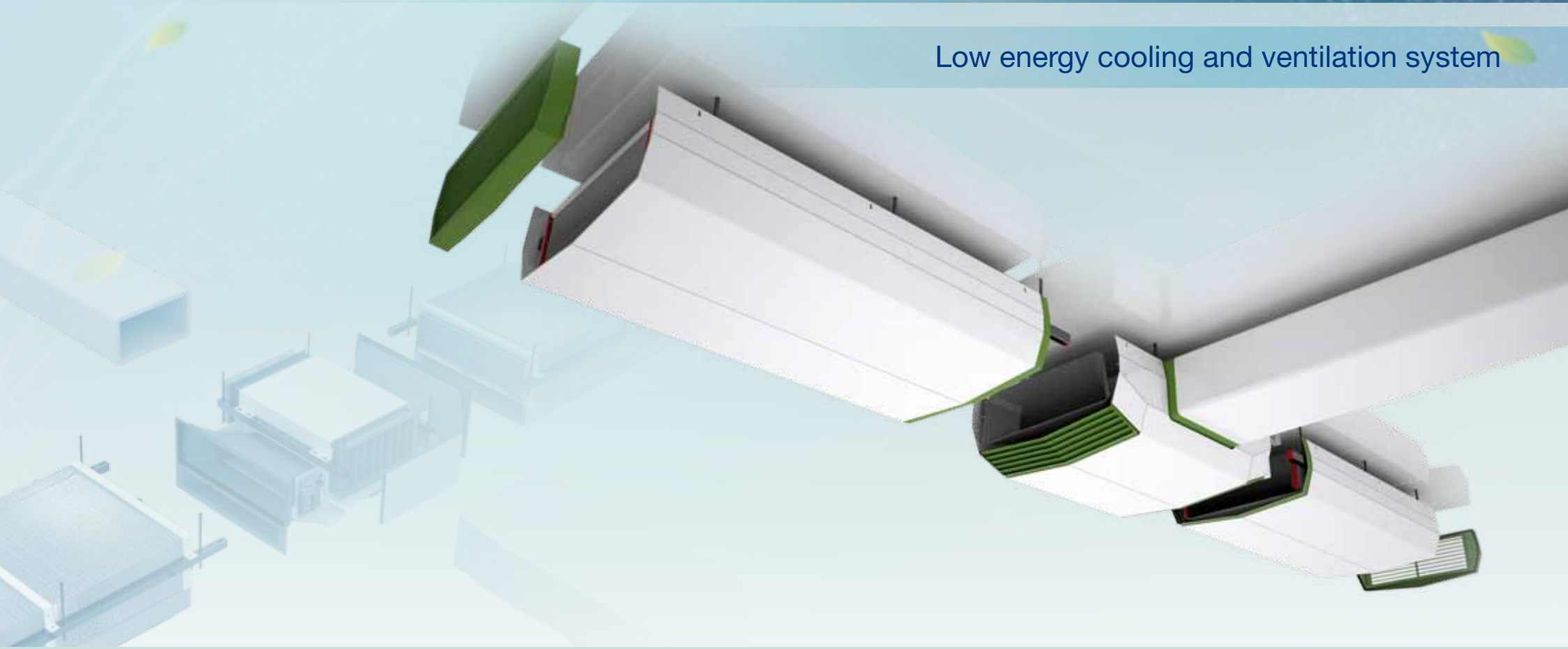
Coolphase

Low energy cooling and ventilation system



Monodraught

Contents

Page 2/3	Benefits
Page 3	Applications
Page 4/5	How it Works
Page 6/7	Key Features
Page 8/9	Comfort Cooling
Page 10	Ventilation & Heat Recovery
Page 11	Case Studies
Page 12/13	Specification
Page 14/15	Accreditation & Modelling
Page 16	Benefits

COOL-PHASE® is a low energy cooling and ventilation system that creates a comfortable, fresh and healthy indoor environment and reduces the running costs of buildings.

