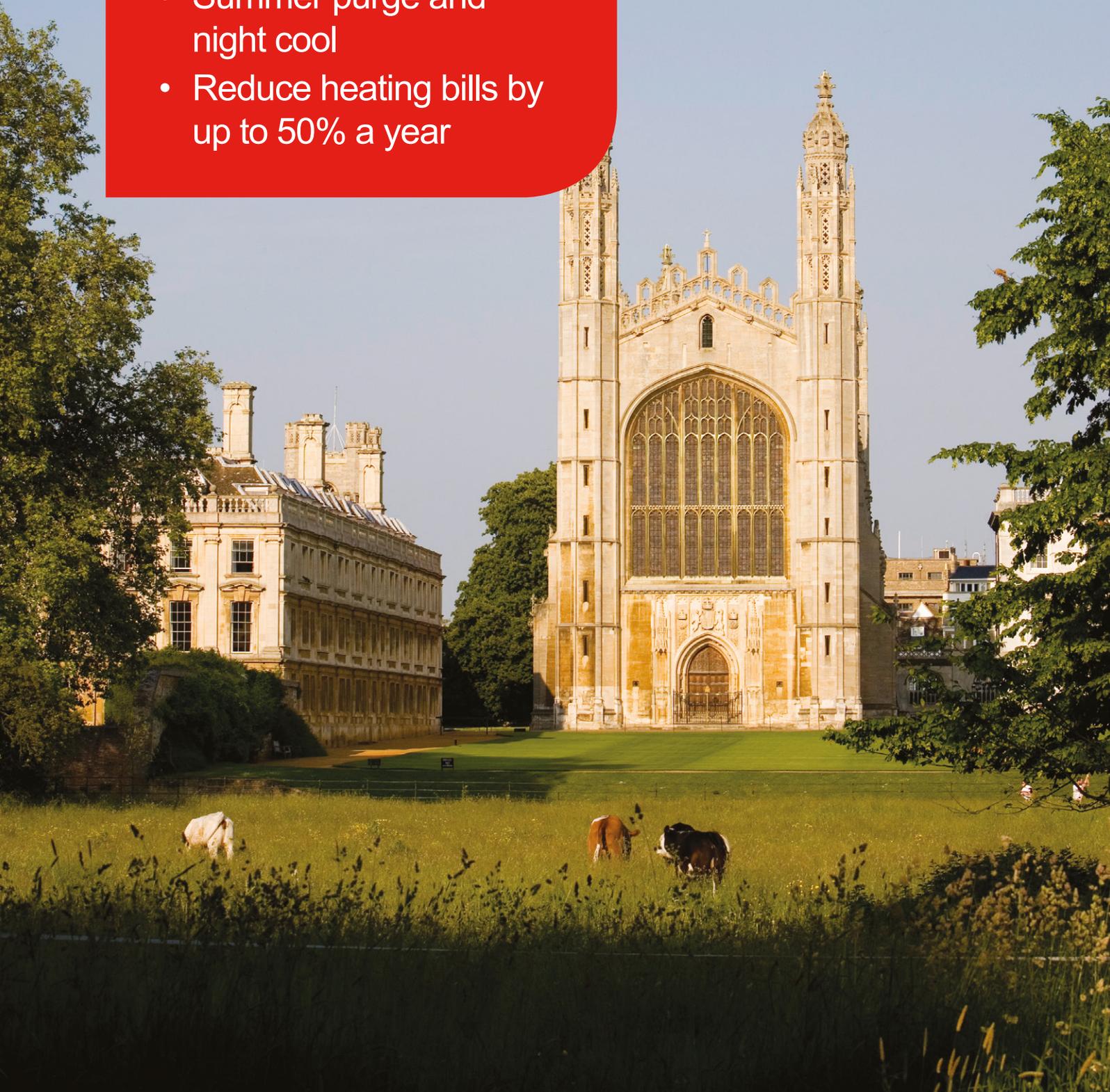
### Case Studies

- 44** Linton Village College
- 46** Hammerson Retail
- 48** Asda Langley Mill
- 50** Houghton-Le-Spring Primary Care Centre
- 52** Barnfield Village College

### Thought Leadership

- 54** The Science of Cold Draughts
  - 56** Thermal Modelling, WaterBath Modelling and CFD
  - 58** Building Bulletin 101 - User Guide
  - 66** Modelling Ventilation in IES
  - 67** The Breathing Buildings Difference
-

- Superb internal climate
- World leaders in winter mixing ventilation
- CO<sub>2</sub> and temperature monitoring
- Summer purge and night cool
- Reduce heating bills by up to 50% a year





**Breathing Buildings is the leading solutions provider in the field of Natural and Hybrid Ventilation. We offer you a full turnkey service and a selection of services to suit your needs.**

#### **1. Advisory Services**

- Expert consultation on natural and hybrid ventilation

#### **2. Design Services**

- Dynamic thermal modelling
- Computational fluid dynamics
- Water bath modelling
- Design responsibility with full PI cover

#### **3. Product Solutions**

- Products to meet your criteria
- Fully automatic controls or manual controls
- Integration with other building systems including BMS, HVAC and heating

#### **4. Installation Support**

#### **5. Commissioning and User Training**

#### **6. Service**

- Maintenance, Software Upgrades  
Extended Warranty

#### **7. Monitoring**

Let us help you  
change the world...

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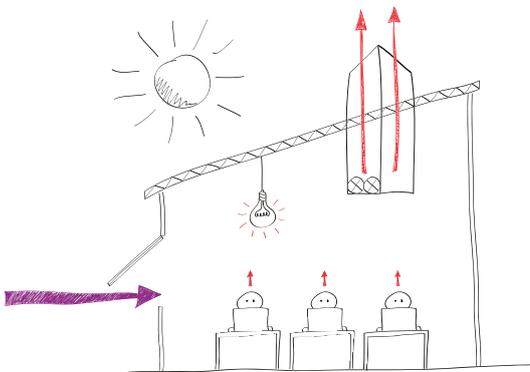
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# Breathing Buildings

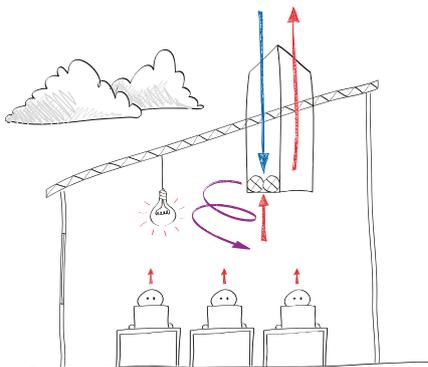
Breathing Buildings is the UK's leading low energy ventilation company – a spinout from Cambridge University that is changing the world of natural ventilation

## E-Stack Mixing Ventilation

A research programme at Cambridge University created a new concept for ventilation that combines the principles of natural mixing ventilation in winter and natural upward displacement ventilation in summer. This was patented in 2005 and the company was set up to develop an easy-to-install system derived from the patent, and to provide the resulting E-Stack product range to the industry.



Summer Strategy  
Upwards Displacement Ventilation



Winter Strategy  
Mixing Ventilation

## What We Do For Our Clients

### Our Mission is Simple

We aim to help clients create the lowest energy building possible with minimum associated CO<sub>2</sub> emissions and capital cost, whilst providing appropriate levels of ventilation and thermal comfort at all times of the year. We do this through our range of innovative ventilation products and through our unique design consulting.

### Natural and Hybrid Ventilation Products

- E-Stack Mixing Ventilation (p15)
- Passive Stack Ventilation (p42)

### Design Consulting

- Online Design Tools
- Dynamic Thermal Modelling
- Computational Fluid Dynamics
- Water Bath Modelling
- All design work covered by Professional Indemnity Insurance

## Installation and After Sales Support

We offer a turnkey solution for our clients, including:

- Design support throughout the project
- In-room user interface
- BMS integration
- Installation
- Final inspection
- Service and maintenance contracts
- Ongoing monitoring

We will work with you from start to finish to ensure a successful project.

We have projects all over the country so let us take you to one near you:

## Seeing is Believing

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**Samuel Lister Academy Yorks PSBP** is one of the first UK schools to make use of the NVHR+ enhanced natural ventilation system. The NVHR+ heater pod variant incorporates a 'Low Temperature Hot Water' heating coil, and is an example of Breathing Buildings' continued product development. The BB team worked closely with the architect and main contractor to develop a precisely-tailored solution for the needs of this development.



**YMCA East Anton** is a purpose-built nursery for 0-5 year olds which opened in October 2017. At early design stage it was suggested that the classrooms should have mechanical ventilation systems. However, YMCA had concerns about the energy use as well as maintenance costs associated with a mechanical ventilation scheme. Breathing Buildings were approached by Darcy Construction to design a natural ventilation system that would be unobtrusive and provide high levels of ventilation to keep the rooms fresh.



**St Raphael's Primary School** in London features a low-energy ventilation solution designed by Breathing Buildings for a new teaching block. The building, completed in January 2015, includes a double-height dance/activity hall (ventilated with e-stack S1500 units), three ground floor classrooms (ventilated with NVHR units) and three first floor classrooms (ventilated with e-stack R-Series units).



## Awards

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See our website for a list of Awards which Breathing Buildings and our clients have won

Find a project near you:  
[www.breathingbuildings.com/projects](http://www.breathingbuildings.com/projects)

Call us now and find out  
how we can help:  
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# What Is Natural Ventilation?

Natural Ventilation is the process of using natural air movement, caused by the effects of wind and buoyancy, to provide fresh air into buildings

In its simplest form natural ventilation is opening windows to allow air into and out of a room. This solution might be appropriate if the requirements are simply “some” fresh air in the immediate proximity of the window. Our products can help address the other factors which are important to a successful natural ventilation system; these include:

**Winter Mixing** - avoiding cold draughts in colder weather: Our patented E-Stack Mixing Ventilation system actively mitigates cold draughts using a duct temperature sensor and control strategies developed over the last ten years.

**Thermal Comfort** - preventing overheating in hotter conditions: Our unparalleled technical expertise ensures that the system is correctly sized. The E-Stack systems incorporate night cooling as standard to make the most of the thermal mass of a building. We can back this up by taking on design responsibility supported by Professional Indemnity insurance.

**Heat Gains and Occupancy** - designing a system that responds to conditions in the room and outside: We actively monitor and respond to the temperature and CO<sub>2</sub> levels in a room, with our control strategy ensuring the right ventilation strategy at all times.

Breathing Buildings has significant experience helping teams to design both simple buildings and complicated spaces.

By understanding these factors and sizing the system correctly we can design a natural ventilation system that provides appropriate air flow without the need for a mechanical system. Most building types are suitable for natural ventilation including homes, offices, schools, theatres and healthcare centres. Natural ventilation also works with acoustic constraints and we have designed systems that work under flight paths and next to motorways.

“ We do not leave you once our systems are installed - we offer an ongoing maintenance and extended warranty service ”



# Why Use Natural Ventilation?

The built environment accounts for around 45% of the energy consumption in developed countries

Naturally ventilated buildings use 60% less energy than a traditional mechanically ventilated air conditioned building

## Winter

The E-Stack Mixing Ventilation system saves energy in winter by avoiding the wasteful pre-heating required in other systems. This cuts heating bills and saves you money.

Natural ventilation avoids the electrical energy required by MVHR systems to force air through high resistance heat exchangers, cutting electricity bills and saving money.

## Summer

The E-Stack Ventilation system uses buoyancy and wind effects to allow air to move through the building without using electrical energy to push the air.

E-Stack also includes a night cooling strategy that takes advantage of cooler night air to cool the fabric of the building. This keeps the building cooler for longer removing the need for air conditioning and saving you money.

“We are very hopeful that this unique approach will deliver carbon emission savings and energy cost savings in excess of any we could achieve using either mechanical or traditional natural ventilation systems”

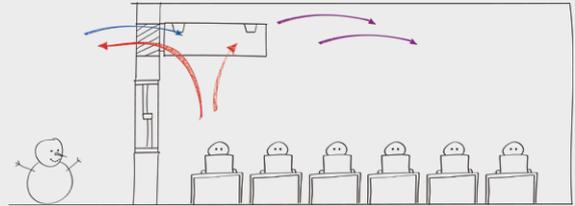
Asda, Head of Corporate Sustainability, Julian Walker Palin



# Control Strategy

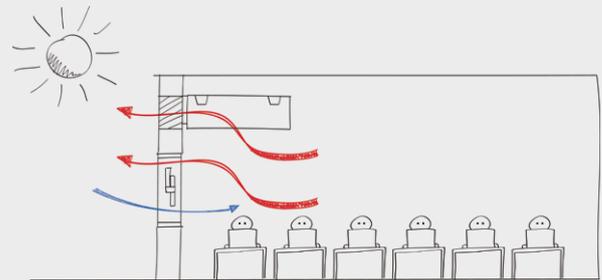
## 01 Mixing Ventilation

- Patented ventilation strategy
- Pre-mixes incoming fresh air with room air to mitigate cold draughts
- Monitors internal and external temperature, and temperature of mixed air
- Responds to CO<sub>2</sub> in the room
- Reduces heating bills



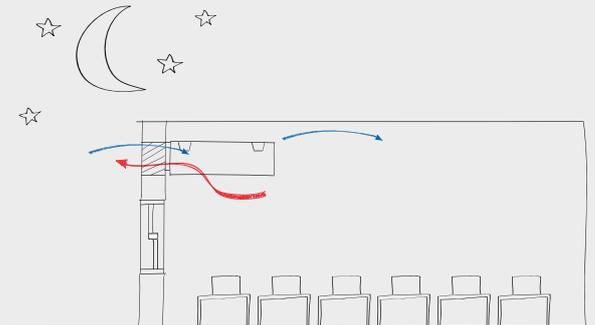
## 02 Displacement Ventilation

- Buoyancy and wind driven flow
- Maximum stack effect when combined with low level openings
- Monitors internal and external temperature
- Responds to CO<sub>2</sub> and temperature in the room



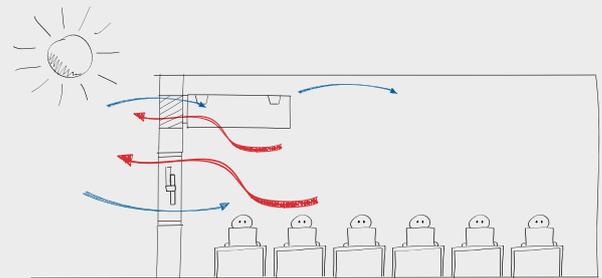
## 03 Night Cooling

- Provided through secure openings
- Buoyancy and wind driven flow
- Cools fabric down overnight to provide convective and radiative cooling the following day
- Fan boost function at 3am on warm nights to ensure fabric is cooled
- Monitors internal and external temperature



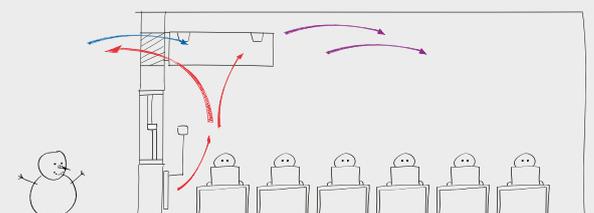
## 04 Summer Boost

- Fan-assisted ventilation on hottest days
- Monitors internal and external temperature



## 05 Heating Control

- Patented system
- Local control of radiator valve or underfloor heating manifold
- Ensures ventilation system integrates with the heating system
- Minimises heating bills



# Ventilation Systems

## Roof Mounted Ventilation

Page 14 to 23

- Patented mixing system for draught mitigation
- Passive stack option for taller spaces or where draughts are not a problem
- Mushroom cowl or penthouse louvre terminals
- Damper, internal grilles and mixing system
- Acoustic attenuation option for noisy sites
- R Series or S Series options



## Atrium Ventilation

Page 24 to 27

- A500 and Passive options
- High level automated windows and/or dampers in atrium
- In - and outflow through high level vents, and transfer to occupied rooms through A Series units
- Rooms with lower heat gain benefit from rooms with higher heat load to minimise heating bills
- Acoustic attenuation option for noisy sites



## Facade Ventilation

Page 28 to 31

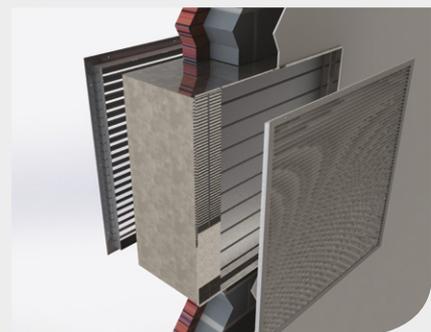
- Patented mixing system for draught mitigation
- F500, F1000 options
- Louvre, damper, internal grilles and mixing system
- Acoustic attenuation option for noisy sites
- Can be combined with passive attenuators to link to atrium



## System Components

Page 32 to 42

- Louvres
- Dampers
- Grilles
- Acoustic attenuators
- Mechanical Ventilation



# Our Product Solutions

Smart design is important but we want to change the world of ventilation and we have the product range to help you

				Control Options						
		Occupancy per unit	Type	NV Smart	NV Smart +	NV Smart + Connected	Stackvent	Stackvent Connected	Manual Control	Without Control
Roof Units	R Series	10-35	Stack	•	•	•				
	S1500	35-100	Stack	•	•	•				
	S1200	10-35	Stack	•	•	•				
	S1000	10-17	Stack	•	•	•				
Atrium	A500	10-35		•	•					
Façade	F1000	10-35	Façade	•	•	•				
	F500	10-17	Façade	•	•	•				
NVHR	NVHR	10-17	Façade	•	•	•			•	
	NVHR+*	10-17	Façade			•				
Passive Stack	PS600	Design	Stack				•	•	•	•
	PS800	Design	Stack				•	•	•	•
	PS1000	Design	Stack				•	•	•	•
	PS1200	Design	Stack				•	•	•	•
	PS1500	Design	Stack				•	•	•	•
	PSR	Design	Stack				•	•	•	•

\*Heating control is included

	Strategy					Integration						
	Natural Displacement Ventilation	Summer Boost / Purge	Night Cool	Winter Mixing	Draught Mitigation Strategy	BMS Integration	Cooling Interlock	Heating Interlock	Heating Control	Actuated auxiliary damper control and power	Actuated window control	Actuated window control and power
NV Smart	•	•	•	•	•							
NV Smart +	•	•	•	•	•		•	•	◦	•	◦	◦
NV Smart + Connected	•	•	•	•	•	•	•	•	◦	•	◦	◦
Stackvent	•		•									
Stackvent Connected	•		•			•				◦		
Manual Control	•											
Without control	•											

Key: • Comes as standard ◦ Option at additional cost



The R Series unit is a ceiling mounted unit that has been designed to...

ventilate a room  
with occupancies  
from 10-35  
people.

The split shaft provides inflow and outflow in winter and combines with opening windows in the summer to create a stack effect. Integrated fans mitigate cold draughts in a low energy way delivering appropriate ventilation and superb thermal comfort with fan boost and night cooling as standard.



# R Series

The R Series is one of our most popular units. Designed for a space the size of a standard 55-65m<sup>2</sup> room, ventilation is provided through a split shaft giving access to the roof

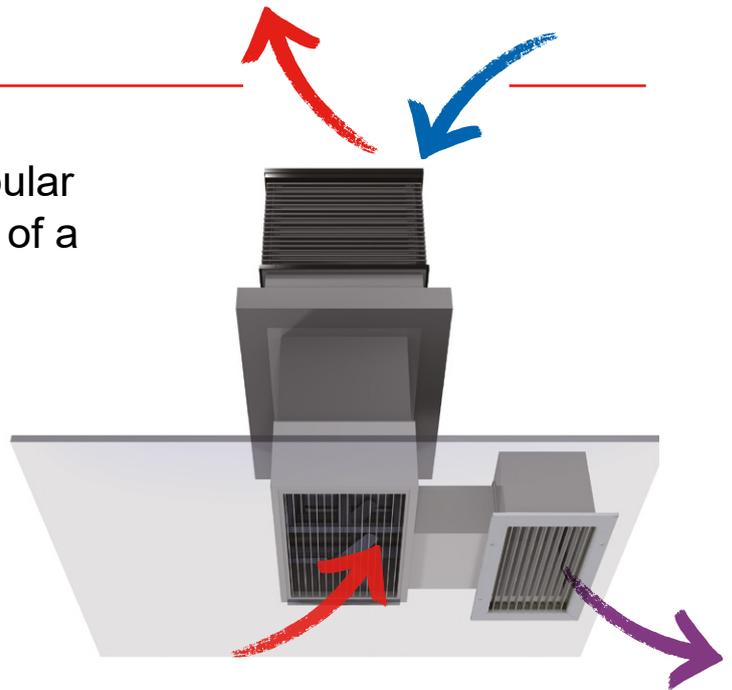
## Product Information

### Features

- Low energy mixing fans to mitigate against cold draughts in winter
- Summer exhaust boost mode
- Night cooling
- Insulated volume control damper ensures appropriate ventilation rates
- Internal temperature sensor with integrated CO<sub>2</sub> sensor
- External temperature sensor
- Integral control responds to environmental conditions
- Ready fitted mounting brackets
- Three choices of mixed air delivery direction
- Key switch for automatic operation; test; off

### Options

- Penthouse louvre or mushroom terminal
- Integrated noise attenuation unit offering 33dB D<sub>new</sub> for noisy sites, more available on request
- Patented heating control strategy ensures minimum energy use
- Control signal for automated actuation of low level windows or dampers
- Modbus link for integration into wider Building Management Systems (BMS)
- Eggcrate grilles

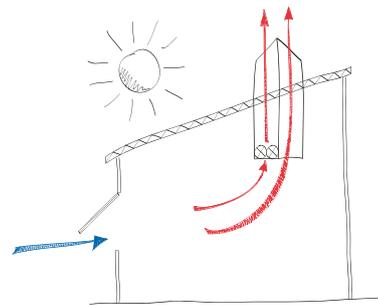


## Air Flow Strategies

### Summer Mode

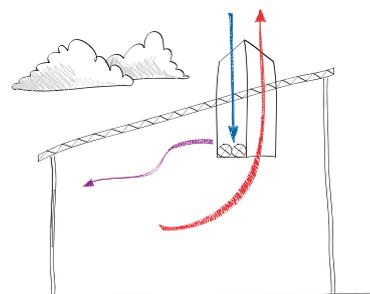
When it is warm outside the system operates in upflow displacement mode, using the stack effect to achieve high air flow rates and keep the room at a pleasant temperature.

Fan boost and night cooling modes offer greater thermal comfort in exceptional summer conditions.



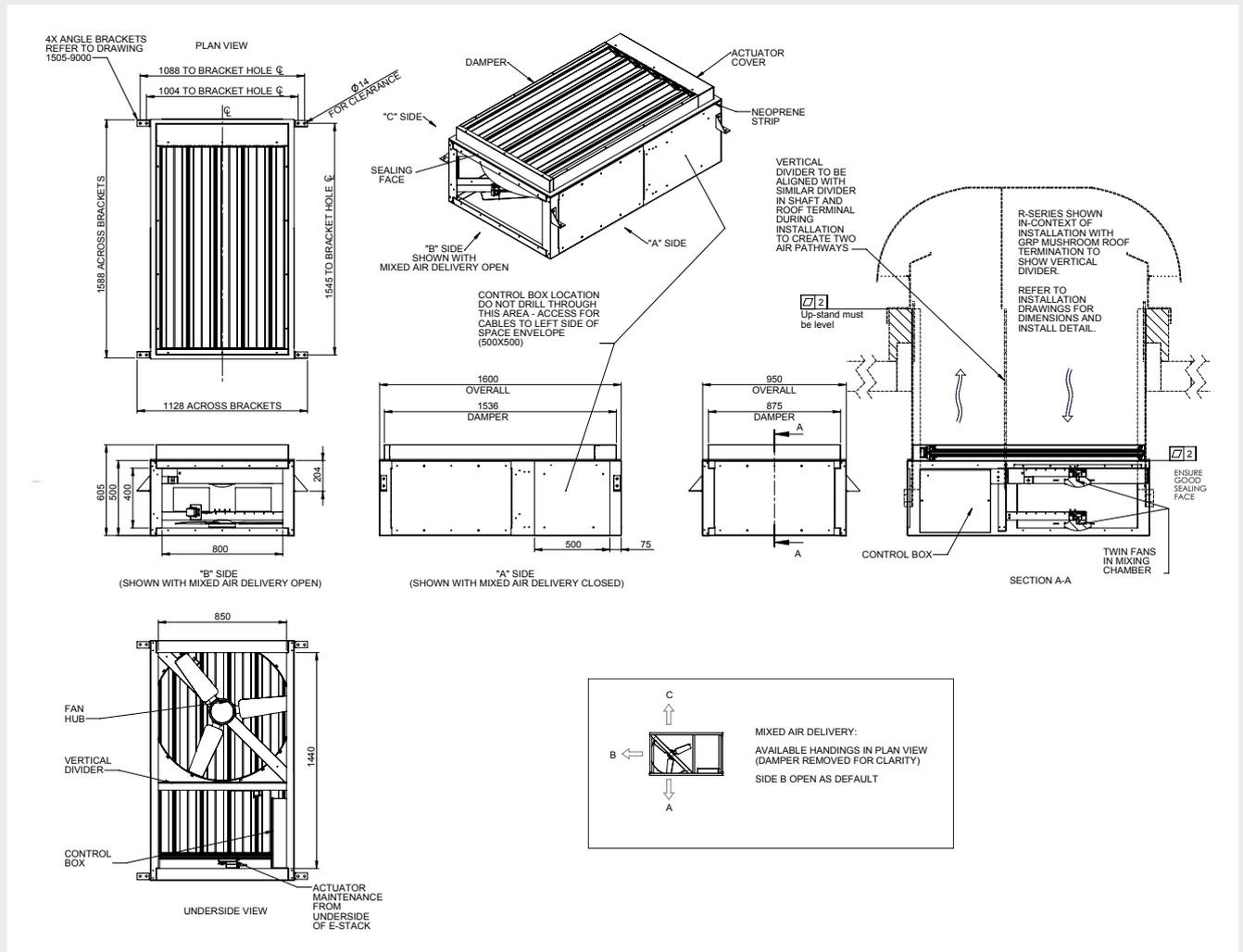
### Winter Mode

When the outside temperature becomes too low to bring directly onto the occupants the R Series unit operates as inflow and outflow. The fans in the unit pre-mix the incoming air with air from within the room, preventing the need for wasteful pre-heating.