COOL-PHASE uses a thermal energy store utilising a Phase Change Material (PCM) in combination with an intelligently controlled Air Handling Unit to actively ventilate and cool the building. The COOL-PHASE system can maintain temperatures within the comfort zone, while radically reducing energy consumption by up to 90%, compared to a conventional cooling system. Unlike conventional cooling approaches, COOL-PHASE uses no refrigerants making it an environmentally sound solution to cooling our buildings.

Benefits of the COOL-PHASE system over conventional HVAC systems

- Low running costs – The system has low servicing, maintenance and energy costs, combined with a long life that provides an impressive payback on the capital cost of the system.
- Energy and carbon saving – The COOL-PHASE system uses an energy efficient variable speed fan with no compressors, pumps or other energy intensive components. A 5A single phase mains supply is all that is required.
- Healthy and productive – The COOL-PHASE system creates a healthy and productive environment by monitoring internal air quality and ensuring there is a supply of fresh air.
- High performance – The COOL-PHASE system is able to reliably meet both requirements for thermal comfort, energy, efficiency and ventilation, even in the toughest of scenarios.
- No external units – COOL-PHASE does not require any external units. This makes COOL-PHASE particularly suitable in applications where access to outside space or planning constraints are an issue.
- No refrigerants – The COOL-PHASE system does not use the coolants often found in conventional cooling approaches. Therefore Regulations controlling the use and disposal of refrigerants do not apply to COOL-PHASE.

- Modular design – The COOL-PHASE system can be installed in small modular spaces or large open plan offices, above a false ceiling or suspended below to suit a range of environments.
- Long life - With a design life in excess of 20 years and a warranty of 5 years, the system provides customers with the reassurance that they have a long term solution to their cooling and ventilation needs.

Applications

The COOL-PHASE system can be installed in new buildings or retrofit to existing ones, from small modular areas to large open plan rooms. The system can be suspended below a ceiling (a floor to ceiling height of 2.8 m or greater is recommended) or within a false ceiling void (a minimum ceiling void of 500 mm is recommended).

Offices

The COOL-PHASE system has been designed to meet the requirements of clients who wish to have a greater level of control over internal temperatures than is achievable with other low energy approaches, but without the high energy and maintenance costs of conventional cooling solutions.

Education

Each COOL-PHASE system includes CO_2 monitoring as standard and can accurately control the level of fresh air within classrooms to provide the ideal teaching environment. The system is capable of meeting the requirements of BB101 even in tough areas, such as an IT classroom.

Corporate

The COOL-PHASE system can operate alongside conventional cooling systems to provide the fine level of climate control that even the most demanding client might expect, but still radically reduce running costs.

Retail

Retailers are under increasing demand to slash their energy consumption and COOL-PHASE has been shown to make significant savings compared to conventional cooling approaches.

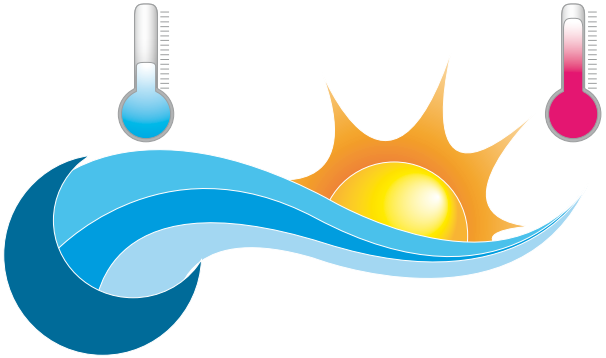
The COOL-PHASE system is not suitable for locations that are occupied 24 hours a day or domestic premises.

How it Works

The COOL-PHASE system uses the concept of a ‘Thermal Battery’ to capture and store heat. The Thermal Batteries use the latent heat property of materials to store large amounts of energy, which is charged and discharged by passing air through a heat exchanger. Materials that change phase at room temperature are frequently referred to as Phase Change Materials (PCMs). To melt or freeze the material contained within, each system requires the same amount of energy to heat up or cool down 32 tonnes of concrete by 1 °C.

Comfort cooling

In the UK, even in the summer, there is a 10 to 15 °C temperature difference between day and night time temperatures; this is known as the diurnal cycle. At night, cool outside air is passed through the heat exchanger recharging the Thermal Batteries and releasing the heat built up during the previous day. As temperatures rise, warm air is passed through the heat exchanger to provide cooling. The total cooling provided is a combination of the use of the thermal energy stored within the unit, the effects of free cooling, and night time ventilation.



Ventilation

COOL-PHASE works all year round to ensure a fresh and healthy environment, monitoring temperature and CO_2 levels to automatically determine how much ventilation is required.

Heat Recovery

In winter, the COOL-PHASE system works in reverse, trapping waste heat and using it to warm up cool fresh air entering the building. Whenever the internal temperature exceeds a preset level, or at the end of the day when the space is unoccupied, warm air from inside the space is passed through the heat exchanger, charging the Thermal Batteries. When ventilation is required, cool air from outside is passed through the heat exchanger, warming the air entering the space and reducing the load on the heating system.

Intelligent thermal mass

The effect of adding thermal mass to a building is a well understood principle, effectively increasing the time that it takes heat gains to raise the temperature of the building. When combined with measures to control internal and external heat loading, it can be a very effective method of ensuring that the building meets requirements for thermal comfort.

However during a period of hot weather, temperatures will invariably rise over time, as there is no method of actively dissipating the build-up of heat. Therefore the effect of adding thermal mass can diminish over a warm spell, although the building takes longer to heat up during the day, it will also take longer to cool down at night time and therefore not all of that heat may be dissipated by the following day.

Unlike passive applications where thermal mass is simply added to a building, the COOL-PHASE system is able to intelligently control how energy is stored and released from the thermal store, by using a heat exchanger and mechanical ventilation. The heat built up during the day can therefore be released at night and the thermal energy store recharged.

A building with a low thermal mass heat up quickly. COOL-PHASE adds thermal mass to buildings which is intelligently controlled to maximise performance