## R Series continued

## R Series Dimensioned Drawing

**Dimensions**

H	500 mm
D	950 mm
W	1,600 mm
Weight	110 kg
Physical area	0.75 m <sup>2</sup>
Effective Area (A*)	0.6 m <sup>2</sup>

**Electrical**

Power Rating	0.1 kW
Voltage	230V AC (+/- 10%)
Full load current	0.5A
Short Circuit Rating	N/A - Control only
Earth Leakage	<3.5 mA

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**Acoustic Performance**

Frequency Band (Hz)	Sound Power (dB)								Overall	Ambient
	63	125	250	500	1k	2k	4k	8k	dB (A)	dB (A) <sup>#</sup>
Winter Slow	41	47	38	35	30	26	18*	24*	36.8	32.8
Winter Fast	44	50	41	38	34	28	18*	24*	39.6	34.4
Summer Boost	44	46	42	40	37	29	18*	24*	39.1	35.0

\* denotes results at background

# Ambient sound pressure in typical classroom for BB93

## Performance

### U-Value

Part L2a requirement	3.5 (W/m <sup>2</sup> K)
R Series	2.2 (W/m <sup>2</sup> K)
Damper section	<0.8 (W/m <sup>2</sup> K)

### Damper Air Leakage

Part L2a requirement	10 m <sup>3</sup> /h/m <sup>2</sup>
R Series	2.9 m <sup>3</sup> /h/m <sup>2</sup>
Tested at 50 Pa across whole damper unit	

### Conformity

CE marking	Yes
BB93 (standard room)	Yes

## Installation

The R Series comes with fixing brackets.

The E-Stack unit can be hung from 4 no. pieces of M10 (drop rods).

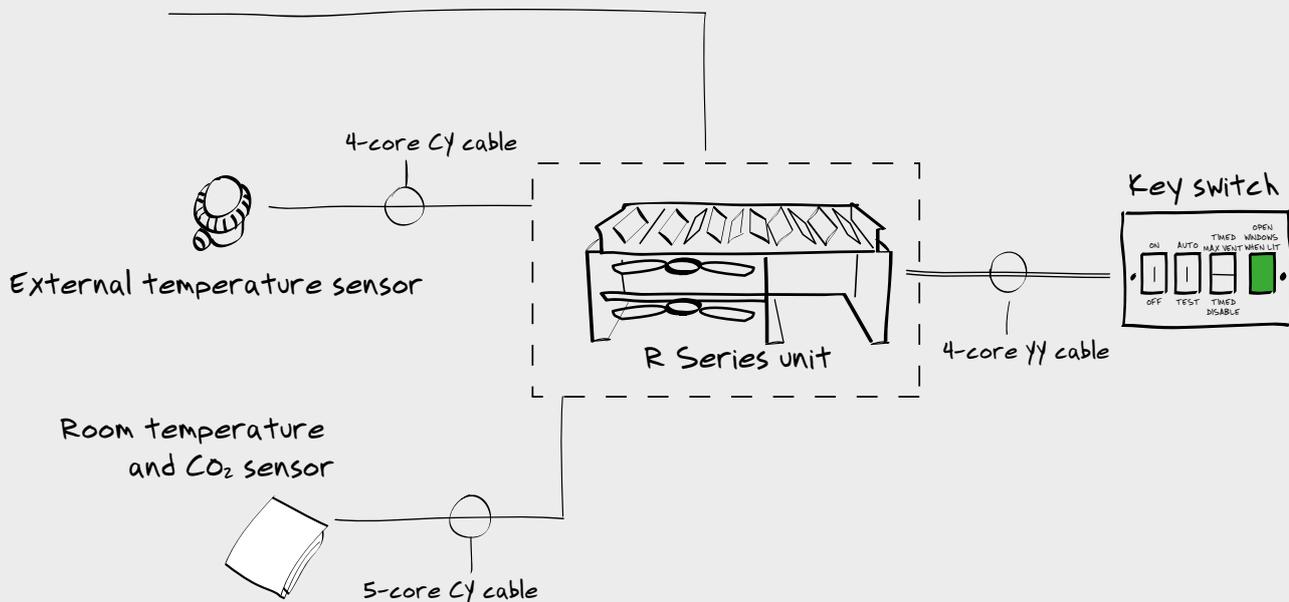
### Mixed Air Temperatures at the Occupied Zone

External Temp	Internal Temperature				
	21	22	23	24	25
14	19.5	20.0	20.5	21.0	21.5
12	18.5	19.0	19.5	20.0	20.5
10	17.5	18.0	18.5	19.0	19.5
4	14.5	15.0	15.5	16.0	16.5

Based on fresh air flow rate of 150 l/s, 30 people at 5 litres/person/s

## System Schematic and Wiring

13A Double Pole Switched Fused Connection Unit (FCU) for complete isolation



# The S Series unit is a ceiling mounted unit that comes in 3 sizes S1500, S1200 and S1000

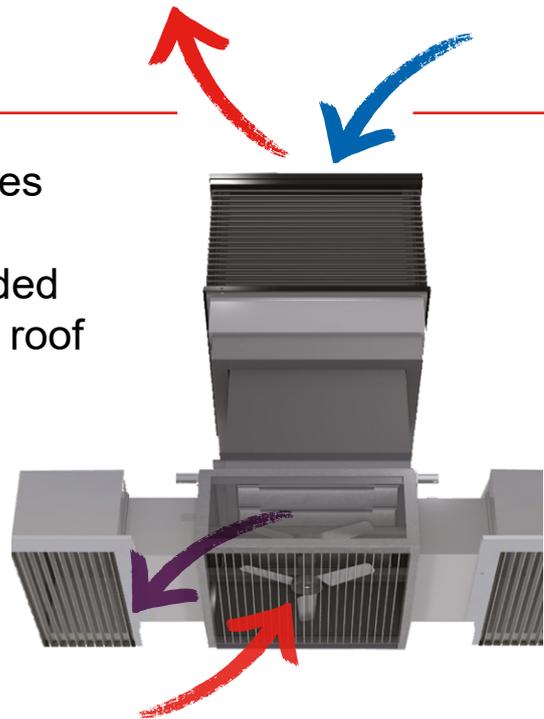
The S1500 has been designed to ventilate a room with occupancies from 35 to 100 people, the S1200 for spaces with occupancies of 15 to 35. S1000 units are suitable for spaces with lower heat gains or when operating as multiple units. For larger spaces multiple S Series units are installed and can be controlled independently or in zones.



# S Series

The S Series is designed for larger spaces such as school halls, theatres or rooms with high occupancy. Ventilation is provided through a split shaft giving access to the roof

The split shaft for the S1500L and S1200L provides inflow and outflow in winter and can combine with opening windows or dampers in the summer to create a stack effect. Integrated fans mitigate cold draughts in a low energy way delivering appropriate ventilation and superb thermal comfort as well as providing fan boost and night cool functionality.



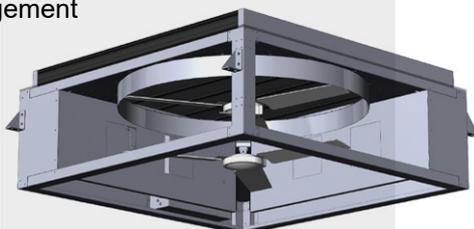
## Product Information

### Features

- Low energy mixing fans to mitigate against cold draughts in winter
- Summer exhaust boost mode
- Night cooling
- Insulated volume control damper ensures appropriate ventilation rates
- Internal temperature sensor with integrated CO<sub>2</sub> sensor
- External temperature sensor
- Integral control responds to environmental conditions
- Traffic light indicator panel for window opening
- Ready fitted mounting brackets
- Three choices of mixed air delivery direction
- Key switch for automatic operation; test

### Options

- Low level control panel
- Penthouse louvre or mushroom terminal
- Integrated noise attenuation unit offering 35dB D<sub>new</sub> for noisy sites, more available on request
- Patented heating control strategy ensures minimum energy use
- Control signal for automated actuation of low level windows or dampers
- Modbus link for integration into wider Building Management Systems (BMS)
- Eggcrate grilles

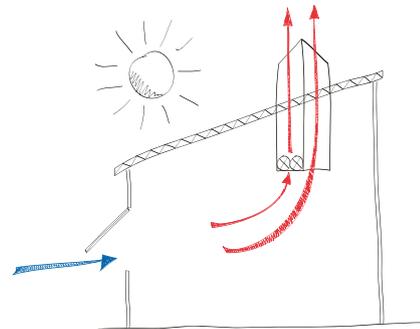


## Air Flow Strategies

### Summer Mode

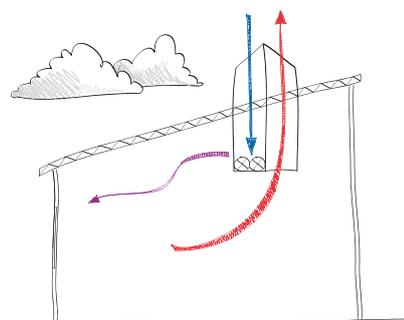
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Fan boost and night cooling modes offer greater thermal comfort in exceptional summer conditions.



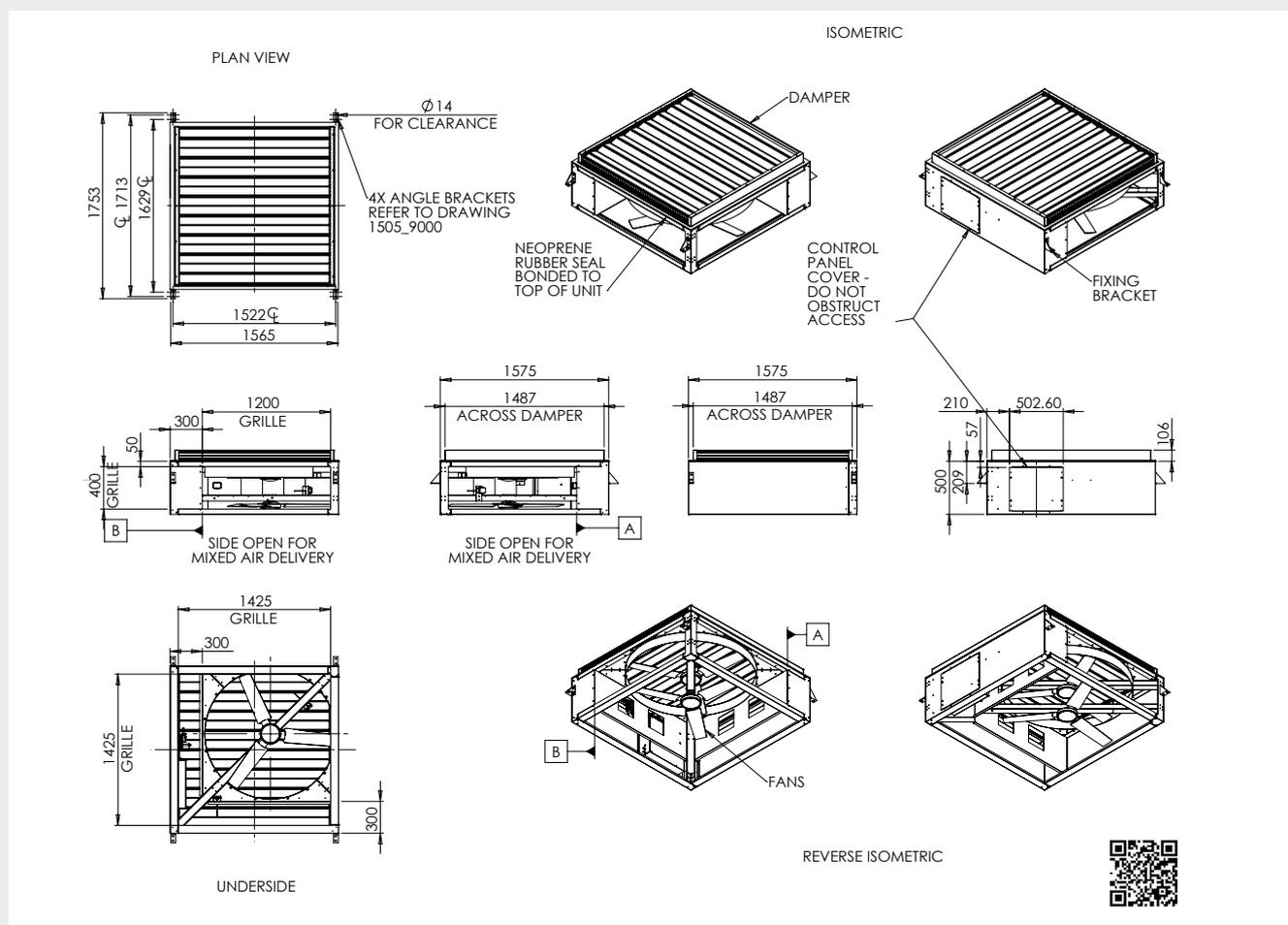
### Winter Mode

When the outside temperature becomes too low to bring directly onto the occupants the S Series unit operates as inflow and outflow. The fans in the unit pre-mix the incoming air with air from within the room, preventing the need for wasteful pre-heating.



## S Series continued

## S1500 Dimensioned Drawing

**Dimensions**

H	500 mm
D	1,500 mm
W	1,500 mm
Weight	168 kg
Physical area	1.54 m <sup>2</sup>
Effective Area (A*)	1.08 m <sup>2</sup>

**Electrical**

Power Rating	0.1 kW
Voltage	230V AC (+/- 10%)
Full load current	0.5A
Short Circuit Rating	N/A - Control only
Earth Leakage	<3.5 mA

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**Acoustic Performance**

Frequency Band (Hz)	Sound Power (dB)								Overall dB (A)	Ambient dB (A)#
	63	125	250	500	1k	2k	4k	8k		
Winter Slow	41	42	39	38	34	24	18*	24*	38.7	31.7
Winter Fast	46	47	44	42	40	30	18*	24*	43.5	33.8
Summer Boost	41	41	40	40	38	28	18*	24*	41.1	32.6

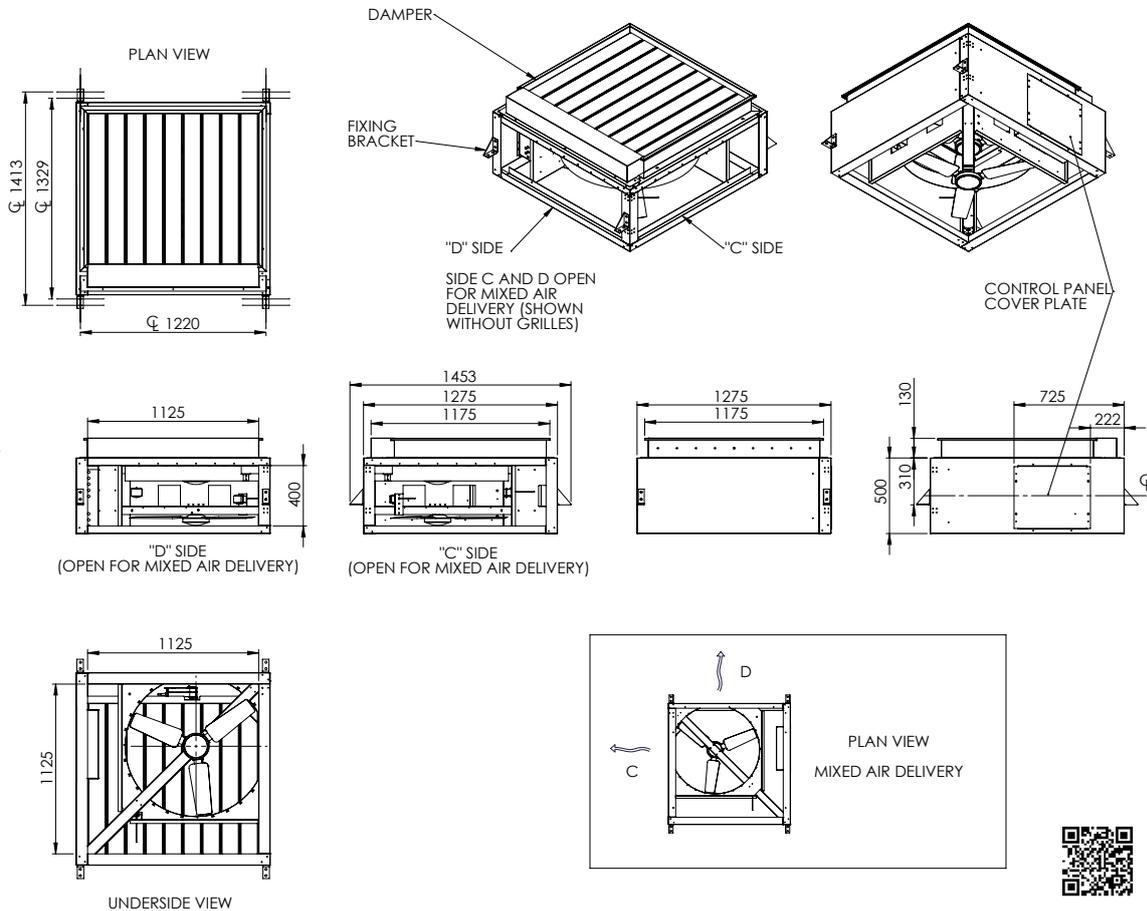
\* denotes results at background

# Ambient sound pressure in typical classroom for BB93

**Shaft Dimensions**

W	1,500 mm
D	1,500mm

## S1200 Dimensioned Drawing



### Dimensions

H	500 mm
D	1,200 mm
W	1,200 mm
Weight	130 kg
Physical area	0.96 m <sup>2</sup>
Effective Area (A*)	0.67 m <sup>2</sup>

### Electrical

Power Rating	0.1 kW
Voltage	230V AC (+/- 10%)
Full load current	0.5A
Short Circuit Rating	N/A - Control only
Earth Leakage	<3.5 mA

[www.breathingbuildings.com/downloads](http://www.breathingbuildings.com/downloads)

### Acoustic Performance

Frequency Band (Hz)	Sound Power (dB)								Overall dB (A)	Ambient dB (A) <sup>#</sup>
	63	125	250	500	1k	2k	4k	8k		
Winter Slow	32	35	29	26	20	16	18*	24*	28.6	30.7
Winter Fast	39	44	44	38	36	22	33	24*	37.1	33.1
Summer Boost	33	41	39	40	35	36	32	24*	36.3	32.7

\* denotes results at background

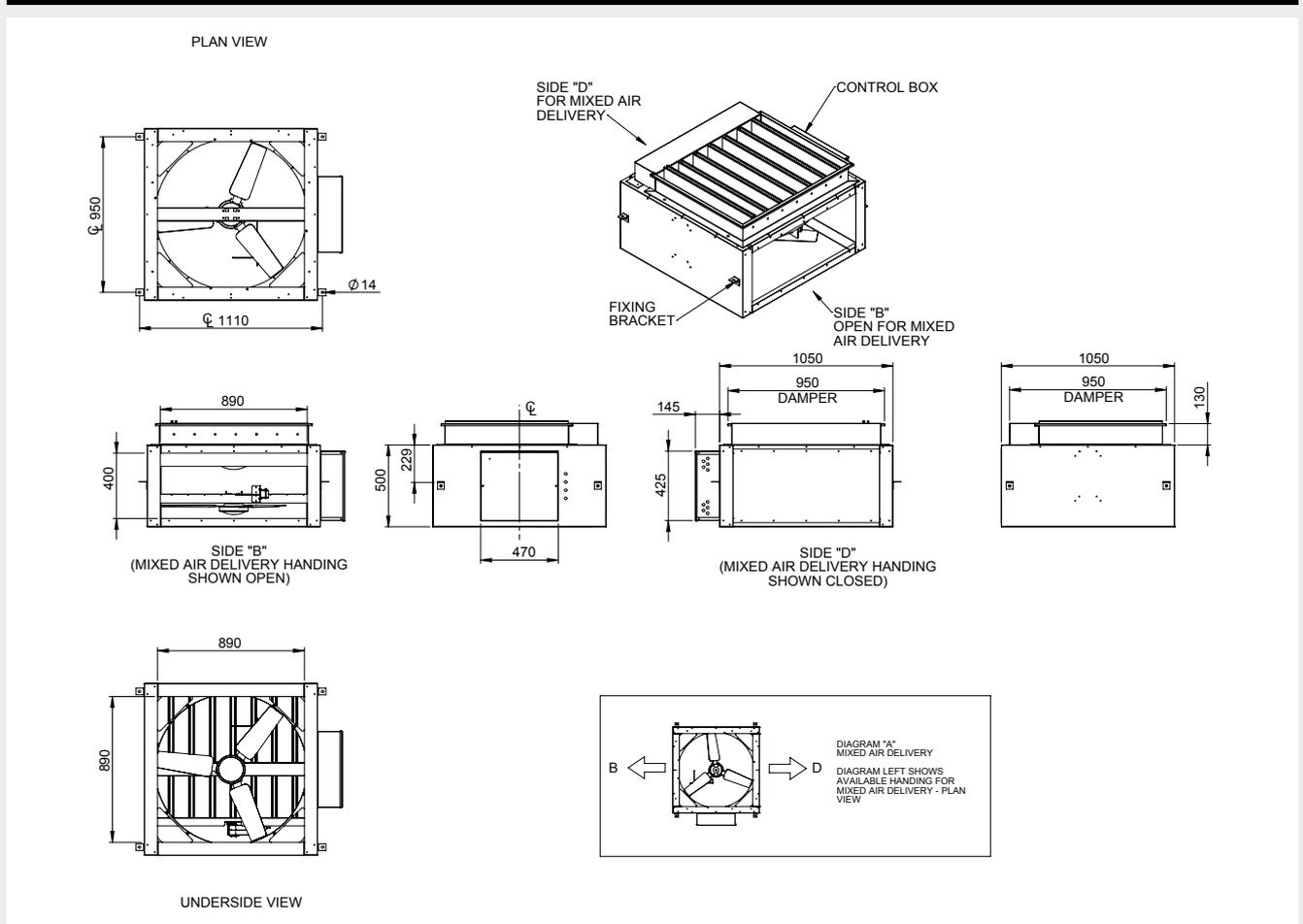
# Ambient sound pressure in typical classroom for BB93

### Shaft Dimensions

W	1,200 mm
D	1,200mm

## S Series continued

## S1000 Dimensioned Drawing



## Dimensions

H	500 mm
D	1,000 mm
W	1,000 mm
Weight	130 kg
Physical area	0.96 m <sup>2</sup>
Effective Area (A*)	0.67 m <sup>2</sup>

## Electrical

Power Rating	0.1 kW
Voltage	230V AC (+/- 10%)
Full load current	0.5A
Short Circuit Rating	N/A - Control only
Earth Leakage	<3.5 mA

[www.breathingbuildings.com/downloads](http://www.breathingbuildings.com/downloads)