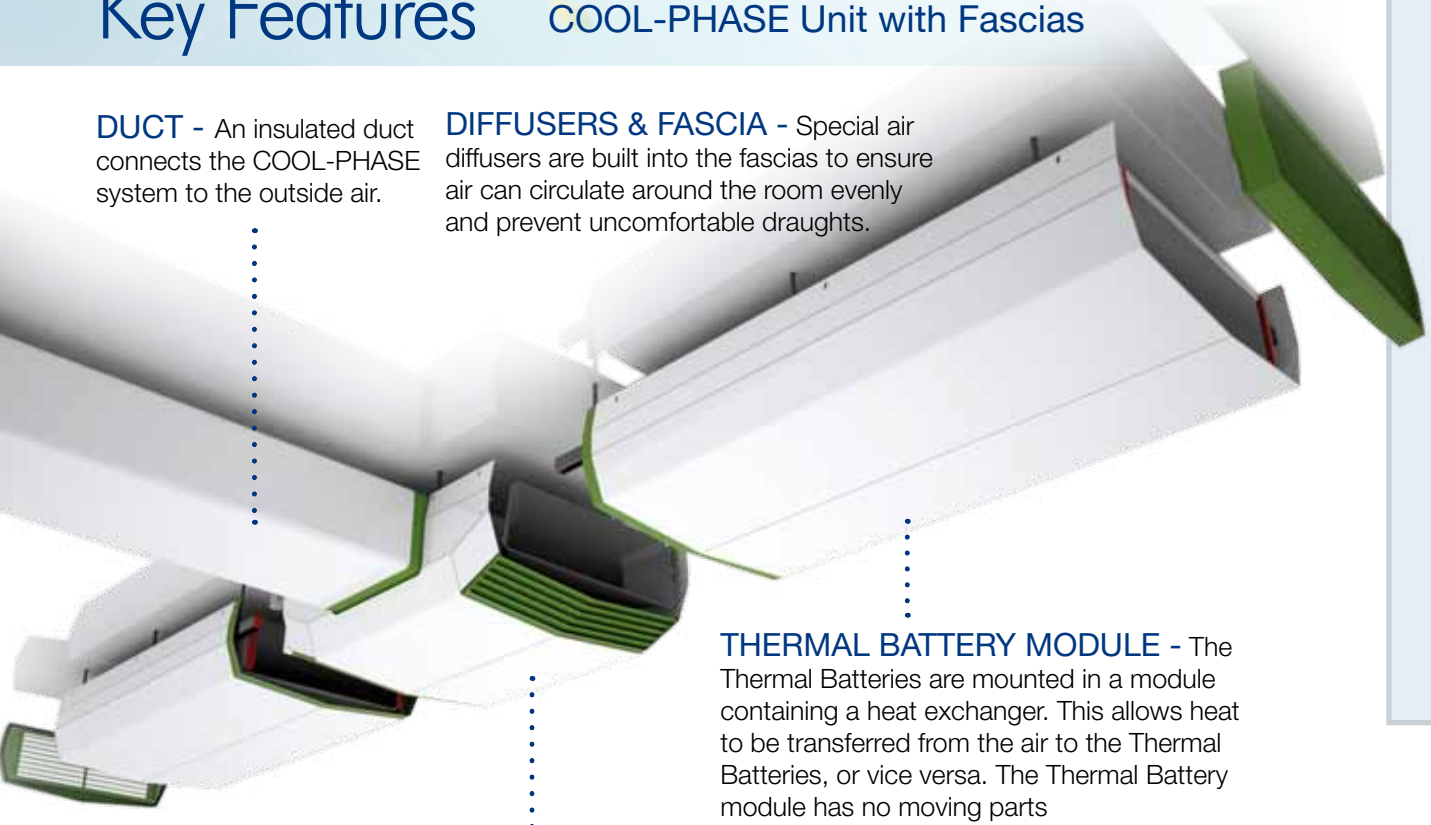
A building with a high thermal mass takes longer to heat up but also to cool down

When this is combined with the effects of free cooling and night time ventilation, the result is a system that can reliably maintain temperatures within comfort zones while radically reducing energy consumption by as much as 90% compared to a conventional cooling system.

Monodraught has an extensive knowledge of how Phase Change Materials (PCMs) can be utilised within buildings. Since the process of changing phase and getting energy in and out of PCMs is complex and requires a carefully controlled heat exchange process, simply trying to combine an off-the-shelf PCM with natural or mechanical ventilation often results in a system that fails to perform as expected. The COOL-PHASE system has therefore been designed from the ground up to maximise performance of the PCM by utilising a self-contained heat exchanger, bespoke control system and Air Handling Unit.

Key Features

COOL-PHASE Unit with Fascias



DUCT - An insulated duct connects the COOL-PHASE system to the outside air.

DIFFUSERS & FASCIA - Special air diffusers are built into the fascias to ensure air can circulate around the room evenly and prevent uncomfortable draughts.

THERMAL BATTERY MODULE - The Thermal Batteries are mounted in a module containing a heat exchanger. This allows heat to be transferred from the air to the Thermal Batteries, or vice versa. The Thermal Battery module has no moving parts and does not require any power, therefore, they are highly reliable, have a long life and require minimal maintenance.

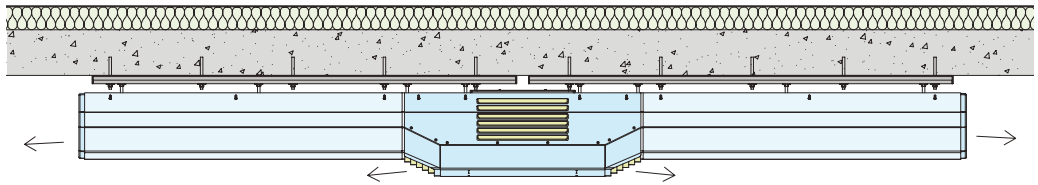
AIR HANDLING UNIT - The Air Handling Unit (AHU) contains an energy efficient EC fan, volume control dampers, actuators, intelligent control system and sensors. The control system monitors indoor air quality, temperatures both inside and outside, and humidity levels. The AHU controls the flow of fresh air into the building, re-circulation of air within the building and how energy is released or stored by the Thermal Batteries.