## Acoustic Performance

Frequency Band (Hz)	Sound Power (dB)								Overall dB (A)	Ambient dB (A)#
	63	125	250	500	1k	2k	4k	8k		
Winter Slow	32	35	29	26	20	16	18*	24*	28.6	30.7
Winter Fast	39	44	38	36	22	33	18*	24*	37.1	33.1
Summer Boost	33	39	35	36	32	28	18*	24*	36.3	32.7

\* denotes results at background

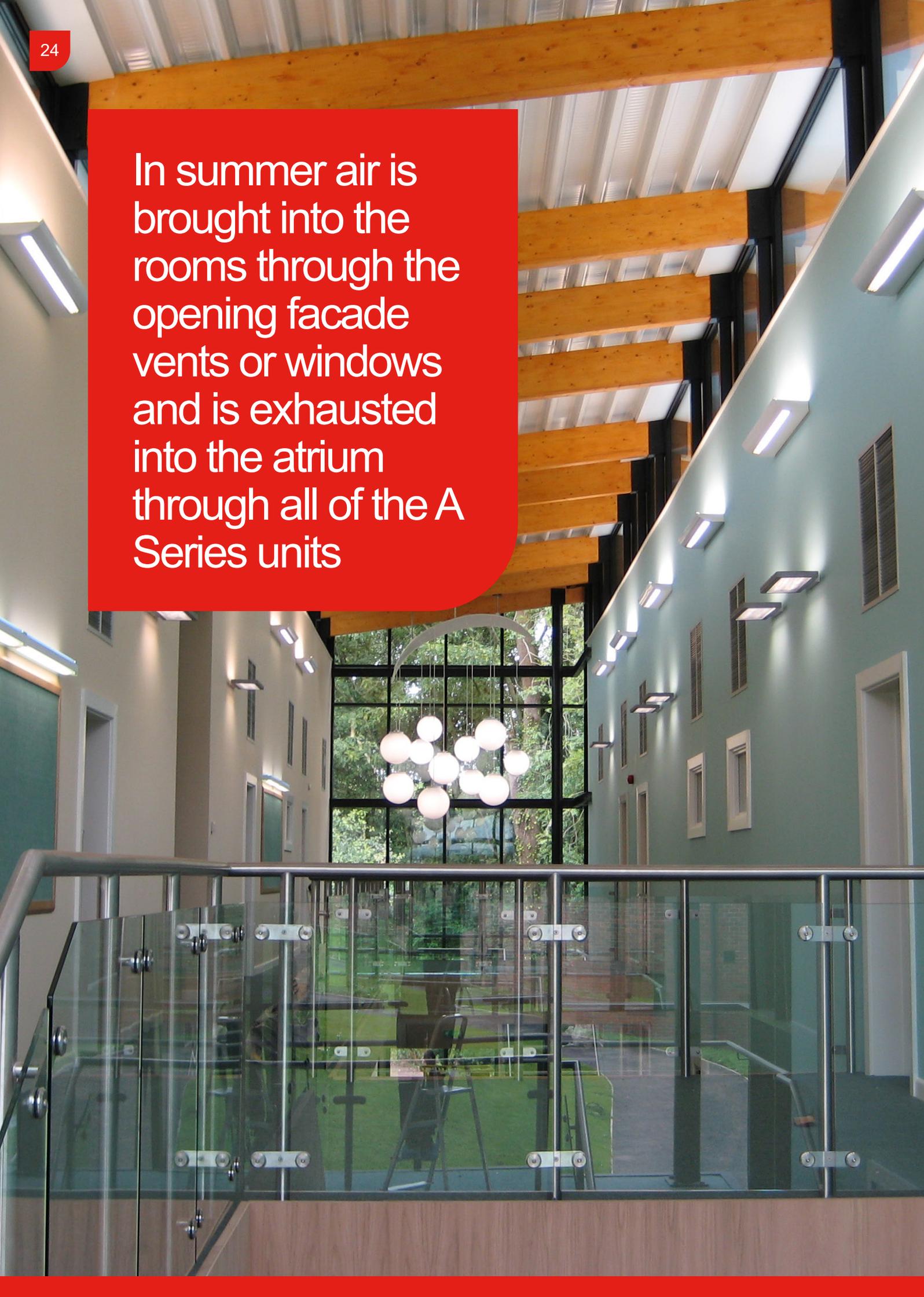
# Ambient sound pressure in typical classroom for BB93

## Shaft Dimensions

W	1,050 mm
D	1,050mm



In summer air is brought into the rooms through the opening facade vents or windows and is exhausted into the atrium through all of the A Series units



# A Series

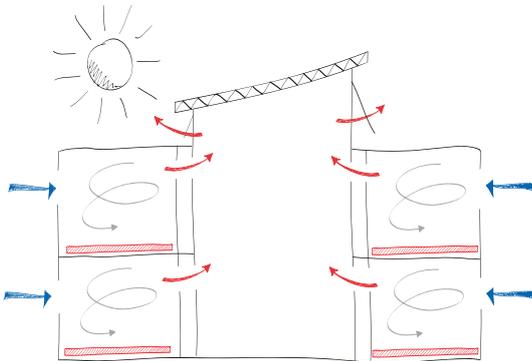
The A Series is designed for a standard school room or office where a corridor or atrium is used and which provides access to the exterior at high level. It is particularly helpful in multi-storey buildings where it is not feasible to create dedicated shafts through upper level rooms to provide air pathways to lower floors from the roof

## Air Flow Strategies

### Summer Mode

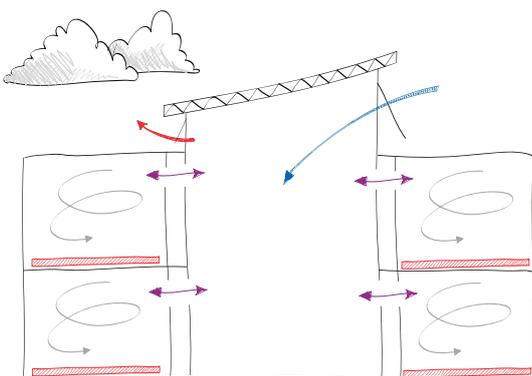
When it is warm outside the system operates in upflow displacement mode, using the stack effect to achieve high air flow rates and keep the room at a pleasant temperature.

Fan boost and night cooling modes offer greater thermal comfort in exceptional summer conditions.



### Winter Mode

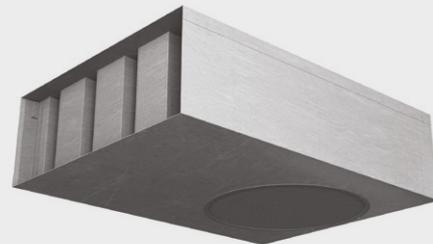
When the outside temperature becomes too low to bring directly onto the occupants the A Series units operate in exchange mode. The building ventilates naturally by exchanging air naturally between the atrium and exterior. The occupied rooms exchange flow using low energy fans within the A Series units, preventing the need for wasteful preheating of fresh air.



## Product Information

### Features

- Low energy mixing fans to mitigate against cold draughts in winter
- Summer exhaust boost mode
- Acoustic attenuator to provide acoustic separation of atrium and occupied rooms
- Night cooling
- Internal temperature sensor with integrated CO<sub>2</sub> sensor
- External temperature sensor
- Networked, integral controllers report to central Atlas Control panel to respond to local conditions
- Traffic light indicator panel for window opening
- Ready fitted mounting brackets
- Key switch for automatic operation; long term off; test

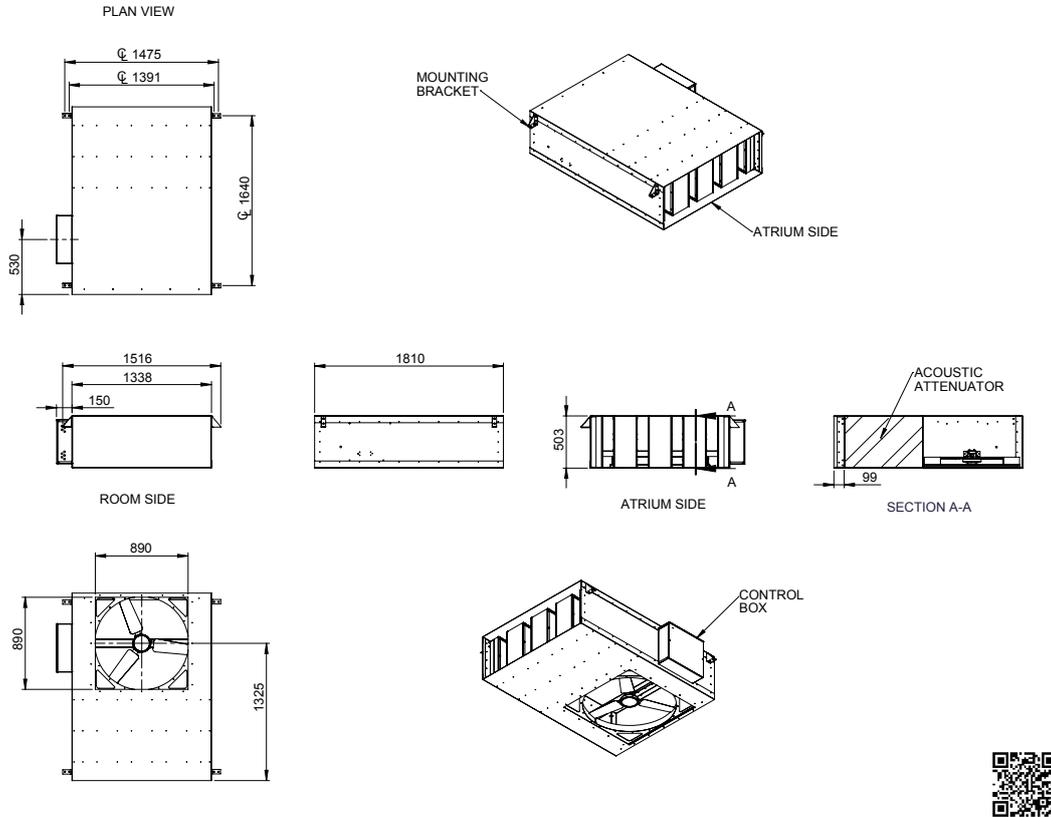


### Options

- A500 to fit ceiling void
- Penthouse louvre or mushroom terminal in atrium
- Actuated windows or dampers in atrium
- Noise attenuation for noisy sites
- Patented heating control strategy ensures minimum energy use
- Control signal for automated actuation of low level windows or dampers
- Modbus link for integration into wider Building Management Systems (BMS)
- Eggcrate grilles
- Different attenuation levels to suit project requirements

## A Series continued

## A500 Dimensioned Drawing

**Dimensions**

H	503 mm
D	1,338 mm
W	1,810 mm
Weight	174 kg
Physical area	0.22 m <sup>2</sup>
Effective Area (A*)	0.15 m <sup>2</sup>

**Electrical**

Power Rating	0.1 kW
Voltage	230V AC (+- 10%)
Full load current	0.5A
Short Circuit Rating	N/A - Control only
Earth Leakage	<3.5 mA

[www.breathingbuildings.com/downloads](http://www.breathingbuildings.com/downloads)

**Acoustic Performance**

Frequency Band (Hz)	Sound Power (dB)								Overall dB (A)	Ambient dB (A) <sup>#</sup>
	63	125	250	500	1k	2k	4k	8k		
Winter Slow	45	43	38	34	31	21	18*	24*	36.2	32.5
Winter Fast	46	45	39	36	34	24	18*	24*	38.3	33.4
Summer Boost	46	45	39	36	34	24	18*	24*	38.3	33.4

\* denotes results at background

# Ambient sound pressure in typical classroom for BB93

**Crosstalk Attenuation**

Frequency Band (Hz)	250	500	1k	2k	4k	8k	Rating D <sub>n,e,w</sub> (C;Ctr)
							dB (A)
Winter Slow	38	36	43	49	43	38	45 (-3;-8) dB

# Installation

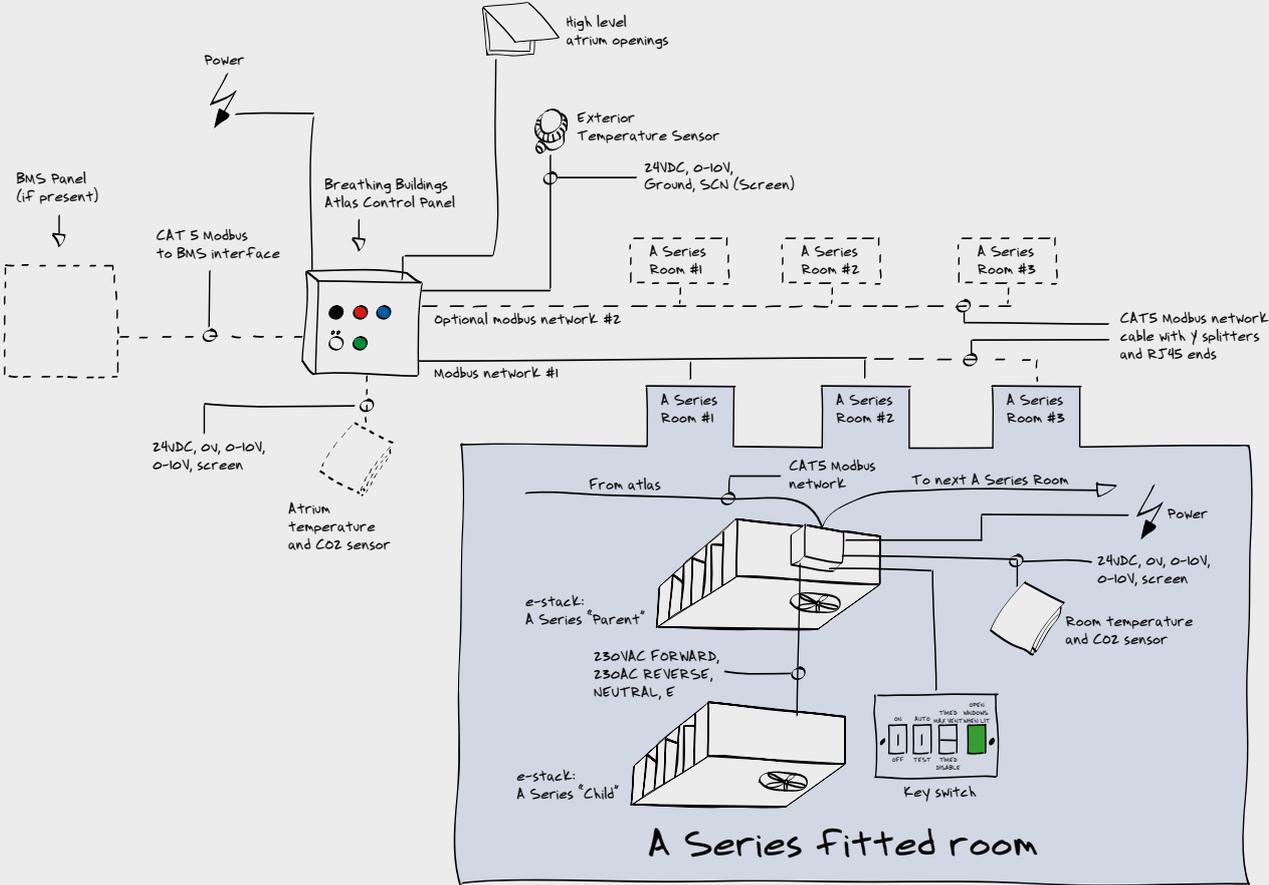
The A Series comes with fixing brackets.

The E-Stack unit can be hung from 4 no. pieces of M10 (drop-rods).



Example installation prior to construction of bulkhead

# System Schematic and Wiring



The F Series  
is designed to  
allow rooms to  
ventilate through  
the facade



# F Series

If there is a clerestory window concept as indicated in the figure shown then the unit operates in single sided mixing ventilation mode in winter and in summer uses displacement cross-flow ventilation. Without an elevated facade the F500 units provide mixing ventilation

The F1000 unit is a facade mounted unit that has been designed to ventilate a room with occupancies from 10 to 35 people. Integrated fans mitigate cold draughts in a low energy way delivering appropriate ventilation and superb thermal comfort. The illustration below shows an F1000 unit located in a room with another variable control damper located on the same facade in the opposite corner of the room



## Air Flow Strategies

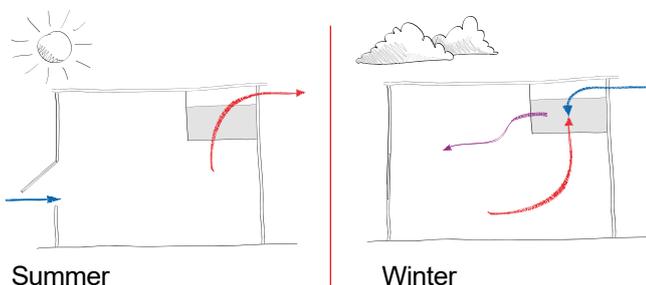
### Summer Mode

When it is warm outside the system operates in upflow displacement mode, using the stack effect to achieve high air flow rates and keeping the room at a pleasant temperature.

Fan boost and night cooling modes offer greater thermal comfort in exceptional summer conditions.

### Winter Mode

When the outside temperature becomes too low to bring air directly onto occupants the F Series operates to pre-mix the incoming cold fresh air with warm room air to mitigate the risk of cold draughts and eliminate the need for wasteful pre-heating with radiators. Exhaust is provided by an adjacent window or variable control damper provided by Breathing Buildings.



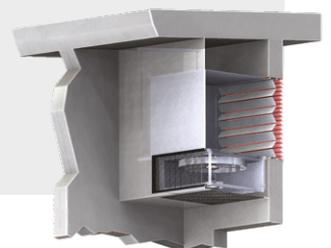
## Product Information

### Features

- Low energy mixing fans to mitigate against cold draughts in winter
- Summer exhaust boost mode
- Night cooling
- Insulated volume control damper ensures appropriate ventilation rates
- Internal temperature sensor with integrated CO<sub>2</sub> sensor
- External temperature sensor
- Integral control responds to environmental conditions
- Indicator panel for window opening
- Ready fitted mounting brackets
- Key switch for automatic operation; long term off; test

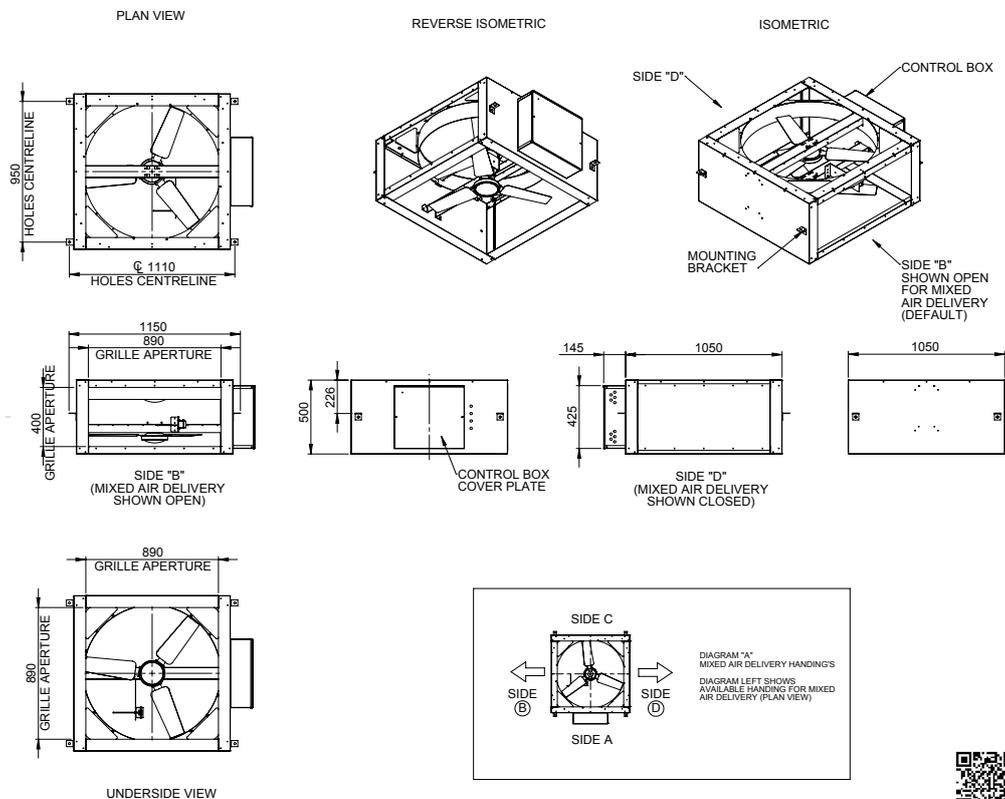
### Options

- F1000 and F500
- Patented heating control strategy ensures minimum energy use
- Weather louvre
- Noise attenuation for noisy sites
- Integrated noise attenuation through combination of acoustic louvres and internal baffles depending on site specific requirements
- Control signal for automated actuation of low level windows or dampers
- Modbus link for integration into wider Building Management Systems (BMS)
- Eggcrate grilles



## F Series continued

## F1000 Dimensioned Drawing



## Dimensions

H	500 mm
D	1,000 mm
W	1,000 mm
Weight	80 kg
Physical area	0.5 m <sup>2</sup>
Effective Area (A*)	0.4 m <sup>2</sup>

## Electrical

Power Rating	0.1 kW
Voltage	230V AC (+/- 10%)
Full load current	0.5A
Short Circuit Rating	N/A - Control only
Earth Leakage	<3.5 mA

[www.breathingbuildings.com/downloads](http://www.breathingbuildings.com/downloads)

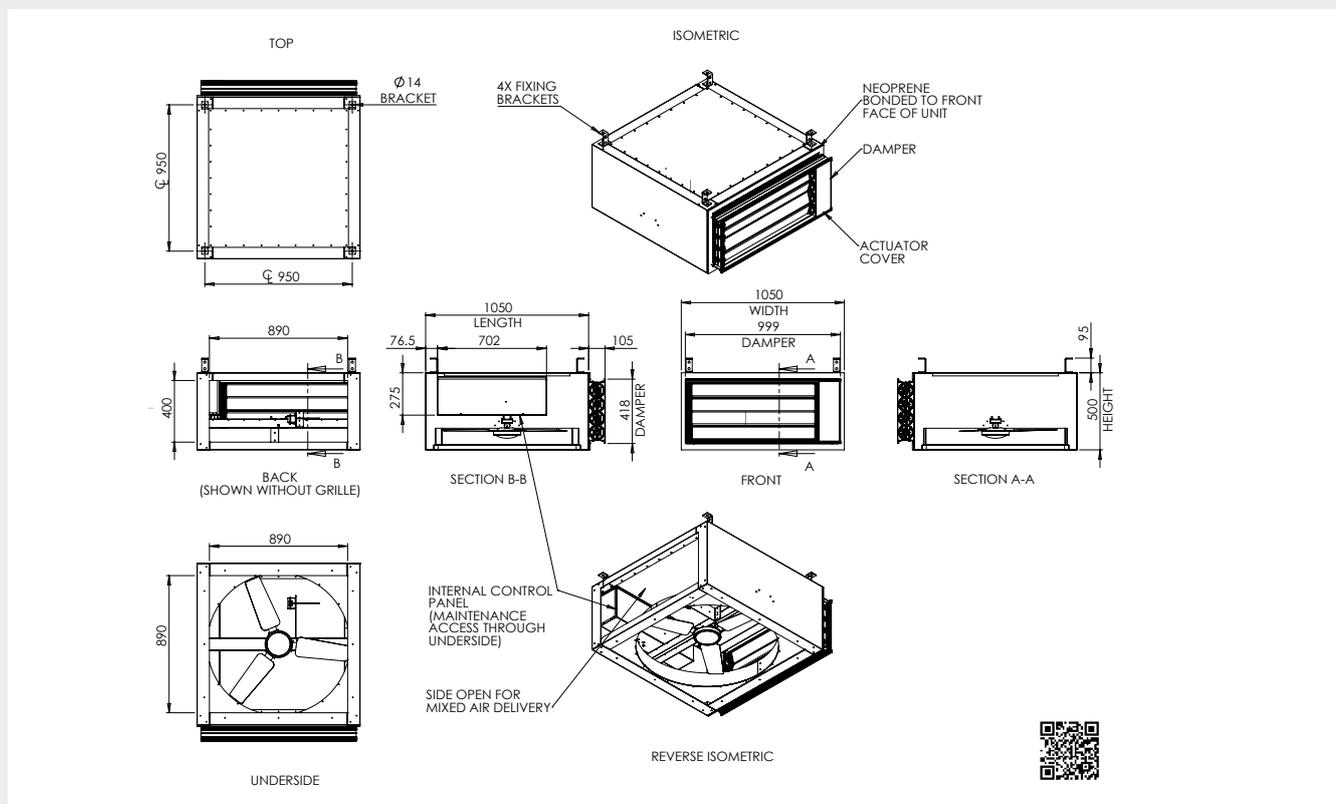
## Acoustic Performance

Frequency Band (Hz)	Sound Power (dB)								Overall dB (A)	Ambient dB (A) <sup>#</sup>
	63	125	250	500	1k	2k	4k	8k		
Winter Slow	33	39	33	29	21	15	18*	24*	30.6	30.8
Winter Fast	41	52	43	40	37	28	19*	24*	41.8	35.0
Summer Boost	38	39	38	37	33	23	18*	24*	37.4	32.3

\* denotes results at background

# Ambient sound pressure in typical classroom for BB93

## F500 Dimensioned Drawing



## Performance

### U-Value

Part L2a requirement	3.5 (W/m <sup>2</sup> K)
F Series	2.2 (W/m <sup>2</sup> K)
Damper section	<0.8 (W/m <sup>2</sup> K)

### Damper Air Leakage

Part L2a requirement	10 m <sup>3</sup> /h/m <sup>2</sup>
F Series	2.9 m <sup>3</sup> /h/m <sup>2</sup>
Tested at 50 Pa across whole damper unit	

### Conformity

CE marking	Yes
BB93 (standard room)	Yes

## Installation

The F Series comes with fixing brackets.

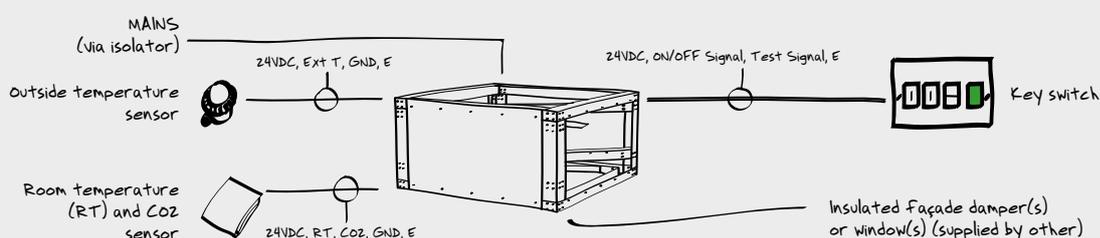
The E-Stack unit can be hung from 4 no. pieces of M10 (drop-rods).

### Mixed Air Temperatures at the Occupied Zone

External Temp	Internal Temperature				
	21	22	23	24	25
14	19.5	20.0	20.5	21.0	21.5
12	18.5	19.0	19.5	20.0	20.5
10	17.5	18.0	18.5	19.0	19.5
4	14.5	15.0	15.5	16.0	16.5

Based on fresh air flow rate of 150 l/s, 30 people at 5 litres/person/s

## System Schematic and Wiring



In a space where mixing is not required we can provide a range of passive ventilation products

- Passive Stack Ventilation
- Roof Terminals
- Dampers
- Cross Talk Attenuators
- Window Actuation Control

# Passive Ventilation

Breathing Buildings offers a full range of passive ventilation products, either as standalone products or incorporated into a Breathing Buildings system

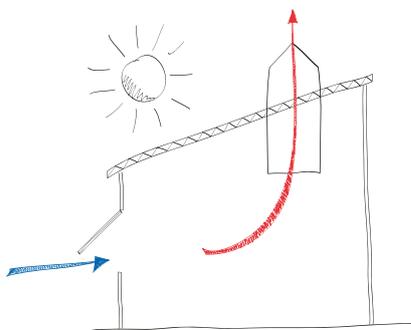
Passive ventilation is an important part of all natural ventilation systems, whether that is providing automated windows in a room, passive acoustic attenuators or high level dampers in an atrium.

Breathing Buildings has a comprehensive range of products to suit any natural ventilation scheme either as standalone products or for integrating into a broader Breathing Buildings system. Whatever the requirements you can be sure that we have an appropriate product.

## Air Flow Strategies

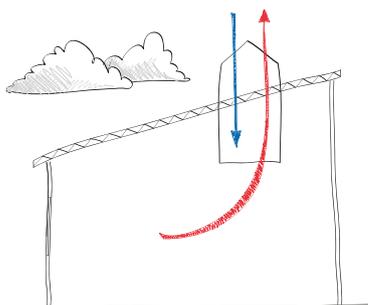
### Summer Mode

When it is warm outside the system operates in upflow displacement mode, using the stack effect to achieve high air flow rates and keep the room at a pleasant temperature.



### Winter Mode

Without low level openings the unit operates in exchange mode providing inflow and outflow through the damper.



## Product Information

### Features

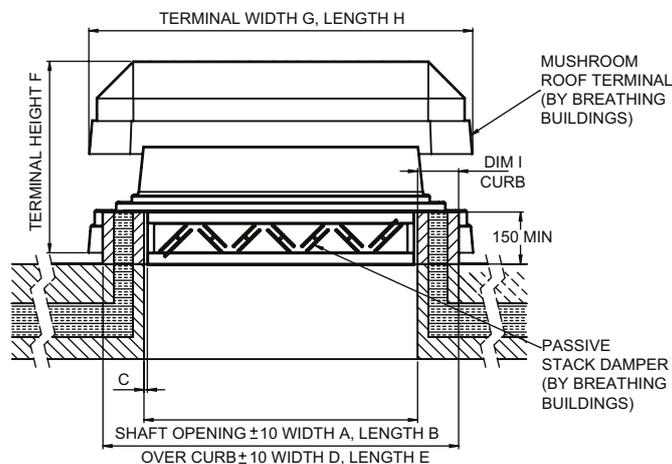
- Upward displacement and wind driven ventilation
- Manual control or Automatic control responding to temperature and CO<sub>2</sub>
- Insulated volume control damper ensures appropriate ventilation rates
- Internal temperature sensor with integrated CO<sub>2</sub> sensor
- Install internal unit from roof or from the room

### Options

- Range of sizes from 600mm square up to 1500mm square
- Penthouse louvre or mushroom terminal
- Integrated noise attenuation unit offering 25dB for noisy sites, more available on request
- Traffic light indicator panel for window opening
- Control signal for automated actuation of low level windows or dampers
- Modbus link for integration into wider Building Management Systems (BMS)
- Eggcrate grilles

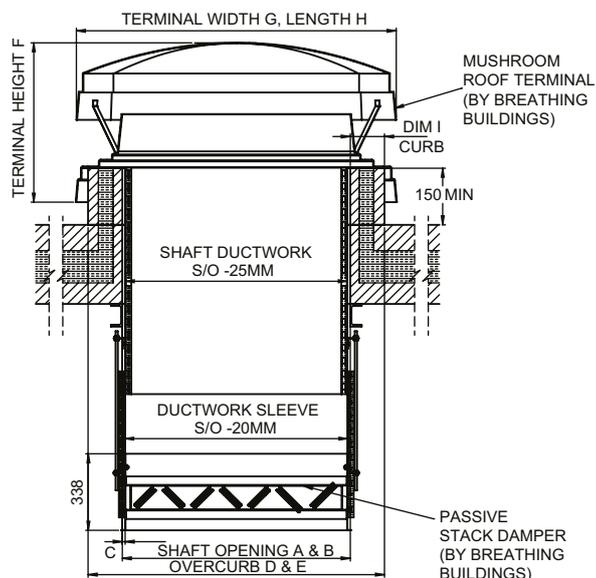
## Passive Ventilation continued

### Type 1 - PS600 to PS1500 Dimensional Drawing



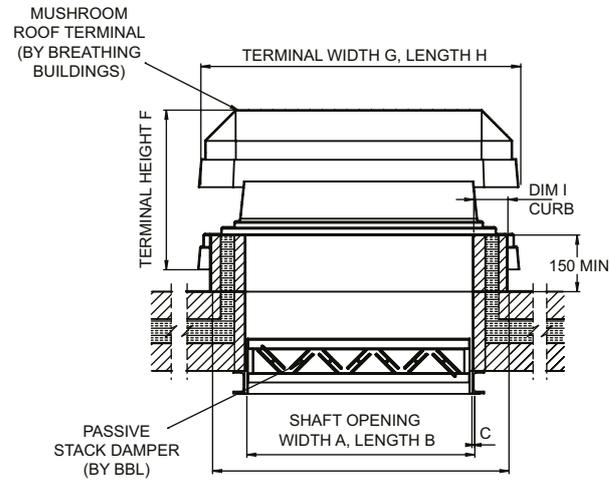
Unit Type	A	B	C	D	E	F	G	H	I	Terminal Mass [kg]
PSS600	600	600	12.5	890	890	550	1000	1000	145	18
PSS800	800	800	12.5	990	990	650	1100	1100	95	25
PSS1000	1000	1000	12.5	1340	1340	750	1403	1403	170	40
PSS1200	1200	1200	12.5	1500	1500	875	1869	1869	150	150
PSS1500	1500	1500	12.5	1800	1800	875	2169	2169	150	160
PSR-SERIES	1550	900	12.5	1850	1200	945	2080	1600	150	150

### Type 2 - PS600 to PS1500 Dimensional Drawing



Unit Type	A	B	C	D	E	F	G	H	I	Terminal Mass [kg]
PSS600	600	600	12.5	890	890	550	1000	1000	145	18
PSS800	800	800	12.5	990	990	650	1100	1100	95	25
PSS1000	1000	1000	12.5	1340	1340	750	1403	1403	170	40
PSS1200	1200	1200	12.5	1500	1500	875	1869	1869	150	150
PSS1500	1500	1500	12.5	1800	1800	875	2169	2169	150	160
PSR-SERIES	1550	900	12.5	1850	1200	945	2080	1600	150	150

## Type 3 - PS600 to PS1500 Dimensional Drawing



Unit Type	A	B	C	D	E	F	G	H	I	Terminal Mass [kg]
PSS600	600	600	12.5	890	890	550	1000	1000	145	18
PSS800	800	800	12.5	990	990	650	1100	1100	95	25
PSS1000	1000	1000	12.5	1340	1340	750	1403	1403	170	40
PSS1200	1200	1200	12.5	1500	1500	875	1869	1869	150	150
PSS1500	1500	1500	12.5	1800	1800	875	2169	2169	150	160
PSR-SERIES	1550	900	12.5	1850	1200	945	2080	1600	150	150



## Roof Terminals

### R Series Terminations

Breathing Buildings offer two roof terminations, the penthouse louvre or the mushroom.

The penthouse louvre is most frequently associated with a natural ventilation system. We offer a double bladed system as standard which offers class A weather performance with a triple bladed system for sites where better weather performance is required. The standard terminal comes in RAL 7035 (Light Grey) with corner posts and gabled roof but other options and sizes are available.

The mushroom terminal is an unobtrusive alternative to the traditional bladed metal louvre and has better standard noise attenuation properties. The terminal is RAL 7035 (Light Grey) as standard but other colours are available on request.

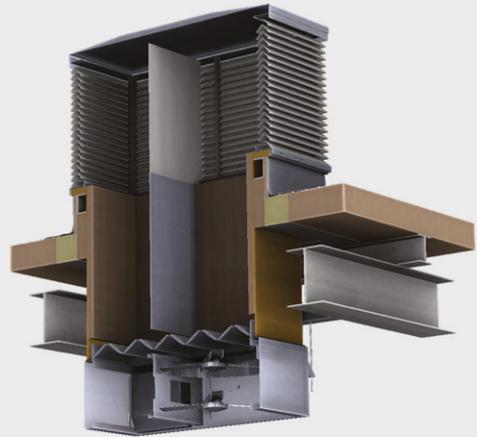
Both terminals offer optional acoustic attenuation.



### Installation

A weathered builders curb around the perimeter of the roof penetration and shaft to the E-Stack supports the roof termination which is usually a minimum height of 150mm above the finish roof surface.

Once in place the roof terminal is fixed to the curb using suitable fixings. Once installed a bead of mastic or similar is laid around the perimeter of the overcurb.



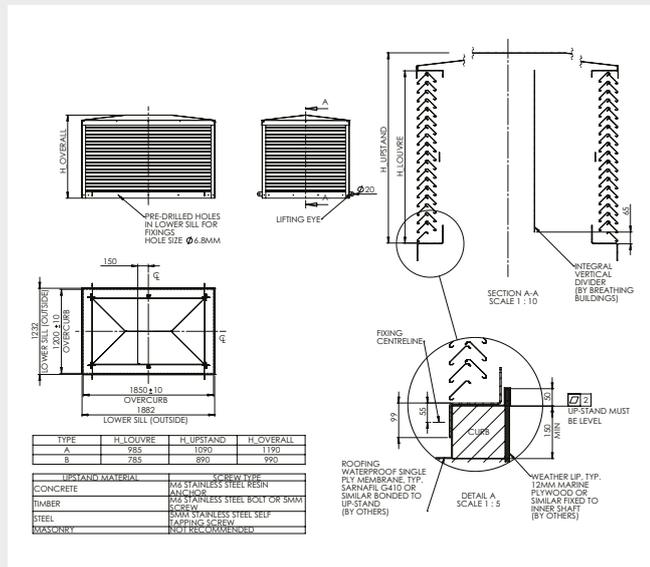
### Shaft

An insulated shaft is required between the bottom of the roof termination and the R Series indoor unit. Breathing Buildings can provide this, or else it can be constructed by others. A rubber seal is provided on the top of the E-Stack indoor unit to ensure air tightness with the bottom edge of the shaft. Breathing Buildings has no preference as to the material of the shaft. Previous examples have utilised the concrete soffit, plywood, plasterboard, and ductwork. This is sized to fit the damper (1550mm x 900mm). The terminal height is pre-fitted with a divider.

The shaft is to be divided into two pathways vertically for separation of inflow and outflow. Usually this is constructed from either plywood, plasterboard or galvanised steel etc. and does not require insulation. Note that the split is not equal, with the larger section above the E-Stack fans in winter.

The vertical divider extends from just above the dampers (typ. 25mm above) on top of the E-Stack unit to the underside of the acoustic attenuator or the penthouse louvre roof terminal.

## Penthouse Louvre Dimensioned Drawing



### Physical Properties

Typical weight	180 kg
Finish standard	MILL Finish
Finish options	Standard RAL
Lifting points	Eyes supplied as standard
Standard attenuation	11 dB D <sub>new</sub>
Optional attenuation	33 dB D <sub>new</sub>

### Shaft Dimensions

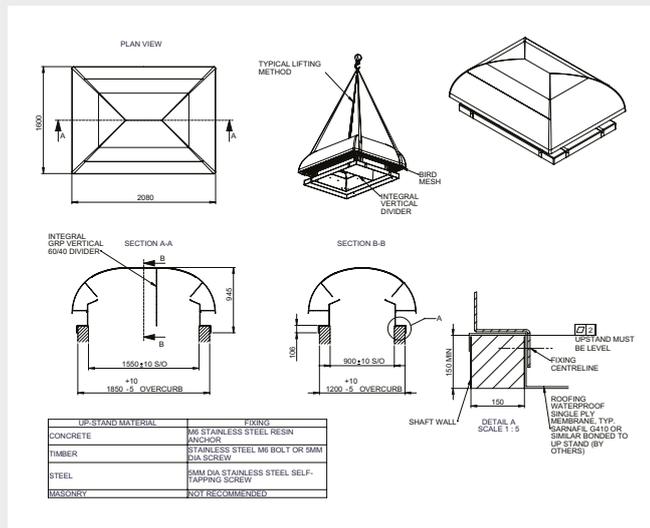
W	1550 mm
D	900 mm

### Weather Performance

	Double blade	Triple blade
Performance	Class A up to 1 m/s airflow face velocity	Class A up to 2 m/s airflow face velocity

Test involves simulated rainfall of 75l/h at a wind speed of 13m/s (29 mph). Full BSRIA weather performance test data available on request

## Mushroom Terminal



### Physical Properties

Height (Inc. base)	945 mm
Curb dimensions	1850 (l) x 1200 (w) x 150 (h)
Typical weight	150 kg
Finish standard	RAL 7035
Finish options	Standard RAL
Standard attenuation	17 dB D <sub>new</sub>
Optional attenuation	21 - 28 dB D <sub>new</sub>

### Shaft Dimensions

W	1550 mm
D	900 mm

### Weather Performance

Water testing has been carried out at the BRE using test method *prEN 15601—Hygrothermal performance of buildings—resistance to wind driven rain coverings with discontinuously laid small elements*. The terminal was subject to 75mm/hr/m<sup>2</sup> at a wind speed of 30mph (13.4 m/s). Water ingress during the tests was too small to measure in meaningful terms. Terminal has also been tested under storm conditions at BRE with 60 mph wind.

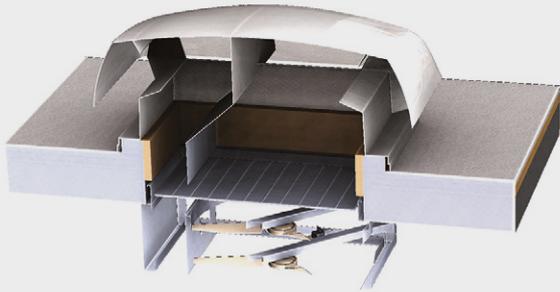
## Roof Terminals

### S Series Terminations

An insulated shaft is required between the bottom of the roof termination and the S Series indoor unit. Breathing Buildings can provide this, or else it can be constructed by others. The penthouse louvre units are offered in both double and triple blade arrangements and we now have mushroom terminations available across the product range.

### Installation

A weathered builders curb around the perimeter of the roof penetration and shaft to the E-Stack supports the roof termination which is usually a minimum height of 150mm above the finished roof surface. Once in place the roof terminal is fixed to the curb using suitable fixings. Once installed a bead of mastic or similar is laid around the perimeter of the overcurb.

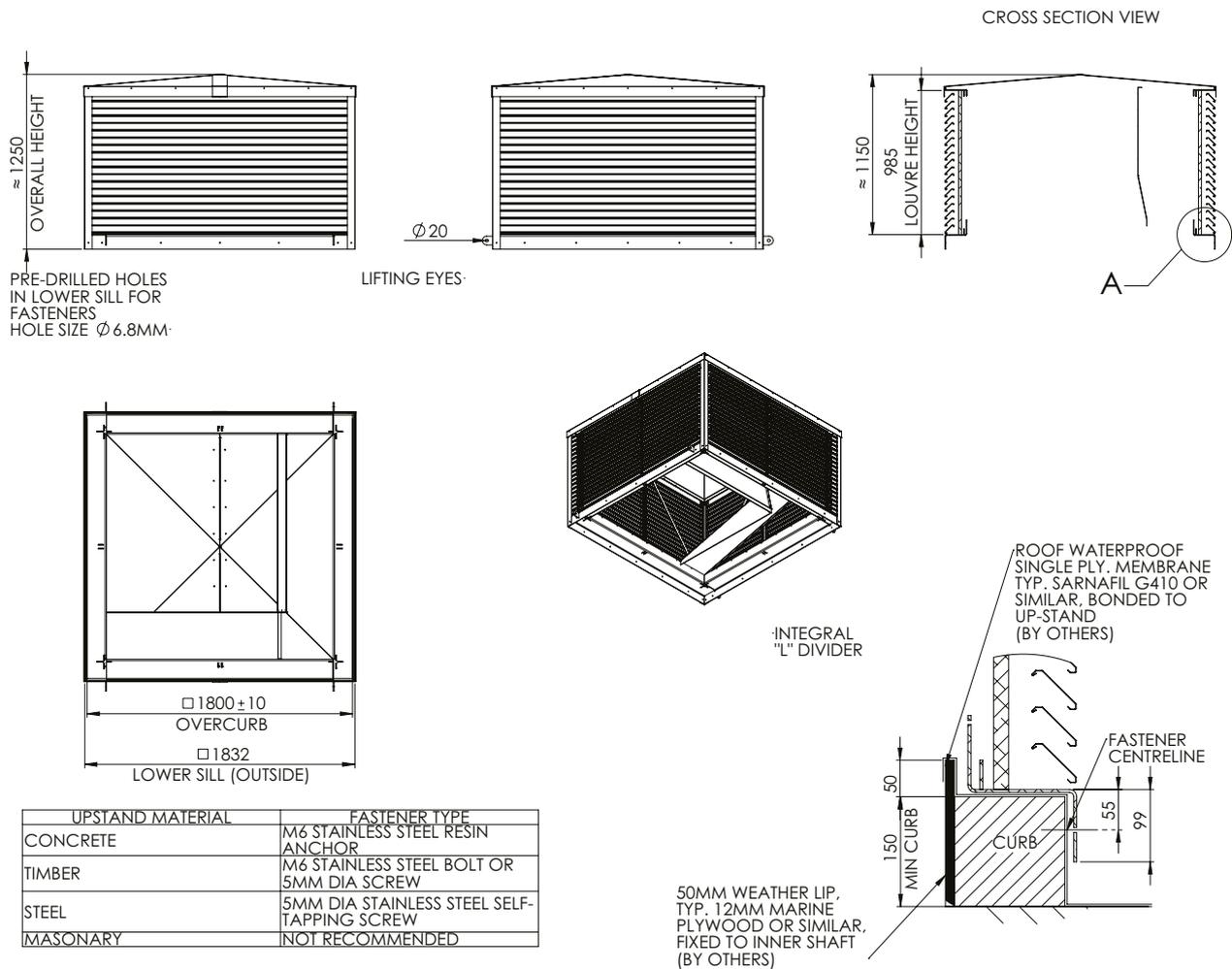


### Shaft

An insulated shaft needs to be constructed by others between the bottom of the roof termination and the S series. A rubber seal is provided on the top of the e-stack to ensure air tightness with the bottom edge of the shaft wall. Breathing Buildings has no preference as to the material of the shaft. Previous examples have utilised the concrete soffit, marine plywood, plasterboard, and ductwork. This is sized to fit the damper (1500mm x 1500mm or 1200mm x 1200mm).

An L divider is required in the shaft (by others or by Breathing Buildings). The L divider is located to form a smaller square section in the corner of the square shaft, thereby creating an L shape division. The L divider is orientated so that it matches similar dividers in the mushroom or penthouse termination and the S series unit. The shaft divider commences just above the top of the S series unit (typically 25mm above) and extends up through the shaft to mid-way to the curb level (just underneath the roof terminal).