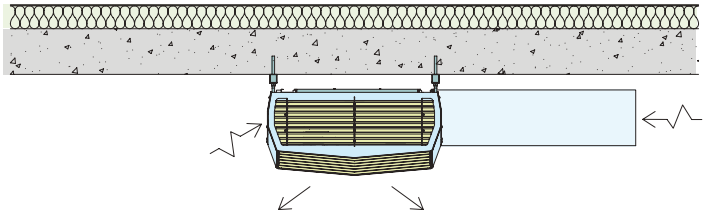
WEATHER LOUVRE –
A weather louvre with bird guard is provided at the point where air enters the building. Access to outside air can be achieved either by replacing a window pane or through an opening in the wall or roof.

CASE STUDY

E1 Business Centre & Holywell Centre

The first COOL-PHASE ceiling mounted units were installed in two serviced offices in central London for Workspace plc in 2009.
They have proven to be a great success, resulting in a significant reduction in the peak temperatures recorded during the summer.





COOL-PHASE Unit above false ceiling

FILTER BOX & EXTERNAL FILTER - A filter box and G4 filter is positioned at the point where air enters the building to remove particles, allergens and pollutants from the incoming air. An access hatch is provided to change the filter.

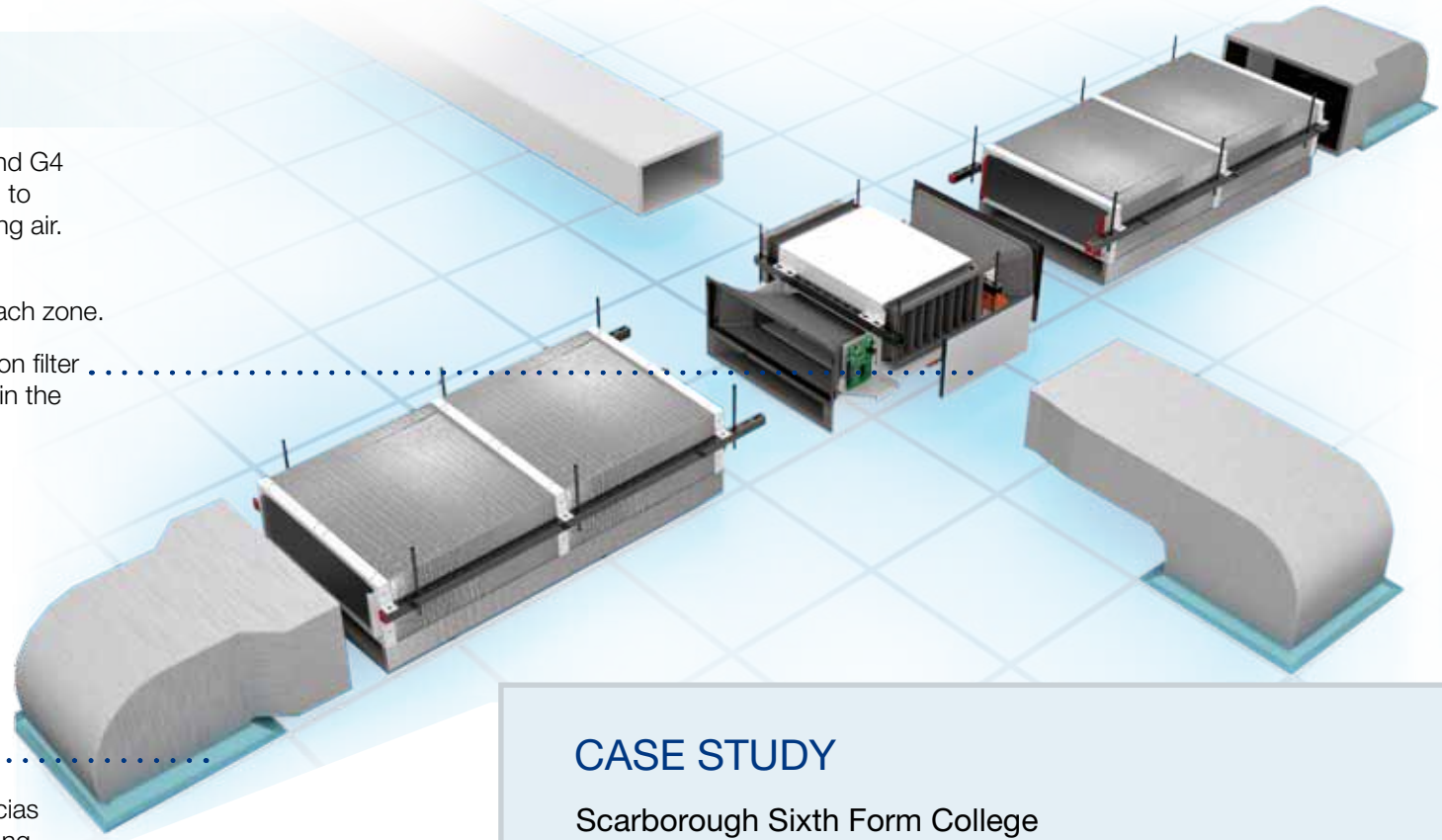
USER INTERFACE – A user interface is provided in each zone.