## S1500 Penthouse Louvre Dimensioned Drawing



### Physical Properties

Typical weight	220 kg
Finish standard	MILL Finish
Finish options	Standard RAL
Lifting points	Eyes supplied as standard
Standard attenuation	11 dB $D_{new}$
Optional attenuation	33 dB $D_{new}$

### Shaft Dimensions

W	1,500 mm
D	1,500 mm

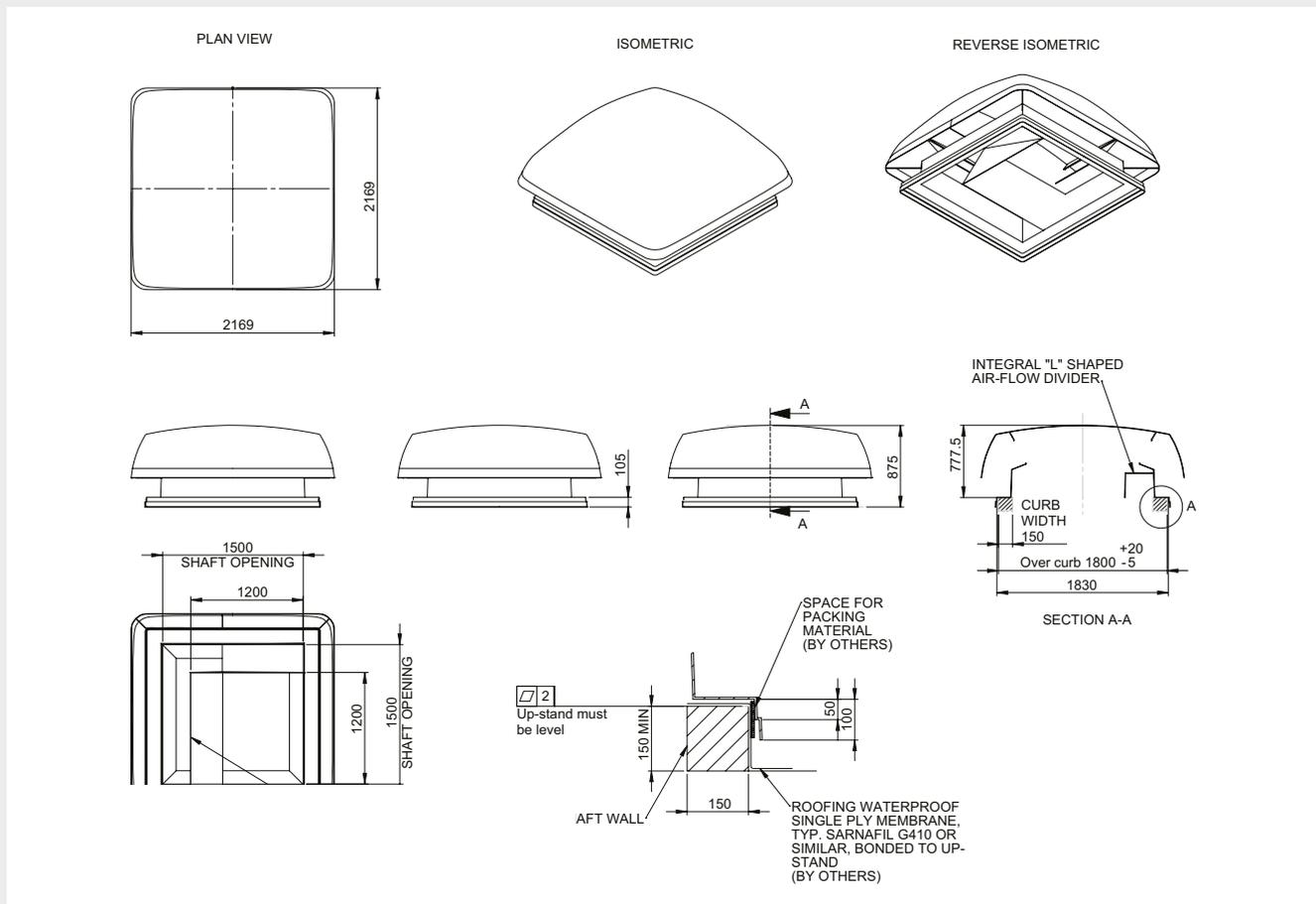
### Weather Performance

	Double blade	Triple blade
Performance	Class A and 99.9% rejection at face velocity up to 0.5 m/s	Class A and 99.9% rejection at face velocity up to 2 m/s

Test involves simulated rainfall of 75l/h at a wind speed of 13m/s (29 mph).  
Full BSRIA weather performance test data available on request

## Roof Terminals continued

### S1500 Mushroom Terminal Dimensioned Drawing



#### Physical Properties

Max Height (Dome to sill bottom)	875 mm
Max Length (across dome)	2170 mm
Max Width (across dome)	2170 mm
Height above curb	780 mm
Typical weight	<140 kg
Finish Standard	RAL 7035
Finish Option	Standard RAL
Lifting points	Not fitted

#### Key Dimensions

Overcurb	1800 x 1800 mm
Shaft	1500 x 1500 mm
Curb Height	150 mm
Curb Thickness	150 mm

#### Weather Performance

Water testing has been carried out at the BRE using test method *prEN 15601—Hygrothermal performance of buildings—resistance to wind driven rain coverings with discontinuously laid small elements*.

The mushroom profile terminal was subject to 75mm/hr/m<sup>2</sup> at a driving wind speed of 30mph (13.4 m/s). Water ingress during the tests was too small to measure in meaningful terms. Terminal has also been tested under storm conditions at BRE with 60 mph wind.



## Dampers

Many natural ventilation systems incorporate façade dampers to provide air pathways where it isn't desirable or possible to have windows. We provide a large range of variable control dampers and associated weather louvres. The dampers are insulated and have seals to minimise the air leakage from them when closed. The dampers are supplied with fully modulating actuators

In noisy locations, acoustic linings or acoustic attenuators are provided so that sufficient attenuation is provided. The extent of attenuation depends on the specific site conditions.

The actuators can be controlled using the Breathing Buildings range of ventilation controllers, or if supplied as product-only they can be controlled by the Building Management System.

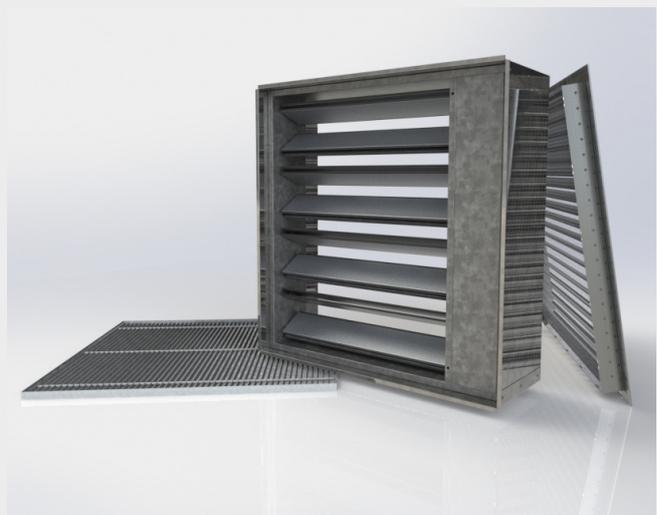
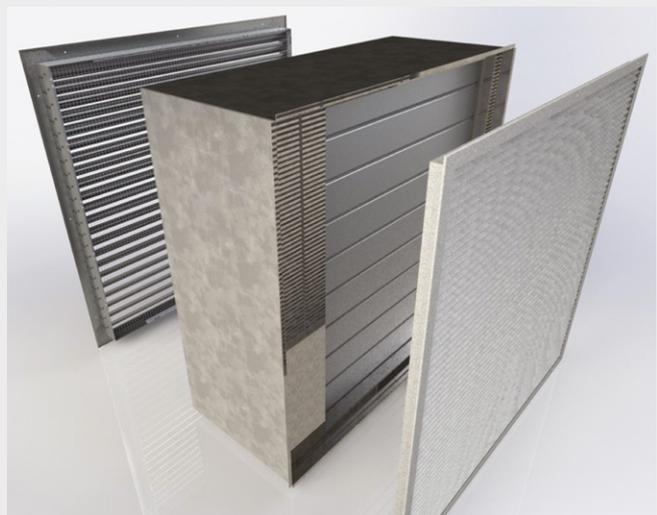
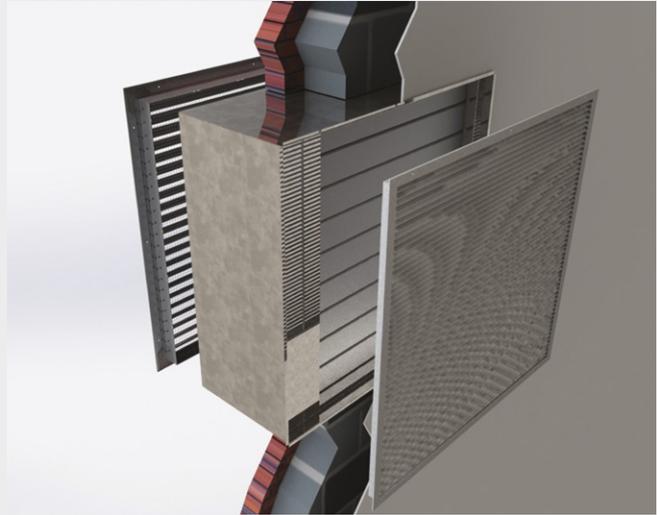
### U-Value

Part L2a requirement	3.5 (W/m <sup>2</sup> K)
Passive Stack	<0.8 (W/m <sup>2</sup> K)

### Damper Air Leakage

Part L2a requirement	10 m <sup>3</sup> /h/m <sup>2</sup>
Passive Stack	1.26 m <sup>3</sup> /h/m <sup>2</sup>

Tested at 50 Pa across whole damper unit



## Passive Stack Ventilation

### Passive Stack Ventilation

There are climates and building types when controlled natural mixing ventilation is not required. For example, if a building is located in a zone where the external temperature is consistently above 15°C then it is not necessary to pre-mix the incoming fresh air with room air in order to mitigate cold draughts. Alternatively, if the building is a factory with doors open a lot for loading, then the building may be ventilated adequately in winter through the loading doors and no winter mixing system is required. Finally, if the high level dampers are sufficiently high away from occupants in an occupied room, then it may be possible to achieve sufficient ventilation and natural mixing of the incoming plumes of cold air with the warm room air to prevent cold draughts in winter.

In all of these scenarios the most cost effective means of providing natural ventilation is via a damper in a shaft or a damper in a wall. The high level damper will be used to provide outflow and a cooling effect in warmer weather. In colder weather, the damper can be used to provide both the inflow and outflow if necessary, but in this case it is necessary to ensure that low level openings (such as doors) are closed.

We provide a full range of roof and façade based dampers, penthouse louvres, mushroom terminals, façade louvres and grilles.

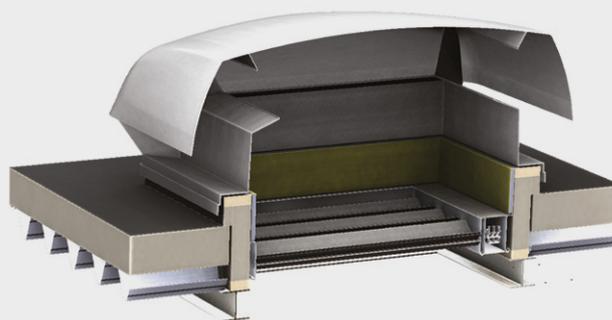
#### U-Value

Part L2a requirement	3.5 (W/m <sup>2</sup> K)
Passive Stack	<0.8 (W/m <sup>2</sup> K)

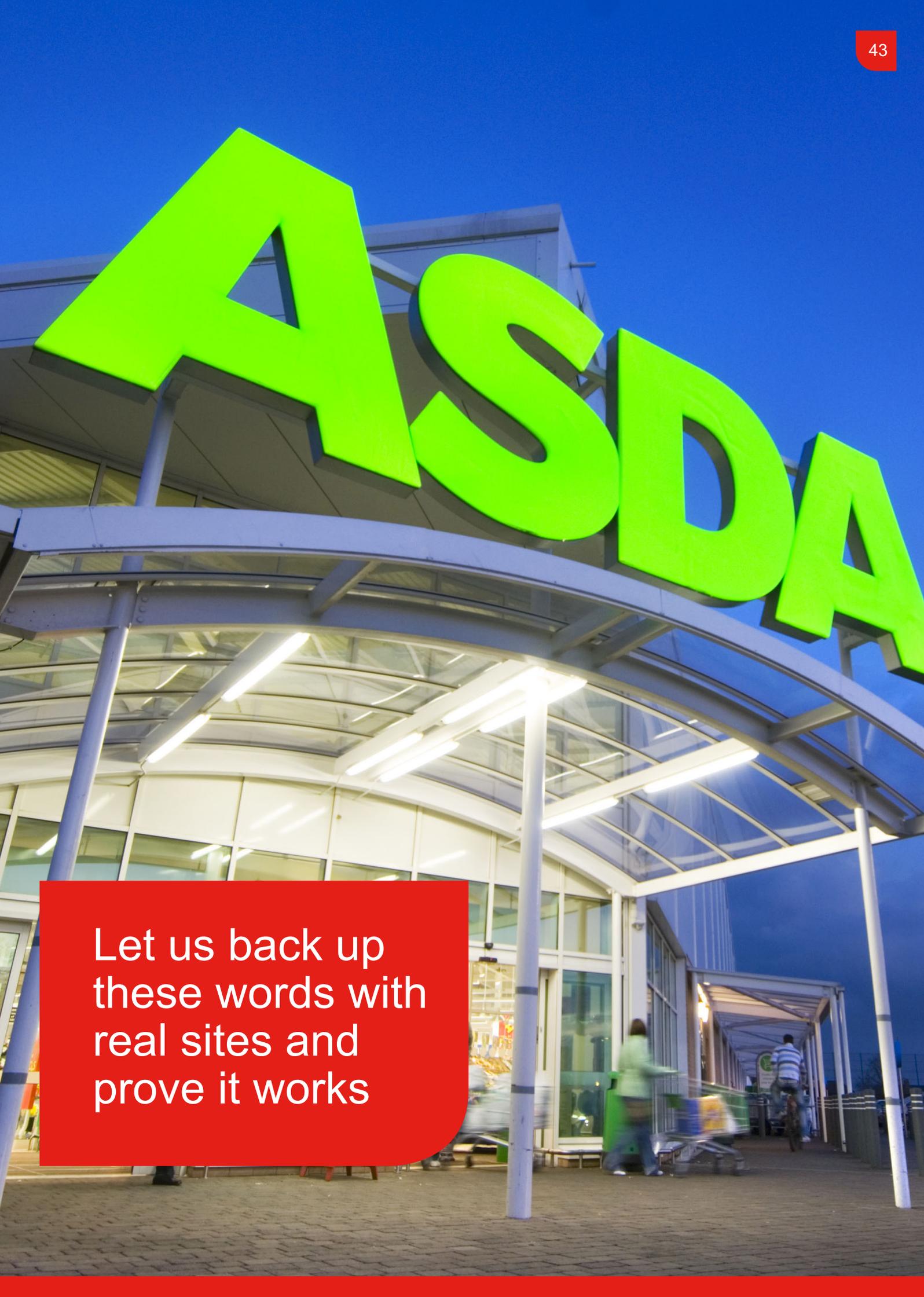
#### Damper Air Leakage

Part L2a requirement	10 m <sup>3</sup> /h/m <sup>2</sup>
Passive Stack	2.9 m <sup>3</sup> /h/m <sup>2</sup>

Tested at 50 Pa across whole damper unit



# ASDA



Let us back up  
these words with  
real sites and  
prove it works

# Linton Village College



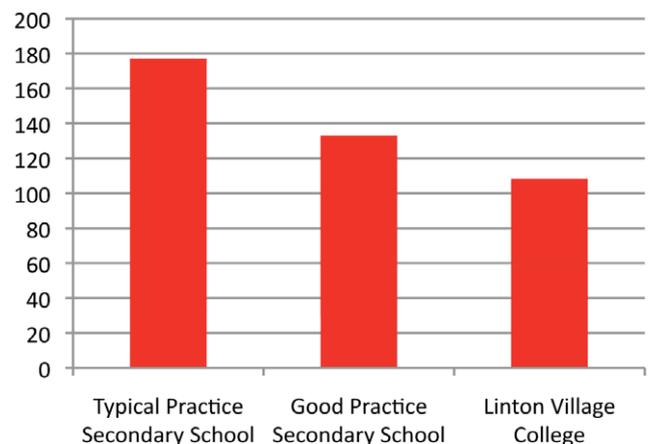
We provided an E-Stack ventilation scheme for a new science block and a performance space at Linton Village College, a Secondary School near Cambridge. This involved ten S1200 E-Stack units split over three floors.

The increased height available in multi-storey buildings offers the potential for enhanced natural ventilation flow in summer. However, this often involves installing shafts through the building which can restrict the usable space on the upper floors. We worked closely with the architect to design the shafts so that they had the benefits of a stack-based system whilst maintaining the design of the classroom spaces.

Heating in the classrooms was provided by radiant heating panels. We provided a link from these panels to our system to minimise energy consumption whilst maintaining comfortable conditions within the classrooms.

We monitored two classrooms over the winter and summer of 2010. The results show the building performed significantly better than CIBSE Good Practice guidelines and B101 summer over-heating criteria. We also monitored the temperature of air delivered to the space to prove that the E-Stack mixing system was effective at mitigating cold draughts.

## Total Energy Use (kWh/sq.m/yr)



Monitoring of thermal comfort and energy use in our buildings is important to us. We understand that the performance of the building also depends on factors which are not directly linked to the ventilation system. However, our input at the design stage of a building as well as the supply and control of the ventilation system contributes to overall improved performance and take pride in the results from our buildings.

## Natural Ventilation Delivered

### Winter Supply

In winter ventilation it is important to balance the ventilation requirements with heating and thermal comfort. As you can see from chart 01 even when the outside temperature is below 5°C we are able to successfully mitigate cold draughts, the supply temperature remaining at a comfortable level.

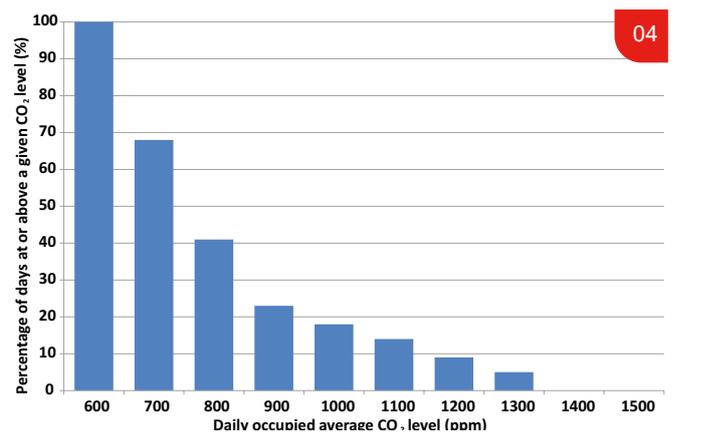
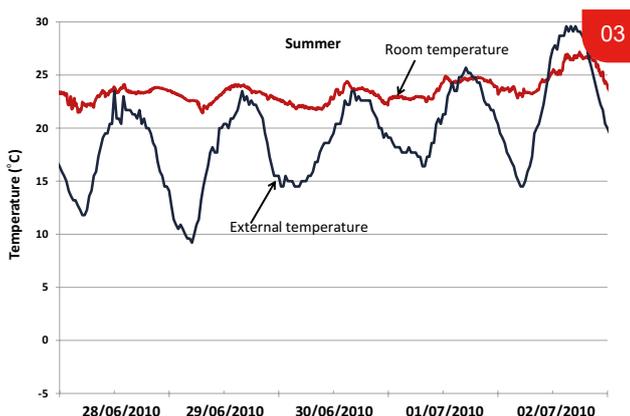
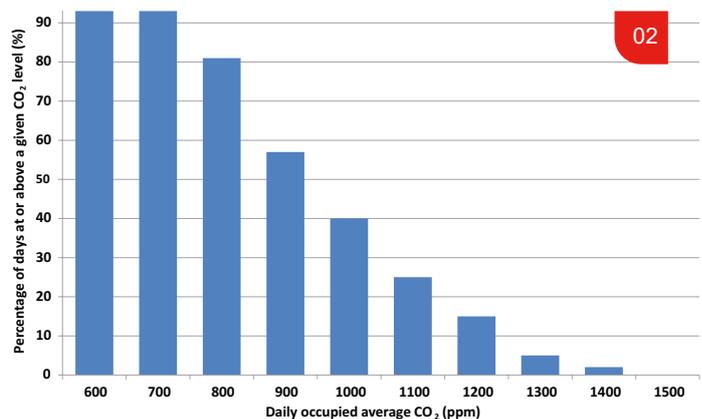
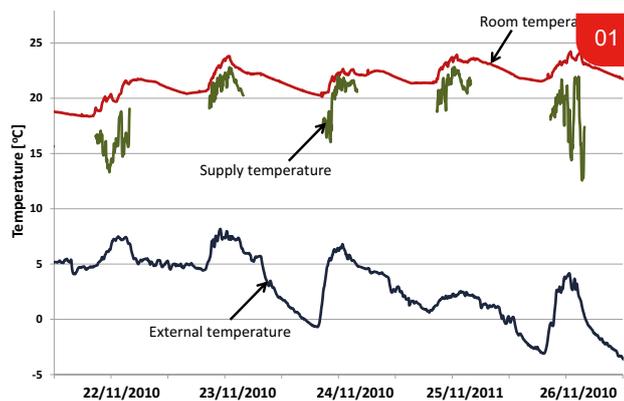
Chart 02 looks at the daily average CO<sub>2</sub> levels in the space during the winter months, which BB101 requires to be below a daily average of 1,500ppm.

### Summer Supply

In summer ventilation the primary concern with BB101 is ensuring that the ventilation rates are adequate to prevent the rooms from overheating. Using our E-Stack units we are able to achieve this even when the outside temperature climbs above 30°C. (Chart 03).

Chart 04 looks at the daily average CO<sub>2</sub> levels in the space during the summer months, which confirms that average remained below the BB101 requirement of 1,500ppm.

We are proud of our understanding of natural ventilation and our ability to deliver low energy buildings with great internal environments. We have monitored several installations to make sure that they are ventilating properly and mitigating cold draughts. These charts show data from Linton Village College where we installed E-Stack, roof based units.



# Hammerson Retail



<b>PROJECT</b>	Concept studies to investigate natural ventilation opportunities in a number of UK shopping centres
<b>LOCATION</b>	Five Hammerson shopping centres; The Oracle in Reading, WestQuay in Southampton, Queensgate in Peterborough, Brent Cross in London and Bullring in Birmingham
<b>SECTOR</b>	Retail
<b>FEATURES</b>	Research, Consultancy, Design
<b>HISTORY</b>	Project started in Spring 2010 Concept studies carried out over 12 months Comprehensive report produced for each site with individually tailored solutions

## Project Overview

Shopping centres present key challenges in effectively and efficiently providing adequate ventilation, whilst limiting the potential for summer overheating and cold draughts in winter.

Breathing Buildings was commissioned by Hammerson to investigate and establish what energy savings could be made by implementing natural ventilation systems at five of their shopping centres.

Each of the Hammerson centres was examined and thermal modelling calculations carried out, using Breathing Buildings' in-house modelling expertise.

This determined what improvements could be made by adopting natural ventilation technology and where greater efficiencies could be introduced by retaining some mechanical ventilation.

## The Challenge

Huge areas of glass with large heat gains in summer and losses in winter, large heat gains from lighting, vast numbers of people entering and leaving, and doors more often open than closed at certain times of the year, are just some of the problems faced by owners of retail property. The size and structure of the buildings means that heating and ventilation systems are often inefficient and working overtime.

### The Solution

Given that most retail centres are currently mechanically ventilated, Breathing Buildings partnered with sustainable building design specialists Max Fordham for advice on mechanical ventilation methods and to help develop hybrid solutions. The result was a combination of the best elements of natural and mechanical ventilation to most appropriately fit the architecture of each individual mall.

### Natural Ventilation Delivered

Breathing Buildings took a holistic view to discover the best way to improve energy efficiency and made cost savings. For each site a comprehensive and detailed report was produced that considered the unique challenges for each location.

### Client Partnership

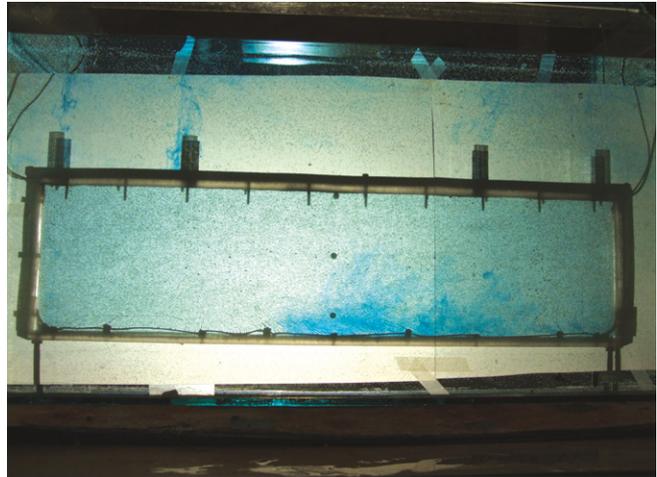
Shaun Fitzgerald says “Our brief was to see what energy savings could be delivered predominantly within the sphere of natural ventilation. The collaboration with Max Fordham allowed us to offer more thoughtful options and provide a solution that went beyond natural ventilation on its own. The collaboration also demonstrated our willingness and ability to adopt hybrid technologies that meet the requirements of the client and of the buildings.”

Phil Armitage, Senior Partner at Max Fordham, says: “Our aim is to facilitate architecture through innovative engineering, whilst at the same time addressing global warming issues. Working with Breathing Buildings was a fantastic opportunity to address the energy usage of such large-scale sites. Together with Breathing Buildings we provided functional solutions to challenging problems.”

### HAMMERSON'S VIEW:

**Incorporating natural ventilation into our buildings will reduce our energy bills and our carbon footprint as well as our exposure to any pricing mechanisms on carbon that the Government have or may introduce. It will ensure that our buildings can cope with projected changes to temperatures over the next three or four decades due to the effects of climate change. Further, simplifying the mechanical and electrical systems on site will reduce costs associated with maintenance and on-going programmes of plant replacement.**

### Water Bath Modelling



Water bath model displaying the natural air flow patterns within a building

“The key challenges were limiting the potential for summertime overheating and cold draughts in wintertime. On top of this each retail centre has its own unique challenges ranging from the fabric quality of the centre, the number of floors and entrances and the extent of glazing through to the state of the ventilation equipment currently used.”

Shaun Fitzgerald  
Breathing Buildings' CEO

# Asda Langley Mill



<b>PROJECT</b>	36,000 square foot Asda store
<b>LOCATION</b>	Langley Mill, Derbyshire
<b>SECTOR</b>	Retail
<b>FEATURES</b>	Consultancy, Design, Implementation
<b>HISTORY</b>	Project begun 2009 Store open for business November 2010 Systems monitoring and support work continues

## Project Overview

Supermarkets and large retail outlets are notoriously difficult to ventilate effectively and economically, especially during colder months, as outside temperatures fall below 16°C.

Asda turned to specialists Breathing Buildings to partner them in developing a ventilation solution for their new Langley Mill store that would effectively manage temperature fluctuations in colder weather, while also being able to cool the building on hot, windless days.

Langley Mill is a £25million development by Asda and the first UK store to operate the Breathing Buildings E-Stack natural ventilation system which allows the use of natural ventilation even when outside temperatures are as low as 10°C.

The store has no air conditioning too – this is impressive!

## The Challenge

Asda's business model makes environmental considerations the priority and the retail giant's environmental agenda includes:

- Cutting greenhouse gas emissions
- Ensuring new stores are 30% more Energy efficient\*
- Ensuring existing stores are 20% more energy efficient\*

The challenge for Breathing Buildings, working in close partnership with Asda, was to design a system that would not only deliver effective ventilation in a store with 36,000 square foot of sales space, but also meet Asda's strict criteria for lower energy consumption, reduced carbon emissions and greater energy efficiency.

Shaun Fitzgerald, Breathing Buildings CEO says: "Asda had very clear environmental targets for

Langley Mill and we met them at a very early stage of the design process.

“We modelled our ventilation system for the store early on and this showed that with our natural ventilation system, as opposed to a conventional mechanically ventilated system, Langley Mill would enjoy savings of up to approximately 110,000 kWh/year and as much as 150,000 kWh/year of gas.”

### The Solution

Breathing Buildings offered a holistic ventilation solution, drawing on their considerable consultancy experience and sector-leading knowledge, featuring a range of measures that mean Langley Mill is 30per cent more energy efficient than a store of the same size built in 2005 (a result that meets Asda’s strategic requirements).

The ventilation system ensures that during the hottest summer months, even with no wind blowing, the system effectively ventilates and cools the building. However, it also allows the store to use natural ventilation as temperatures fall to as low as 10°C.

### Natural Ventilation Delivered

The solution is delivered through the use of 12 Breathing Buildings E-Stack units mounted on the roof of the Langley Mill store. By capturing and reusing the heat generated within the store by electrical equipment, lighting, ovens, chillers and freezers, and the body heat of staff and customers, the system significantly reduces the amount of pre-heating needed in the building, so cutting energy use and greenhouse gas emissions.

With the store open for business an independent review of actual performance is ongoing and the building’s management system continuously monitors energy use and temperature.

### Client Partnership

Dr. Shaun Fitzgerald, CEO of Breathing Buildings, says: “We take a very team-based approach and we are delighted to be forging the way ahead with Asda as they pioneer our unique system at Langley Mill.

“Supermarkets are open for many hours each week and they need to be confident in the systems they use. Natural ventilation is still regarded by many in this competitive sector as a relatively untried concept. However, we have found that many supermarkets want to secure for themselves the

benefits of ultra low-energy ventilation.

“If designers want to see us we would be delighted to discuss their projects and proud to take them to see Langley Mill. The Asda store is a very big project but we are always happy to consult about any project, small or large.”

### ASDA’S VIEW:

#### We Hate Waste of Any Kind

##### We will:

- Reduce energy requirements for our existing stores and distribution stores by 20% by 2012\*.
- Reduce new store energy requirements by 30% by 2010.
- Build wind turbines to power 6 of our depots by 2012.

### SUSTAINABLE BUILD IN LANGLEY MILL

Our store in Langley Mill will feature a range of measures to ensure that it is 30% more energy efficient than a store built in 2005.

We are continuing to invest in technologies to reduce our carbon footprint even further.

“We are very hopeful that this unique approach will deliver carbon emission savings and energy cost savings in excess of any we could achieve using either mechanical or traditional natural ventilation systems.”

**Julian Walker Palin**  
Asda, Head of Corporate Sustainability

# Houghton-Le-Spring Primary Care Centre



<b>PROJECT</b>	Houghton-Le-Spring Primary Care Centre
<b>LOCATION</b>	Sunderland
<b>SECTOR</b>	Healthcare
<b>FEATURES</b>	Consultation, design and implementation of a bespoke, innovative low carbon ventilation system
<b>HISTORY</b>	Project began in 2009. Project completed in 2011

## Key Message

Breathing Buildings instrumental in Health Centre design achieving BREEAM 'Outstanding' rating.

## Introduction

Sunderland Primary Care Trust (PCT) at Houghton-Le-Spring has recently seen the completion of a development to provide a range of local healthcare services. The building includes large public spaces for a café and waiting areas, in addition to the patient and consulting rooms.

Working for the PCT, Breathing Buildings was asked to develop a design strategy for natural ventilation particularly of the public areas but also other spaces within the building. Following the completion of this initial stage, Breathing Buildings worked closely with the project team to design and deliver bespoke ventilation equipment.

## The Challenge

- To maintain an interior temperature below 25°C
- To provide a low-carbon solution

An extremely challenging brief was given by the PCT, stating that the interior temperature is to remain below 25°C, for all but 100 hours per year in order to ensure patients are kept comfortable and in well ventilated conditions at all times.

Traditionally, this would have been achieved through the use of mechanical ventilation and air conditioning. The objective of the design team here, however, was to create an innovative, low-carbon solution for summer cooling through the use of natural ventilation and thermal mass.

### The Solution

Breathing Buildings designed a bespoke 50m long thermal wall, which was constructed along the spine of the building. This provides ventilation for the consultancy rooms as well as the open-plan waiting area and café. The wall is split into 49 individual shafts to separate the ventilation for individual spaces and therefore reduce the potential for infection transfer.

### Natural Ventilation Delivered

In order to optimise both comfort and energy savings, different strategies have been applied for summer and winter ventilation.

In summer, the thermal wall is used to passively cool the incoming air. Cold air is drawn down the shafts into the wall during the night and the cooled shafts are then used to reduce the temperature of the warm outside air which is brought into the building the following day.

In winter, a mixing ventilation strategy is used involving six Breathing Buildings' unique E-Stack R Series units within the open plan areas and café. Cold air is brought into the buildings from outside and is diluted with interior warm air within the buildings before it reaches the occupants.

### Partnership

Andy Mackintosh, Director at Willmott Dixon, said:

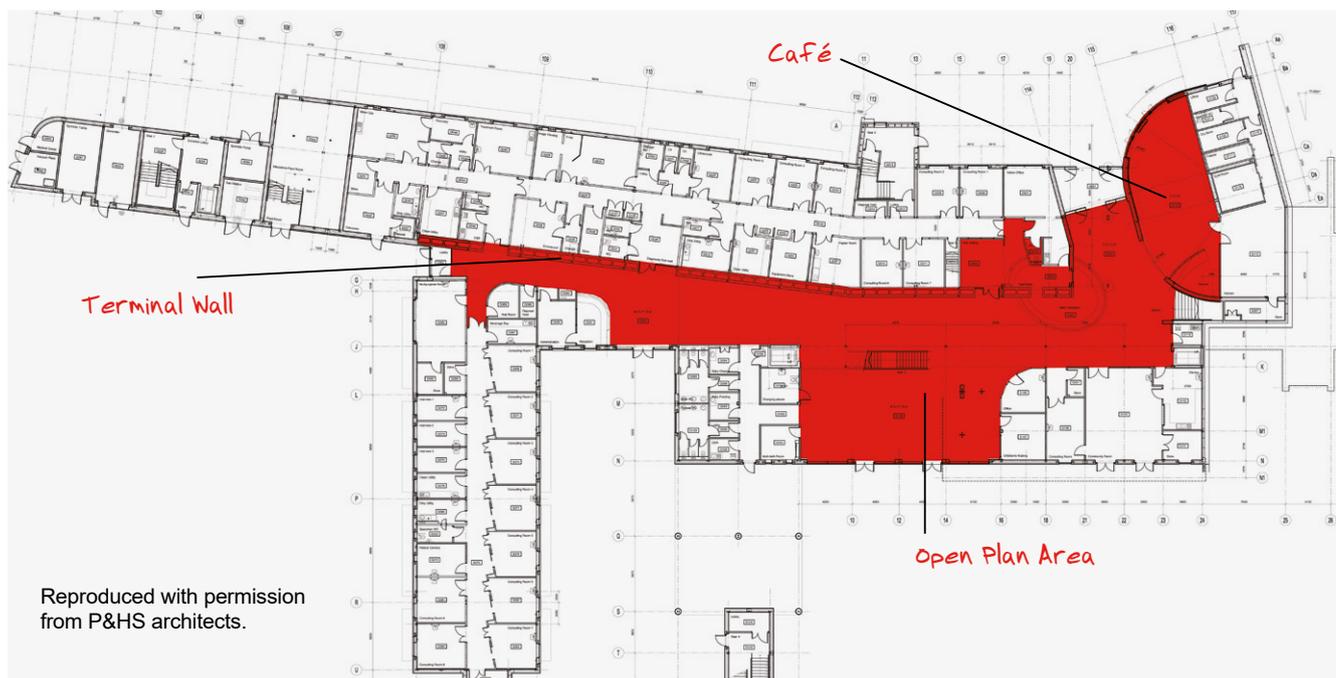
“Willmott Dixon is delighted how the whole team has worked together to achieve BREEAM Outstanding. This is the first healthcare project in the UK to achieve BREEAM Outstanding.”

“We are delighted to have been chosen by Willmott Dixon to be involved in this project and to have played a part in the achievement of the industry-first Outstanding BREEAM rating.”

Shaun Fitzgerald  
Breathing Buildings' CEO

Houghton-le-Spring Primary Care Centre won the BREEAM Healthcare Award.

### Architectural plan



# Barnfield South Academy



<b>PROJECT</b>	Barnfield South Academy
<b>LOCATION</b>	Rotheram Avenue, Luton LU1 5PP
<b>SECTOR</b>	Education
<b>FEATURES</b>	Unique noise attenuation technology
<b>HISTORY</b>	Project begun in 2009

## Project Overview

A school's requirement for a quiet learning environment, minimal energy consumption and high air quality to enhance student concentration, all combine to create ventilation and noise attenuation issues that pose highly specialist challenges for designers and developers.

This uniquely specialised field is one in which the innovative expertise of Breathing Buildings is widely recognised.

## The Challenge

Barnfield South Academy sits close to the M1 motorway near Luton and the resulting acoustic requirements were the main challenge for the design of the ventilation system. Resolving these issues made this a unique project.

The challenges were to:

- Effectively and efficiently ventilate the school
- Meet BB101 summertime overheating criteria
- Meet acoustic requirement BB93
- Ensure minimal energy consumption via natural ventilation rather than mechanical ventilation

## The Solution

Breathing Buildings' aim for the Academy was to create a holistic solution that would meet the primary goals of good air quality in the study areas, energy conservation, and the required ventilation standards.

This complex challenge demanded that ventilation issues were addressed while keeping to a minimum potentially distracting noise ingress from the nearby M1 motorway.

This was achieved by significantly reducing the ingress of high level noise through the fitment of acoustic baffles into the roof terminals and ventilation shafts.

David Palmer says: “Our design for Barnfield South Academy meant we not only met the BB101 summertime requirements but also the BB93 acoustic specification that we were working to, underlining the success of our design in mitigating ingress of external noise.

### Natural Ventilation Delivered

This is a reasonably large project ventilating 39 classrooms. The holistic approach uses a Breathing Buildings’ E-Stack R series in each of the individual classrooms.

David Palmer adds: “What makes this initiative unique is that the shafts have within them acoustic attenuator units comprised of a series of noise-attenuating baffles. So instead of an open shaft, the baffles mean that the incoming sound rebounds around between the baffles, losing power as it does so. This results in up to 25dB Rw sound reduction\* – a major reduction in noise ingress. Balancing this need for noise attenuation whilst not compromising the ventilation design proved to be a fascinating engineering challenge.”

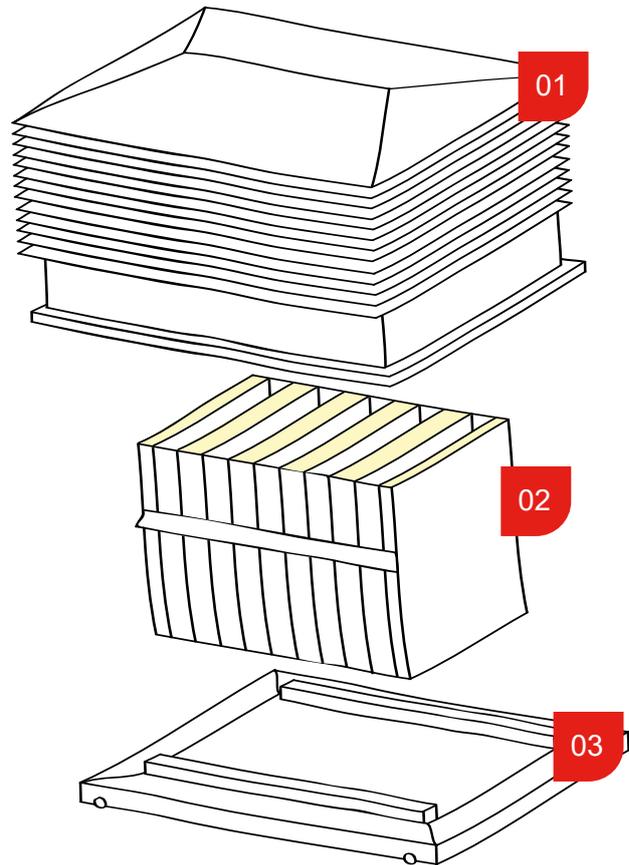
### Client Partnership

Breathing Buildings worked closely with the project’s mechanical and electrical consultants Cundall Johnston and Partners, the main contractors Wates Construction and Breathing Buildings’ actual customer the Briggs & Forrester Group.

“We developed our attenuated roof terminal design along with acoustic specialists, and then had it independently certificated at acoustics consultants Sound Research Laboratories in Sudbury, Suffolk.”

David Palmer  
Breathing Buildings’ Project Engineer

General assembly of roof terminal and attenuator as used at Barnfield South Academy.



- 01 **Roof Terminal**  
Assembly constructed from extruded aluminium sections
- 02 **Acoustic attenuator**  
Constructed of 6 baffles @ 900mm high
- 03 **Ring beam**  
Hot dip galvanised welded steel fabrication

\* The Sound Reduction Index is a measure of the resistance to sound of a material in the form of a panel or building element. In effect the SRI measures how much a noise source is reduced by passing it through an attenuator.

# The Science of Cold Draughts

We are often told by consultants, clients and engineers that the 2 main problems with natural ventilation are cold draughts and the associated high energy usage. We agree. Using our patented, low energy, mixing system we introduce turbulence to **mitigate the cold draughts**. But many in the industry ask just how much mixing you can actually get from a louvre or opening window at high level.

Not enough would be our assertion and in our latest blog we share the science behind this assertion. Realistically you can hope to achieve 4°C of mitigation at best, so when it is 5°C outside you would still get incoming air at 9°C, which is cold. I would encourage you to ask your natural ventilation supplier to share their science and if they can't or won't come and talk to us.

So, let's delve a little deeper into the physics and rather than just rely on assertions, see what the experts have to say.

Cold draughts are a real problem with natural ventilation, and we know that curing this problem by passing the incoming cold fresh air over a heating element is just nonsensical in terms of energy use. The heat gains in most non-domestic buildings far outweigh the heat required to maintain an average space temperature of say 21°C in winter for external temperatures in excess of around 6°C. The problem is that if air cooler than around 16°C falls onto you, you'll know it! It is just too cold to handle. One concept which is being discussed in the industry is the use of high level opening vents for winter ventilation. The idea relies on the incoming cold fresh air mixing naturally with the interior warm air before it reaches occupants. A nice idea indeed - but does it work?

The first problem we have in many rooms is that the floor to ceiling height is around 2.8m. Secondly, any high level vent will have a certain depth to it, so the distance from the floor to the bottom of the high level vent is at most 2.3m. Cold air will enter through the bottom of the high level vent when the vent is opened in winter. Finally, if you are sat underneath the window, given typical desk and chair arrangements the distance from the floor to the top of your head is 1.3m. This is a long way of saying, the distance between the top of your head and the bottom of the vent is probably

1m. So, the killer question is "does the incoming cold fresh air mix with enough of the room air as it falls 1m for the temperature to be above 16°C?"

Fortunately, the fluid mechanics experts have provided us with the tools to assess the risk. We are going to use the turbulent plume model calculation using the principle of a virtual origin (Kaye and Hunt), and see what it says.

**Step 1** - for a given required fresh air volumetric flow rate  $V_o$  per unit length of perimeter window, calculate the buoyancy flux  $B_o$  associated with it by noting the temperature of the incoming air  $T_{ext}$  relative to the interior air  $T_{int}$

$$B_o = V_o g (T_{int} - T_{ext})/300$$

where  $g$  = acceleration due to gravity

**Step 2** - calculate the height ABOVE the bottom of the high level window where the fresh air enters which would correspond to a source of pure buoyancy and no mass flux using the developed plume equation for a line source.

$$h_o = \frac{h_o = (\rho_o V_o}{(2 (0.5) a_r)^{2/3} B_o^{1/3}}$$

where  $a_r$  is a constant 0.1, a 0.5 factor is used to account for the fact that the incoming line plume will only entrain air from one side as the window is solid, and  $\rho_o$ .

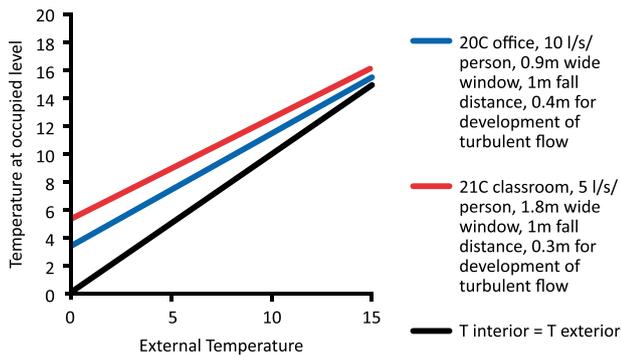
**Step 3** - calculate the reduced gravity  $g'$  of the plume at occupied level distance  $h_1$  below the bottom of the high level window, accounting for the fact that the plume may not be fully developed at the point of entry (e.g. assume 40cm before plume is fully developed)

$$g' = \left( \frac{B_o}{2 (0.5) a_r} \right)^{2/3} \frac{1}{(h_1 + h_o - 0.4)}$$

**Step 4** - calculate the temperature  $T_1$  of the plume at occupied level

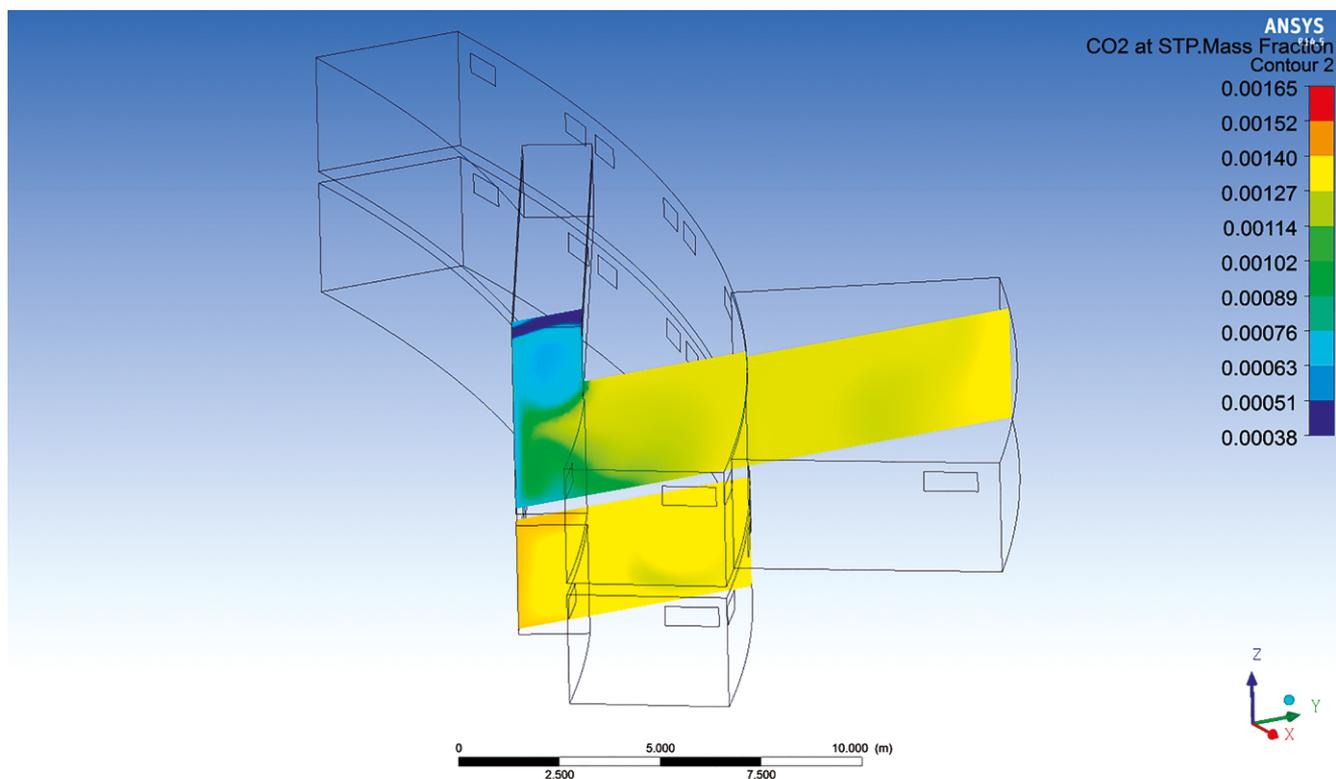
$$T_1 = T_{int} - (300 g'/g)$$

What is the result? See the graph below for two limiting cases of a cooler office with minimum ventilation requirements and a single window, and a warmer classroom with lower fresh air rates and a wider window.



The over-riding conclusion is that if you want to ensure fresh air reaches occupants no colder than 16°C, opening windows are fine but only when the exterior temperature is above 13-14°C. Alas, as we spend so much of the time in the UK with external temperatures below this level, then unfortunately the opening window strategy won't work - you will get cold draughts.

This is part of the reason many schools which just have opening windows are simply not ventilated in winter. The research findings in 2005 of the BRE, who studied 8 primary schools with opening windows, found that in winter more than half the fresh air rates were below the minimum required. Something else is needed - and hence why the E-Stack natural ventilation system was developed.



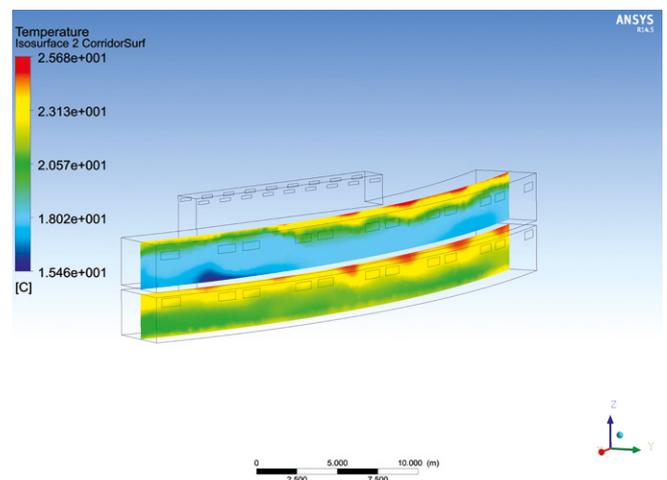
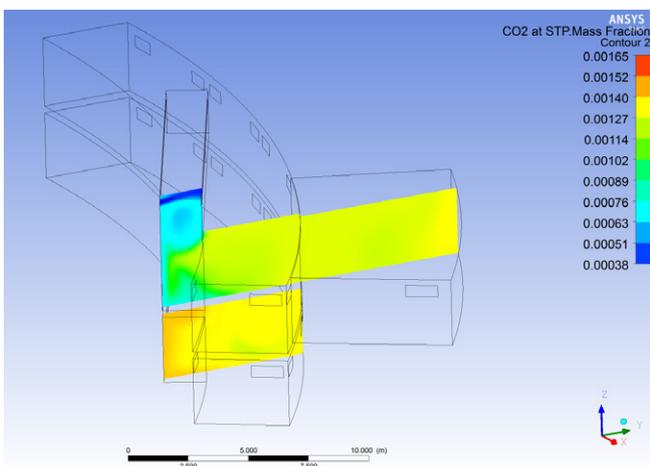
# Thermal Modelling, Water Bath Modelling and CFD

One of the traditional methods of analysing air flow patterns in buildings with topologically complex features is computational fluid dynamics (CFD)

This technique involves dividing the volume of interest in the building into a number of grid cells, and solving the equations for conservation of mass, momentum and energy. One of the reasons this technique is commonly used is because there are software packages which are commercially available. The biggest issue with CFD is that it may not readily reveal the different flow regimes which might actually be experienced in reality.