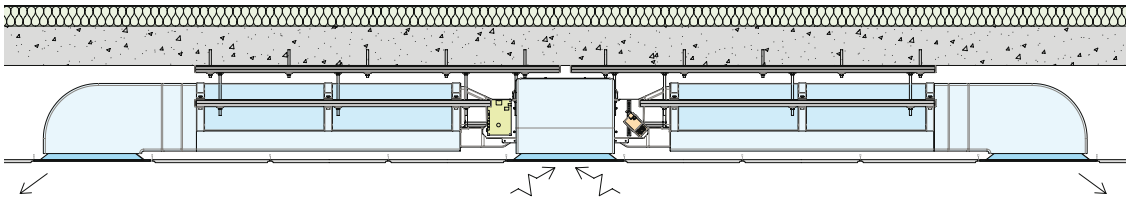
RE-CIRCULATION FILTER - A G2 grade re-circulation filter is positioned behind an access hatch on the fascia or within the re-circulation duct when installed above a false ceiling.

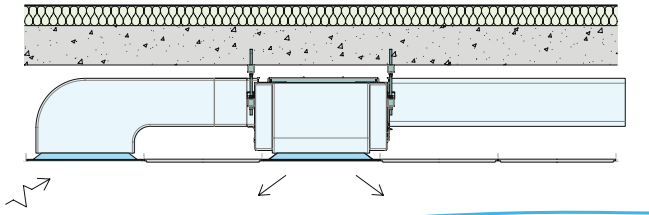
EXHAUST GRILLE – An outlet for air to leave the space is required. This can be through an internal exhaust grille, which allows air to escape through the rest of the building or through a second external weather louvre with volume control damper.

CEILING TILE DIFFUSER - When the system is mounted above a false ceiling, ceiling tile diffusers are used at the end of the PCM module Inlet grilles are provided at the point where air is re-circulated.

OPTIONS - The system can be supplied either with fascias or with the required attachments for use above a false ceiling.