A different modelling technique we use is water bath modelling. This involves constructing a Perspex model of a representative section of the building to a scale of around 1:75, using hot wires or saline solution as a source of buoyancy, and immersing the model in a large tank of water. Once the buoyancy source is started, the water flows in the tank are observed by shining a light through the tank and projecting the image onto translucent paper. The change in refractive index of water at different densities enables the flows to be observed. The water flows in the tank represent the potential building scale air flows so long as there is appropriate dynamic similarity.

Modelling is one thing, delivering low energy buildings is quite another. We work with our clients throughout a project to ensure that their energy bills are as low as possible, including going back to monitor a project where appropriate. This can also be valuable for BREEAM as post occupancy evaluations are an important aspect of the assessment. The information gained from the monitoring provides us with a wealth of information and shows that not only do we design low-energy buildings we also deliver them!



Breathing Buildings' team of consulting engineers undertake thermal modelling simulations for every project at the proposal stage. Our 4DFlo modelling software uses dynamic thermal modelling calculations, using a model based on the formulae of CIBSE "Natural Ventilation in Non-Domestic Buildings", and is compliant with the requirements of CIBSE.

Using 4DFlo dynamic thermal modelling, Breathing Buildings are able to demonstrate that each room complies with the Building Regulations Approved Document Part F as well as the relevant overheating criteria for the building type. Breathing Buildings frequently design to the PSBP Facilities Output Specification, BB101 or CIBSE overheating criteria, but can also meet a client's specific requirements.

Breathing Buildings is also at the forefront of design to meet the new adaptive comfort criteria set out for the Priority Schools Building Programme, CIBSE TM52 and BB101.

When required Breathing Buildings can take design responsibility for the ventilation strategy based on the calculations prepared using 4DFlo.

Breathing Buildings are also able to aid consultants in their modelling of E-Stack ventilation strategies in thermal modelling packages such as IES-VE. Our trained IES-VE users can provide documentation and face-to-face advice to modellers in order to accurately represent the E-Stack's function. Our Consulting Engineers also use IES-VE as a design tool as part of our consultancy work on larger or more complicated projects. Breathing Buildings has also collaborated with IES to produce our NVHR units as a performance component which is available as a drag and drop feature in the IES Navigator tool.

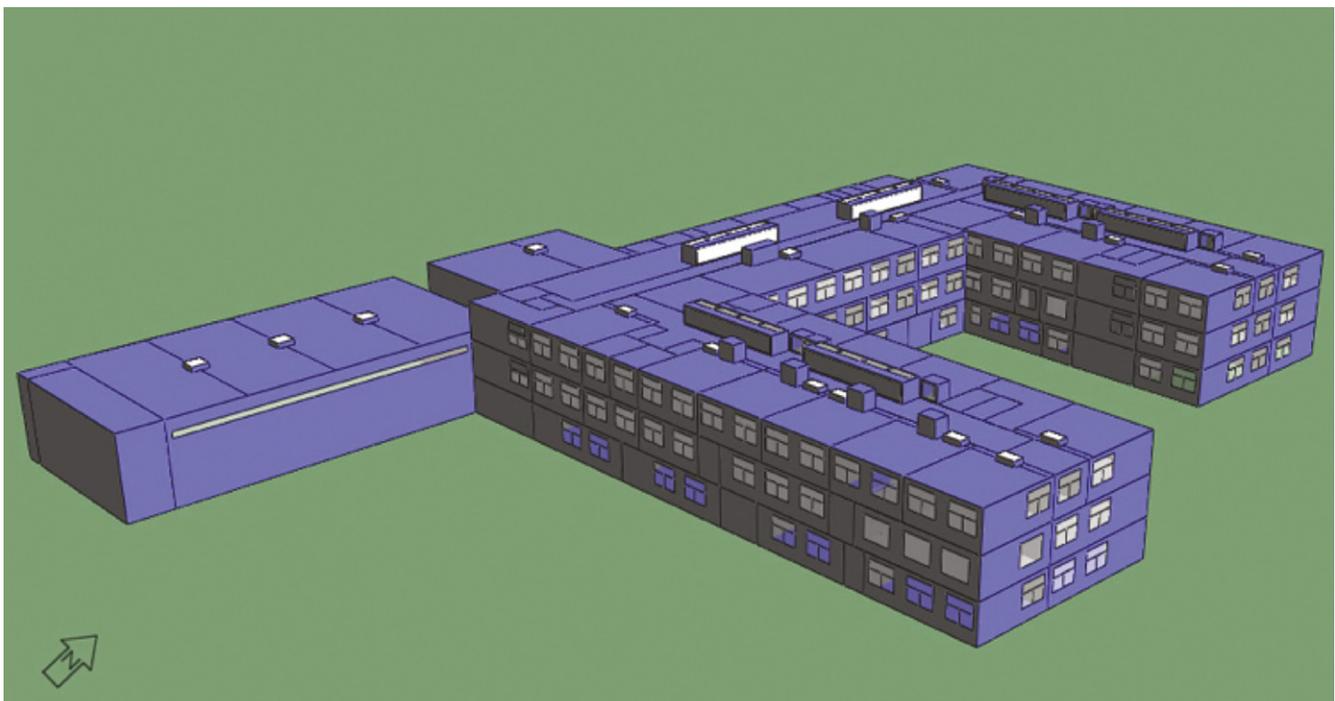
When the design team has particular concerns about air distribution or temperature variation across a space, Breathing Buildings offer consultancy services in CFD (Computational Fluid Dynamics) using ANSYS CFX software.

Breathing Buildings support the design team throughout the design process of a natural ventilation strategy. From providing advice at the concept stage, through to detailed calculations as the building layout and detail design evolves, through to demonstrating compliance and learning from post-occupancy monitoring.

Powered by

**4DFlo**

Dynamic thermal mass simulation



# Building Bulletin 101 - User Guide

**BB101 (2018) guidelines on ventilation, thermal comfort and indoor air quality in schools from the Education and Skills Funding Agency - this User Guide summarizes the changes from the previous guidelines and explains how Breathing Buildings can help you comply with the new standards**



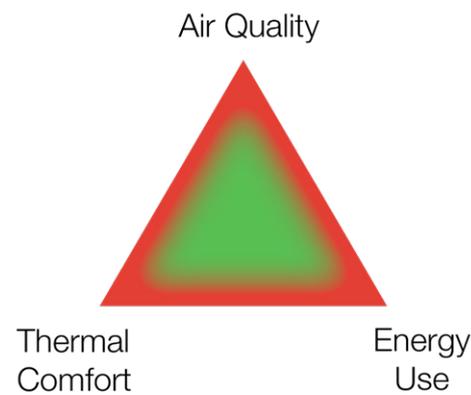
## Background

BB101 2018 sets out regulations, standards and guidance on ventilation, thermal comfort and indoor air quality for school buildings. It replaces the 2006 version. The document first describes the factors that affect the design of the indoor environment of schools. It then lays out the regulatory framework for schools and gives the recommended DfE performance standards for compliance with UK regulations. Critically BB101 provides a summary of regulations and recommended performance standards for school designers. The final sections provide detailed non-statutory guidance on how to design schools to achieve adequate performance for ventilation, indoor air quality and thermal comfort.

BB101 2018 is around 150 pages so Breathing Buildings has compiled this easy-to-read User Guide to help you get up to speed quickly. In addition we have developed some online design tools available at [www.breathingbuildings.com/services/free-design-tools/](http://www.breathingbuildings.com/services/free-design-tools/)

## Executive Summary

The document provides a framework which describes the interplay of three key factors – air quality, thermal comfort and energy use.



These factors need to be considered together. For example, it is important to provide sufficient fresh air in winter, but not at the expense of creating cold draughts or high heating bills to try and overcome them. Holistic design is a key feature in BB101 2018 and aligned with the principles of the Breathing Buildings design approach.

**Breathing Buildings has compiled this guide to help you quickly grasp the key tenets of Building Bulletin 101 and to explain how we can help you comply with the requirements. We have a wealth of design expertise and modelling tools which can be used during the design stage of a project in order to generate a cost-effective design which meets the requirements for air quality, thermal comfort and energy use. We also have a range of products which can then be used to ensure that the schools deliver the intended results.**

**For more information get in touch using our contact details on the back page.**

## Air Quality

The first thing to consider in a project is the external environment and the quality of air in the immediate surroundings.

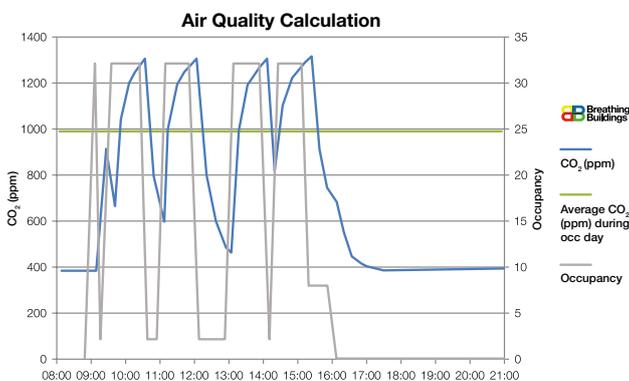
Where outside air pollutants exceed the levels in the National Air Quality Standards consideration needs to be given to means of reducing pollutant levels in the indoor air. This is especially important in Air Quality Management Areas and in Low Emission Zones. Filtration may be needed for two reasons:

1. to prevent dirt accumulating in ventilation equipment such as air handling plant, heat exchangers and ductwork; and
2. to filter out external pollutants if the exterior environment is too dirty to consider unfiltered air. Importantly, the document highlights the fact that filtering out pollutants that have health effects requires more expensive filters.

The air quality in teaching areas is now assessed in the main by monitoring the CO<sub>2</sub> levels. This is because the ventilation rate required in a given space needs to increase with the number of occupants. Occupants generate CO<sub>2</sub> and hence a system which responds to CO<sub>2</sub> levels is a practical way of managing the ventilation rate in accordance with the requirements, and enables ventilation rates to be reduced at times of lower occupancy. However, in some areas such as science laboratories there are further checks because of the potential presence of additional contaminants.

### Online CO<sub>2</sub> calculator

Breathing Buildings has developed an online design tool to help determine the flow rates required to meet the new air quality guidelines. The free tool is available for download from [www.breathingbuildings.com/services/free-design-tools/](http://www.breathingbuildings.com/services/free-design-tools/)



Example output from online design tool CO<sub>2</sub> calculator

For a given occupancy input by the user, the tool provides a graphical output showing whether the chosen flow rate is sufficient.

### Normal teaching areas

#### Mechanical ventilation

Mechanical ventilation is where the driving force for the supply of fresh air and/or extract of stale air is provided by a fan. In general teaching and learning spaces where mechanical ventilation is used or when hybrid systems are operating in mechanical mode, sufficient outdoor air should be provided to achieve a daily average concentration of carbon dioxide during the occupied period of less than 1000ppm, when the number of room occupants is equal to, or less than the design occupancy. In addition, the maximum concentration should not exceed 1500ppm for more than 20 consecutive minutes each day when the number of room occupants is equal to, or less than the design occupancy.

#### Natural ventilation

Natural ventilation is where the driving force for the supply of fresh air and extract of stale air is buoyancy and/or wind. In general teaching and learning spaces where natural ventilation is used or when hybrid systems are operating in natural mode:

- a. Sufficient outdoor air should be provided to achieve a daily average concentration of carbon dioxide during the occupied period of less than 1500ppm, when the number of room occupants is equal to, or less than the design occupancy. In addition, the maximum concentration should not exceed 2000ppm for more than 20 consecutive minutes each day, when the number of room occupants is equal to, or less than the design occupancy; and
- b. The system should be designed to achieve a carbon dioxide level of less than 1200ppm (800ppm above the outside carbon dioxide level, taken as 400ppm) for the majority of the occupied time during the year. This is the criterion for a Category II building in the case of a new building; or 1750ppm (1350ppm above the outside carbon dioxide level), for a category III building, in the case of refurbishment or remodelling (see next page for definitions of Category types).

CO<sub>2</sub> should be measured at seated head height in all teaching and learning spaces.

### Specialist teaching areas such as science laboratories

In accordance with IGEM standards, gas interlocks by environmental monitoring of CO<sub>2</sub> should operate as follows:

- a. During practical activities, the appliances shall not cause the CO<sub>2</sub> level to exceed 2800ppm, which will produce a high level warning signal.
- b. An automatic gas shut down shall operate when the level of 5000ppm of CO<sub>2</sub> is reached.

At 2800ppm supply and extract systems should be automatically switched on or boosted and the teacher should be warned that ventilation needs to be

increased. Systems to control the ventilation can include individual canopies vented externally, supply air fans or opening windows. When the CO<sub>2</sub> level is below 2800ppm these ventilation systems can be under automatic demand control with teacher or user override, so that noise levels can be easily controlled and energy use can be minimised. Openable windows alone is not an adequate means to control CO<sub>2</sub> levels in these practical spaces.

Building regulation AD F requires local extract of moisture, fumes and dust. BB101 therefore states that additional ventilation is needed in spaces such as laboratories, server rooms, design and technology spaces, kiln rooms, food technology rooms and kitchens, to remove fumes and heat from equipment.

Ventilation rates in practical spaces for normal experimental conditions are given below.

Room type	Area (m <sup>2</sup> )	Minimum required flow rate
Laboratories and preparation room	>70	4 l/s/m <sup>2</sup>
Laboratories and preparation room	37-70	11.42 -(0.106 x Area) l/s/m <sup>2</sup> [note that this is equal to flow rate for the room of 278 l/s/m <sup>2</sup> ]
Laboratories and preparation room	<37	7.5 l/s/m <sup>2</sup>
Chemistry store room	All	2 air changes/hour, 24 hrs/day
Art classroom	All	2.5 l/s/m <sup>2</sup>
Metal/wood workshop/ classroom Rooms with 3D printers; laser cutters; and spray booths for spray glue or spray paint aerosols	All	2.5 l/s/m <sup>2</sup>

These area-based ventilation rates in l/s/m<sup>2</sup> apply to spaces of 2.7m height or higher. The equivalent air change rate per hour (ach) can be calculated from ach = (l/s/m<sup>2</sup> rate) x 3.6/(Room height(m)). For spaces below 2.7m in height the equivalent air change rate to a 2.7m high space should be used.

The rates for science rooms have been adjusted to suit school science spaces in the UK and are the result of pollutant tests carried out by the ESFA and CLEAPSS in science labs, with Breathing Buildings in attendance. The exhaust rates are needed during and following experiments and practical activities to purge the room of chemicals and other pollutants.

## Thermal Comfort

There are significant changes to the thermal comfort criteria in BB101. The changes are based on a number of factors and learnings. Firstly, it is acknowledged that the level of thermal comfort which can be achieved is dependent upon whether a building project is a new build or a refurbishment. Furthermore, the level of thermal comfort demanded is dependent on the type of activity in a space. The definition of the categories is as follows.

Category	Explanation
I	High level of expectation and also recommended for spaces occupied by very sensitive and fragile persons with special requirements like some disabilities, sick, very young children and elderly persons
II	Normal expectation
III	An acceptable moderate level of expectation
IV	Low level of expectation. This category should only be accepted for a limited part of the year

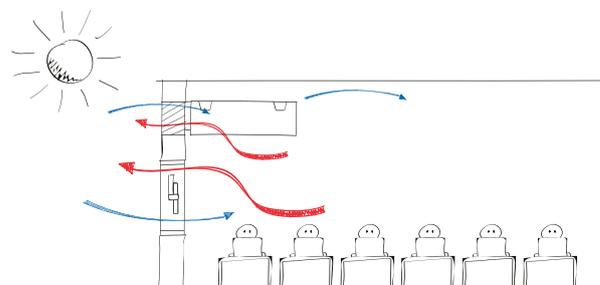
The ESFA has applied categories I-IV for assessment of overheating risk as shown in the following table.

Type of space/activity	New Build	Refurbishment
Teaching and learning, drama, dance, exams, multi-purpose halls	II	III/IV
Practical activities such as cooking	N/A	N/A
Sports Halls not used for exams	III	IV
Working areas, eg, kitchens	N/A	N/A
Offices	II	III/IV
Atria, circulation, reception and corridors - not continuously occupied	III	IV
Areas for pupils with complex health needs	I	I

Note that for refurbished buildings, where III/IV is shown it means that the minimum standard is Category IV where Category III cannot be met for reasons of practicality and due to the extent of refurbishment. However, after refurbishment the criteria should not be worse than before refurbishment in any aspect affecting thermal comfort.

## Weather files

BB101 (2018) now stipulates the use of Design Summer Year DSY1 2020 (50<sup>th</sup> percentile range) weather files. This is a significant change from the 2006 edition of BB101, which required designers to model overheating using the Test Reference Year (TRY) weather file. **Operative temperature**



BB101 sees the use of operative temperature as a measure of thermal comfort. In CIBSE Guide A operative temperature is defined as:

$$\text{operative temperature} = \frac{1}{2} (\text{air temp}) + \frac{1}{2} (\text{mean radiant temp})$$

Breathing Buildings 4DFlo dynamic thermal modelling software

calculates operative temperature at every time step. Furthermore, the software automatically assesses the input parameters against the BB101 overheating criteria, and reports the result to the designer without need for post-processing. This greatly streamlines the process and reduces the time it takes to assess a range of design options.

**Adaptive comfort**

One aspect of the adaptive comfort philosophy is based on the premise that past thermal history modifies building occupants’ thermal expectations, preferences and responses to dress code on any given day.

To calculate the acceptable temperatures and the number of hours exceeding these, BB101 requires the use of a number of values from thermal modelling. These are automatically generated by the Breathing Buildings dynamic thermal modelling software 4DFlo:

- Running mean temperature,  $T_{rm}$  (calculated from weather files)
- Operative temperature,  $T_{op}$  (calculated from dynamic thermal modelling, such as Breathing Buildings 4DFlo)
- Maximum acceptable temperature,  $T_{max}$  (calculated from weather files)
- Hours of Exceedance,  $H_e$  (calculated from dynamic thermal modelling)
- Weighted Exceedance,  $W_e$  (calculated from dynamic thermal modelling)
- Threshold / upper limit temperature,  $T_{upp}$  (calculated from weather files)

**Overheating criteria**

In the previous version of BB101 there were three criteria, of which you had to pass two but could fail one. In general there is a shift from the use of 28°C, 32°C and a 5°C ΔT as a metric, to the use of Adaptive Comfort (EN 15251) to set the maximum desired internal temp ( $T_{max}$ ) in the space. The Adaptive Comfort criteria are in line with the criteria introduced in CIBSE TM52. For free running (not mechanically cooled) normal school buildings  $T_{max}$  is calculated using the equation:

$$T_{max} = 0.33T_{rm} + 18.8 + T_{acceptable\ range}$$

where  $T_{rm}$  is the running mean temperature, which is a weighted daily average of external temperatures over the previous 7 days. This can be calculated using the following equation:

$$T_{rm} = \frac{(T_{(od-1)} + 0.8T_{(od-2)} + 0.6T_{(od-3)} + 0.5T_{(od-4)} + 0.4T_{(od-5)} + 0.3T_{(od-6)} + 0.2T_{(od-7)})}{3.8}$$

where suffix od-1 denotes the average external temperature of the previous day, od-2 the day before that and so on.  $T_{rm}$  can also be found in CIBSE KS16 or TM52. The acceptable range is based on the category of building.

Category	$T_{acceptable\ range}$ (K)
I	2
II	3
III	4
IV	>4

The operative temperature is to be calculated based on design occupancy 0900-1600 with a 1 hour lunch break 1200-1300, for the period 1 May - 30 Sep.

The following is a brief summary of the three criteria:

**Criterion 1** is that the number of Hours of Exceedance must be no more than 40 when the predicted operative temperature exceeds  $T_{max}$  by 1K, or more (c.f. number of hours above 28°C <120 in previous BB101). When sports halls are used for exams this activity shall be taken as weekdays from 1 May to 8 Jul and the number of hours shall be reduced from 40 to 18.

**Criterion 2** is the sum of the Weighted Exceedance ( $W_e$ ) for each degree K above  $T_{max}$  (1K, 2K and 3K) and must not exceed 6 on any one day.  $W_e = \sum h_e \times wf = (h_{e0} \times 0) + (h_{e1} \times 1) + (h_{e2} \times 2) + (h_{e3} \times 3)$ , where the weighting factor  $wf=0$  if  $\Delta T \leq 0$ , otherwise  $wf = \Delta T$ ,  $h_{ey}$  = time in hours when  $wf = y$ , and  $\Delta T = (T_{op} - T_{max})$ , rounded to a whole number (i.e. for  $\Delta T$  between 0.5 and 1.5 the value used is 1°C, for 1.5 to 2.5 the value used is 2°C and so on).

**Criterion 3** is that the predicted operative temperature should not exceed  $T_{max}$  by 4K or more at any time, i.e.  $T_{upp}$  = maximum value of  $\Delta T = 4$  (c.f.  $\Delta T < 5^\circ C$  and  $T_{max} = 32^\circ C$  in previous BB101).

The first of these criteria (Criterion 1) defines a minimum requirement for the overheating risk assessment. In other words, **this criterion must be passed**. The two additional criteria (Criterion 2 and Criterion 3) are primarily measures of short-term discomfort and should be reported for information only. If a school design fails to meet Criterion 2 or Criterion 3 then designers should consider potential overheating mitigation measures and indicate which are viable for the project. The use of these three performance criteria together aims to ensure that the design is not dictated by a single factor but by a combination of factors that will allow a degree of flexibility in the design.

**Performance in Use** (Effectively Criterion 4, which must be met) is that it should be possible to demonstrate within spaces that are occupied for more than 30 minutes at a time that, during the school day, the average internal air temperature does not exceed the average external air temperature measured over an occupied day by more than 5°C; both temperatures being averaged over the time period when the external air temperature is 20°C, or higher, except when the diurnal temperature range (lowest temperature from the previous night to the maximum daytime temperature the following day) is less than 4°C.

**Expert advice**

Having been heavily involved in the development of BB101 Breathing Buildings are uniquely placed to help contractors and engineers ensure that their school is designed to comply with the new regulations.

## Energy Use and Avoidance of Cold Draughts

One of the most significant changes in the new BB101 pertains to thermal comfort in winter, and in particular the importance of mitigating cold draughts but without incurring excessive heating bills to do so. The new version of BB101 stipulates that in order to reduce the problem of draughts, which frequently prevents windows from being opened in densely occupied classroom spaces with low-level air inlets, the design of ventilation and its control should provide mixing of ventilation air with room air to avoid cold draughts in the occupied zone. Mixing provides heat reuse within the space and is a very energy efficient winter strategy. This is because in new buildings (in the UK) with high levels of thermal insulation the balance point where no heating is required is around 5°C and the number of occupied hours when the external temperature is below 5°C is small.

### Natural ventilation

For naturally ventilated spaces, when the outside air temperature is 5°C and the heat emitters are switched off, the minimum temperature of air delivered to the occupied zone at seated head height should be not more than 5K below the normal maintained operative temperature. Seated head height should be taken as 1.1m above floor level for primary and 1.4m above floor level for secondary school classrooms.

The line plume calculator, developed by Breathing Buildings, can be used to estimate the temperature of the incoming plume of air from high level openings when it reaches the occupied zone. Alternatively measurements can be made in test rooms or CFD models can be used.

### Mechanical ventilation

In a mechanical system where the driving force for the supply air is a fan, the design should meet the comfort criteria in BS EN 15251 for mechanical ventilation systems.

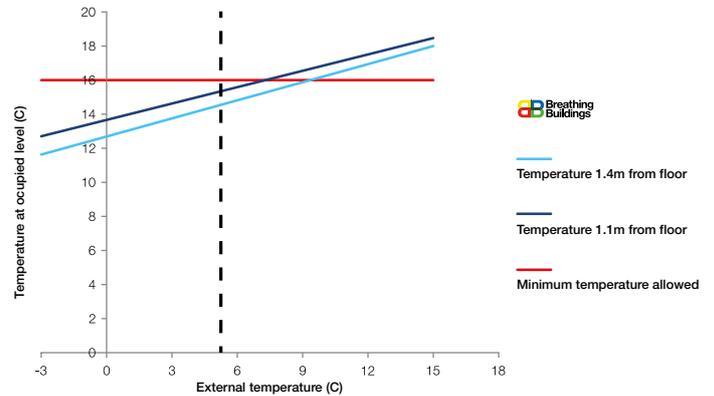
### Line plume calculator

Breathing Buildings has developed an online design tool to help designers determine when a simple opening is likely to be sufficient to meet the cold draught criterion.

This spreadsheet tool is based on standard plume theory from Turner (1973), Buoyancy Effects in Fluids. It also uses the concept of a virtual origin for plumes following the work of Kaye & Hunt. It shows how the temperature of an incoming stream of cold air through a high level window or damper into a warm room increases as the turbulent plume falls under gravity and entrains warm room air. The entrainment is just from one side of the line plume since the other side is against the window. When the temperature of the plume 1.4m from the floor (represented on the following chart by the light blue line for secondary schools) or 1.1m from the floor (represented on the following chart by the dark blue line for primary schools) is below the minimum acceptable level for schools (given by the red line) for any external temperature above 5C (denoted

by the dotted black line), the system **FAILS** to meet the criterion for draughts. When the temperature of the plume (blue line) is above the minimum temperature (red line), the system **PASSES** the criterion for cold draughts.

The model assumes that the flow is fully turbulent the moment air enters the room. This is the most optimistic assumption with regards to the effectiveness of mixing. The modelling results therefore indicate an optimistic view of the mixing effectiveness and colder temperatures at the occupied level may be experienced.



Example output from online design tool Line Plume Calculator ([www.breathingbuildings.com/services/free-design-tools/](http://www.breathingbuildings.com/services/free-design-tools/))

### The results should be interpreted as follows:

1. If the temperatures predicted show a **FAIL** then it is very likely that draughts will be a serious issue in your design and **alternative solutions such as Breathing Buildings equipment are recommended.**
2. If the temperatures predicted show a **MARGINAL PASS** then anyone using this design should only do so with **extreme caution** as draughts may well still be a problem.
3. If the temperatures predicted show a **CLEAR PASS** then the designer can **proceed**, but note that the results do not guarantee draught free conditions at all times. If completely draught free conditions are desired under all weather conditions then **alternative ventilation solutions such as Breathing Buildings equipment should be used.**

This spreadsheet tool was developed by Shaun Fitzgerald, Breathing Buildings. It is free for designers to use to help them in the assessment of the most appropriate openings for wintertime ventilation. Breathing Buildings is grateful to Prof Malcolm Cook (Loughborough University) and Prof Colm Caulfield (University of Cambridge) for discussions regarding the modelling of plumes. The entrainment coefficient for turbulent plumes is usually taken to be 0.102. However, following work undertaken by Prof Malcolm Cook for a line plume against a solid boundary it has been recommended that the coefficient be 0.09 and this value is therefore used.

## Breathing Buildings solution for the PSBP Fingerblock School

Breathing Buildings have used IES-VE software to model their low energy natural and hybrid ventilation solution for the PSBP Fingerblock School.

The 2018 version of BB101 states that;  
 “for naturally ventilated spaces, when the outside air temperature is 5°C and the heat emitters are switched off, the minimum temperature of air delivered to the occupied zone at seated head height should be not more than 5K below the normal maintained operative temperature. For mechanically ventilated spaces comfort criteria in BS EN 15251 need to be met.”

This functionality is provided by the Breathing Buildings NVHR, R Series and S Series equipment, which offers a lower energy alternative than a classic mixed mode system that operates in natural ventilation in the summertime (when the external temperature is greater than 16°C) and switches to MVHR when the external temperature is below 16°C in order to prevent cold draughts.

The fingerblock school is well suited to the NVHR system. The rooms on the ground floor and the first floor will use the NVHR units which provide mixing on the facade for use in wintertime. Once external temperatures are sufficiently high that opening windows can be used the NVHR units operate in their passive natural mode. On the hottest summer days the units provide fan assisted inflow to help provide air flow to the rear of the classrooms. The units also provide automatic night cooling of the classrooms in summer. On the second floor, the rooms have easy access to the roof and therefore there are two options for these spaces; either the natural ventilation R Series units can be used or else the hybrid NVHR units can be installed as per the lower floors. Similar to the NVHR units, our R Series units work in conjunction with opening windows in the summertime. In the wintertime, they operate a mixing ventilation strategy, but in this case use sweep fans in the unit.

Some types of room are not suited to natural ventilation, such as landlocked server rooms etc. Breathing Buildings can provide access to mechanical ventilation solutions via partners. Small rooms such as single person offices can usually be ventilated adequately just with opening windows. The rooms using Breathing Buildings natural and hybrid ventilation equipment are shown on the next page. In order to demonstrate compliance with BB101 2018, Breathing Buildings have modelled the building using the following parameters for the typical classrooms.

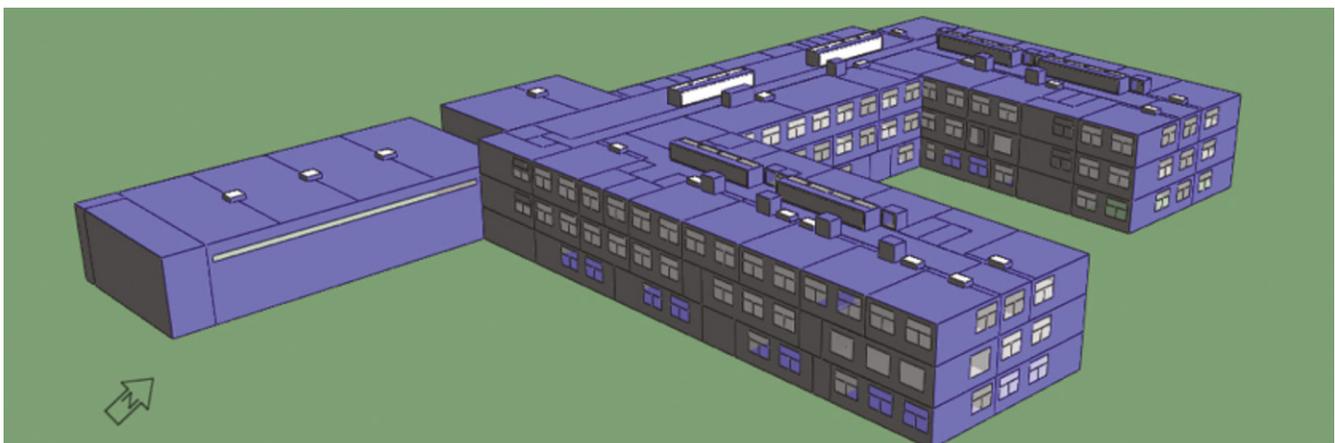
Hours of Exceedence ( $H_e$ )

Daily Weighted Exceedence ( $W_e$ )

Upper Limit Temperature ( $T_{upp}$ )

Occupancy (people)	32
Occupancy Heat Gain (W/person)	75
Occupied Hours	9am - 12pm 1pm - 4pm
Lighting (W/m <sup>2</sup> )	10
Additional Small Power (W)	1,000
Low Level Opening Effective Free Area	0.5m <sup>2</sup> per std window
Glazing G-value	0.64
Heating Setpoint Classrooms	21°C
Heating Setpoint Class Pre-heat	18°C
Heating Setpoint Atria	18°C
U-value of Walls (W/m <sup>2</sup> K)	0.35
U-value of Roof (W/m <sup>2</sup> K)	0.25
U-value of Floor (W/m <sup>2</sup> K)	0.25
U-value of Windows (W/m <sup>2</sup> K)	2.2
Infiltration (ach)	0.25
Thermal Mass	100mm exposed concrete soffit

Our modelling demonstrates that each room which uses the Breathing Buildings equipment will meet the necessary summertime overheating criteria, when simulated using the Manchester DSY1 2020 weather file. For more extreme weather files such as London DSY1 2020 it is necessary to reduce internal gains, for example by reducing the glazing G-value to around 0.32.



**Breathing Buildings natural and hybrid ventilation systems are the best way to ensure compliance with the air quality, summertime overheating, and energy targets/requirements in BB101. In summertime the system uses buoyancy and wind with fan boost and night cooling modes where required. In wintertime, fans in the units are used to mix warm room air with incoming cold fresh air. This is the most efficient way of ventilating buildings because the fan power used for mixing is much lower than that needed in heat recovery systems, and the heat gains in the spaces are sufficiently high that typically additional heating isn't needed until the exterior temperature falls below 5°C.**

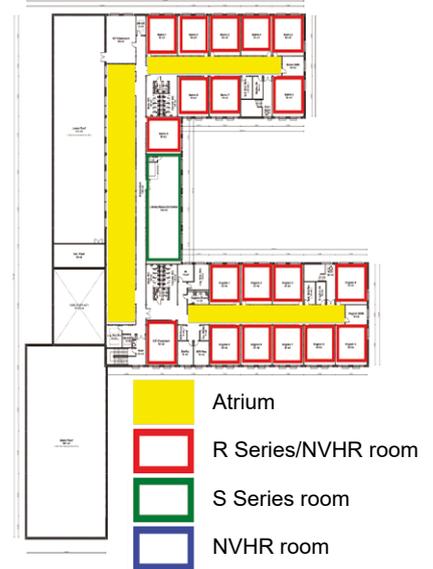
Ground Floor



First Floor

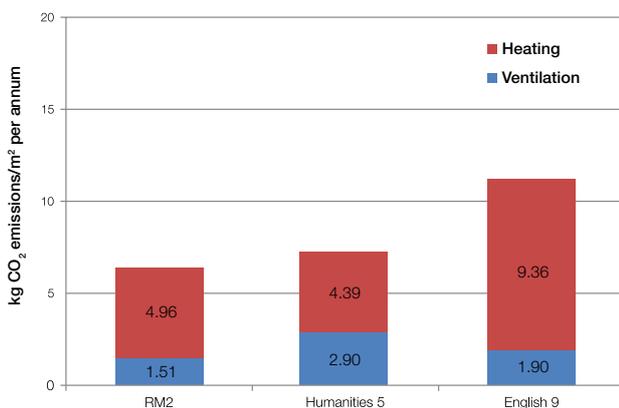


Second Floor



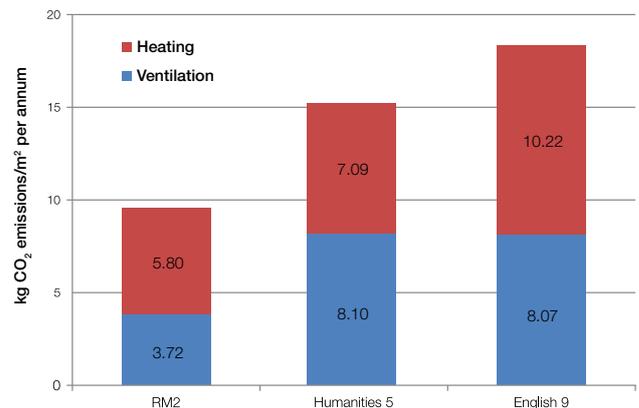
## Breathing Buildings System

The carbon emissions of a typical, highly glazed, South facing classroom from the Fingerblock School baseline design can be seen below. RM2 is a ground floor room, Humanities is a first floor room and English 9 is a second floor room.



## MVHR System

The Carbon emissions of the same rooms using MVHR can be seen in the chart below.



In addition both systems have identical Equipment (15.63 - 30.05 kg/m<sup>2</sup>) and Lighting (13.13 - 27.88 kg/m<sup>2</sup>) loads, which have been omitted for clarity.

## Summary

A review of a number of schools built under the previous BB101 guidelines found that although many of them were intended to be low energy, the heating bills were significantly higher than forecast. Furthermore, a number of them still overheat. The new edition of BB101 has been created to help overcome these issues. The Breathing Buildings unique approach to natural and hybrid ventilation is the easiest and most robust way of meeting the air quality, thermal comfort and energy targets.

## Proving it Works

We are proud of our understanding of natural and hybrid ventilation and our ability to deliver low energy buildings with great internal environments. We have monitored many installations to make sure that they are ventilating properly and mitigating cold draughts. These charts show data from Linton Village College where we installed S Series units.

### Winter Supply

In winter it is important to manage the ventilation requirements with heating and thermal comfort. As can be seen from Figure 01 even when the outside temperature is below 5°C we are able to successfully mitigate cold draughts with the supply temperature remaining at a comfortable level.

Figure 02 looks at the daily average CO<sub>2</sub> levels in the space during the winter months, which BB101 require to be below a daily average of 1,500ppm. The Breathing Buildings system delivers this using CO<sub>2</sub> sensors in the space and our patented winter mixing system. Independent research of our competitor systems has shown that without a draught mitigation strategy occupants simply turn the system off in winter, the space does not ventilate and CO<sub>2</sub> rises significantly.

### Modelling

We are often asked what IES shows for natural ventilation and alternative ventilation strategies. The short answer is the Breathing Buildings mixing systems provide significant energy savings not just compared with traditional natural ventilation but also with MVHR, as shown in Figures 03 and 04. But don't take our word for it, let us help you to model your classroom with different ventilation strategies using our 4DFlo and IES software.

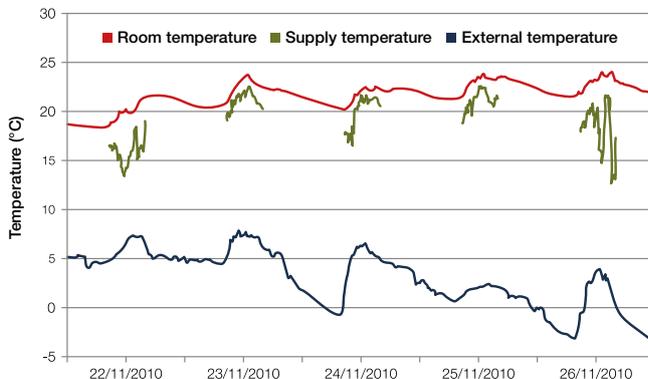


Figure 01

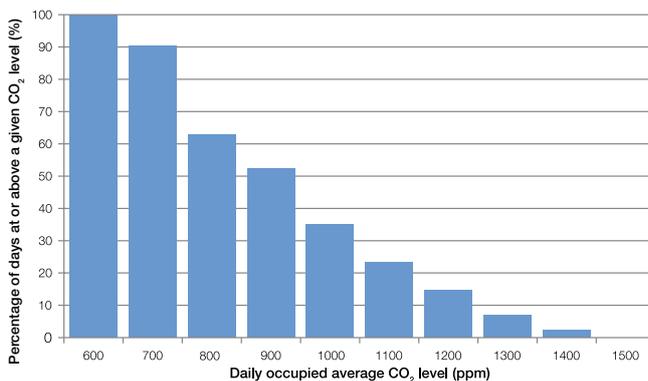


Figure 02

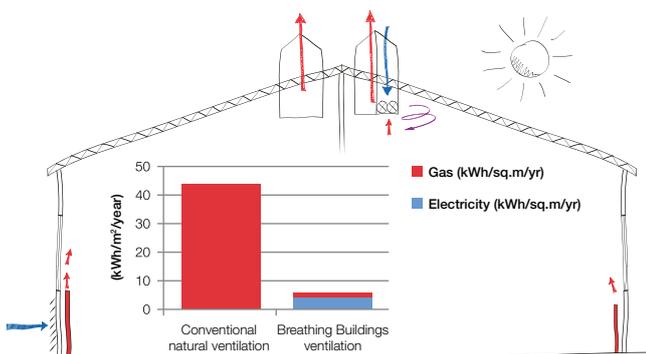


Figure 03

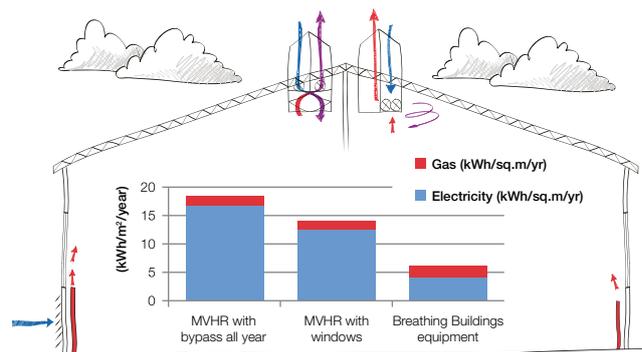
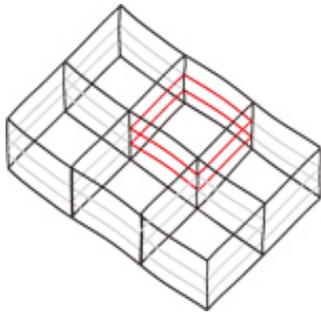


Figure 04

# Modelling Ventilation in IES

This is a summary of an article on our website the full version can be found along with downloadable models <http://www.breathingbuildings.com/products/modelling-ventilation-in-ies>

We are often asked what IES shows for natural ventilation and alternative ventilation strategies. The short answer is the E-Stack system provides significant energy savings. But don't take our word for it let us help you to model your classroom.

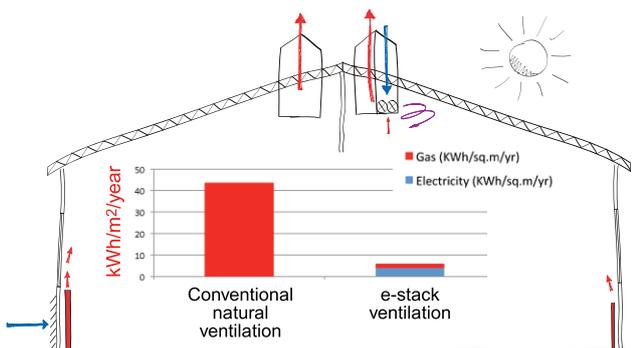


We have modelled four different ventilation strategies:

- E-Stack®
- Conventional Natural Ventilation
- Mechanical Ventilation with Heat Recovery (MVHR)
- MVHR with opening windows in the summertime

The energy consumption associated with the choice of ventilation strategy is obviously dependent upon the occupancy and heat loads within the space, the U-values of the building and where the building is located.

In the UK, we have looked at the energy consumption, of buildings built to good practice U-value standards. We can see that E-Stack ventilation uses far less energy than conventional natural ventilation. The main reasons for this are:



- We use the heat gains in a space rather than wastefully pre-heating the incoming air with radiators or heating elements.
- Pre-heating the incoming air in this way adds to the overheating problem in a typical classroom, which means that the ventilation rate has to be higher than minimum ventilation. The extra incoming cold air then requires more pre-heating, wasting further heating energy.

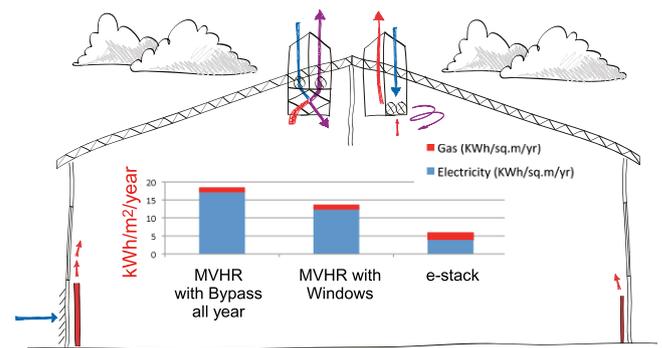
The high energy bills associated with natural ventilation have led to many in the industry using mechanical ventilation with heat recovery as an alternative.

However, we can see that E-Stack still saves energy with comparison with MVHR. The reasons for this are:

- MVHR causes the room to overheat in winter, requiring increased ventilation rates and therefore fan power
- Even when MVHR is combined with opening windows the fan power used in the winter and as a summer boost means that the E-Stack ventilation option is the lowest energy.

For most building types **E-Stack® Ventilation is the lowest energy option** in the UK. By downloading the IES model from our website, you can see how significant this energy saving might be for your building.

In some cases, mechanical ventilation may be needed simply for practical reasons. For example, a landlocked occupied room with no easy access to the exterior will need to be mechanically ventilated year round, and hence in these cases we recommend mechanical ventilation. Similarly, we recommend that toilet and kitchen areas should also be mechanically ventilated.



# The Breathing Buildings Difference

## The Breathing Buildings philosophy of natural ventilation stems from pioneering research at Cambridge University and the groundbreaking E-Stack® Natural Ventilation system

The research at Cambridge identified a paradox with ventilation - many naturally ventilated buildings were found to use more energy than mechanically ventilated ones! This was solved by developing a new approach to natural ventilation which is now completely changing the industry.

### Before E-Stack

The traditional method of naturally ventilating a building was to bring air in at one location and to exhaust it from another. In winter, the problem of cold draughts was overcome by pre-heating the air with a radiator or other such device. However, in modern well insulated buildings, if the cold fresh air has been pre-heated to 16°C by a radiator then the space becomes incredibly hot if the ventilation rate is limited to the minimum required in terms of CO<sub>2</sub> levels. This results in spaces being over-ventilated, and therefore the radiators emitting more heat to pre-heat higher quantities of cold air.

### Winter Mixing

This conundrum was solved by treating the heat gains in the space as a benefit to be used rather than a problem. A new method of naturally ventilating a building in winter was devised which requires the incoming cold fresh air to be mixed with warm room air before it reaches occupants. With this winter mixing natural ventilation strategy, the heat gains in the space are used to effectively pre-heat the air and the heating bills for naturally ventilated buildings can be reduced dramatically; by 50% over the whole year.

### Summer Strategy

In warmer weather, when cold draughts are no longer a problem, the strategy reverts back to the conventional displacement natural ventilation concept with Night Cooling and Summer Boost. If openings are available at lower level then these are used as the inflow and the higher level vents provide the exhaust.

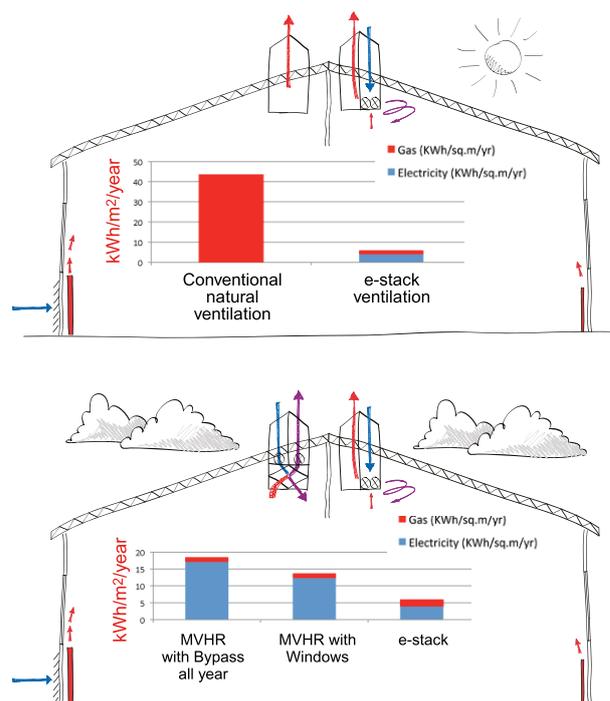
### Natural Ventilation Delivered

The patented system developed by Breathing Buildings which utilises the pioneering concept is called the E-Stack®. In order to quantify the energy savings of the E-Stack® system, in-depth IES modelling has been undertaken to compare the performance of various ventilation strategies.

The poorest system in terms of energy use is in fact the traditional opening window or low level damper with integrated heating element. The amount of heating energy expended in overcoming the cold draught problem is simply heinous! The excessive heating energy use by this type of system has resulted in the regulations for new schools in the UK stating that fresh air must be pre-mixed in winter.

The next best option is the use of mechanical ventilation with heat recovery (MVHR) in colder weather and in bypass mode in warmer weather. If opening windows are available, then the mechanical ventilation system is only used in colder weather and opening windows are used in warmer weather. However, both of these options use a considerable amount of electricity through the use of fans driving the flow.

The **lowest energy solution is the E-Stack® system**. The heating energy use (denoted by the red portion on the bar chart) is marginally higher than with MVHR, but the fan power is considerably lower. This is because the fans within the E-Stack system are used for mixing rather than driving the flow through ducts and mixing is a much lower energy process.





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