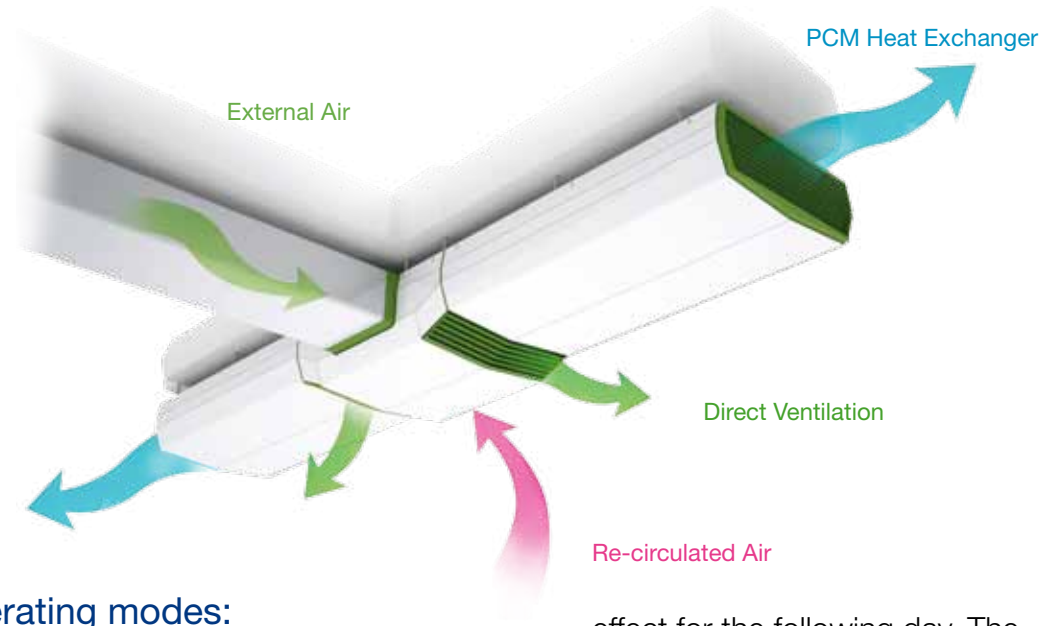


CASE STUDY

Scarborough Sixth Form College

The newly refurbished IT classroom at Scarborough Sixth Form College uses a single COOL-PHASE unit discreetly hidden within the ceiling void. The classroom quickly saw an improvement in air quality following installation, with a significant reduction in CO_2 levels.

Comfort Cooling



Operating modes:

In summer the COOL-PHASE system monitors indoor and outdoor temperatures, internal CO_2 levels and humidity.
Air can be either pulled in from outside, re-circulated within the environment or mixed.

Summer charge mode:

When the room is unoccupied at night, the system will automatically pull in external air and pass it through the heat exchanger to cool the Thermal Batteries, recharging the system and dissipating the build-up of heat from the previous day. This also has the effect of cooling the fabric of the building down; increasing the cooling effect for the following day. The system will alter the charge rate and length of charge depending on the temperature of the outside air, switching off when the Thermal Batteries reach the full capacity.

Ventilation mode:

Should the CO_2 levels within the space rise above a preset level, the system will open the external damper and vary the fan speed until the desired CO_2 levels are achieved, providing ventilation proportional to the requirements of the space.

Cooling mode:

Should the temperature in the room exceed a preset level, the system will provide cooling to meet the requirements of the space, varying the damper positions and fan speed:

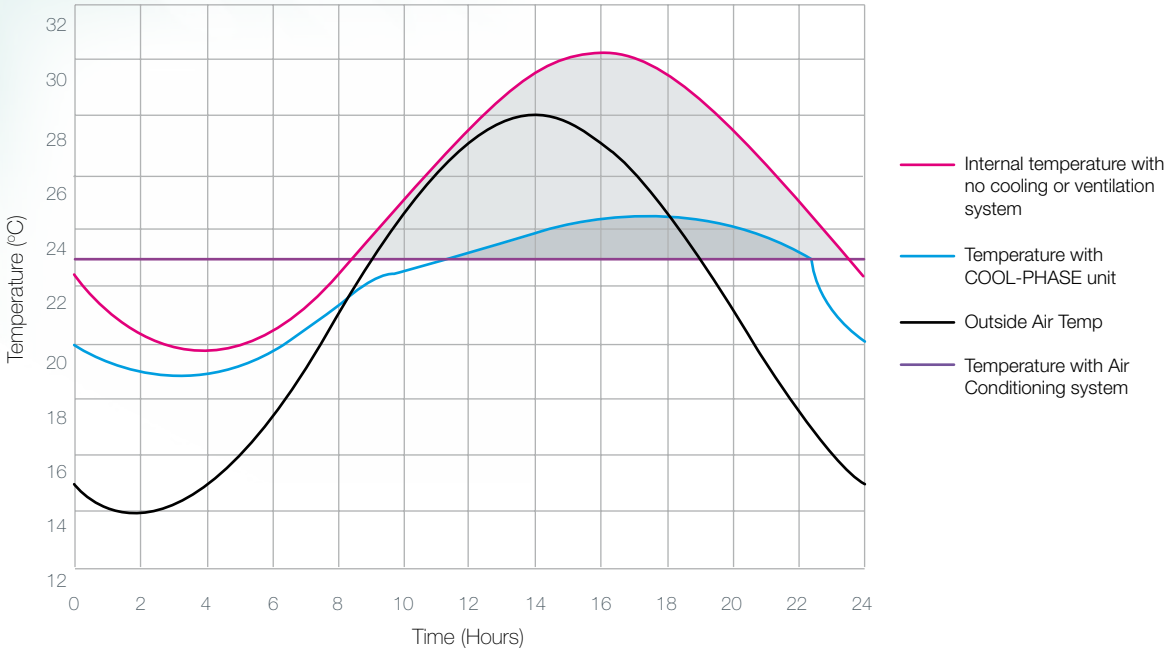
- Direct outside air ventilation – This is used when the outside air temperature is low enough to overcome any overheating in the room, air is passed directly from outside into the space bypassing the Thermal Batteries. Using this function reduces the loading on the fan and preserves the cooling capacity of the Thermal Batteries for when it is most needed.
- Outside ventilation and cooling – This is used when the temperature differential between inside and outside air is insufficient to cool the space but the outside temperature is still lower than the temperature within the room. Air is passed from outside over the Thermal Batteries to drop the temperature of the air and cool the room sufficiently.
- Re-circulation and cooling – This strategy is used when the temperature outside is higher than inside, the unit re-circulates air from within the room and passes it over the Thermal Batteries to provide cooling. A proportion of air is drawn from outside to maintain ventilation levels, a CO_2 sensor and preset level determines the minimal amount of ventilation to be provided.

Total Cooling = Free Cooling (Ventilation) + Night time Cooling (Building + flush) + Thermal Batteries (Energy stored)

The total cooling over a 24 hour period is the sum of the free cooling (when it is cooler outside than inside), the effects of night time cooling (when the fabric of the building is cooled down and the heat built up during the previous day is dissipated), and the use of the energy stored within the Thermal Batteries to temper the air.

The graph on the right shows the performance of the system in a simplified model. The black line shows the temperature in the room varying between 14 °C at night and 28 °C during the day. The temperature in the rest of the building, with no cooling or heating, is shown by the red line and peaks around 30 °C.

The blue line shows the temperature within the same space with COOL-PHASE installed, showing a significant reduction in the peak temperatures. The COOL-PHASE system is not designed to match the outright performance of the Air Conditioning (AC) system, which is typically specified to maintain a temperature of 23 °C; however it has resulted in an 80 to 90% improvement in temperature for 10% of the energy usage of the AC system. When fine levels of temperature control are required, the COOL-PHASE system can be used alongside a conventional cooling solution to reduce the overall energy usage.



Graphic showing the performance of COOL-PHASE in a simplified room model

Ventilation & Heat Recovery

The COOL-PHASE system works all year round to create a fresh and healthy environment by monitoring internal CO_2 levels and ensuring a supply of fresh air into the building.

In typical office applications the temperature will peak during the day and the heat built up over the course of the day is lost overnight. The COOL-PHASE system stores this waste heat and uses it to preheat air coming in the next day, maintaining a fresh and healthy environment while reducing heating loses due to ventilation.

Winter charge mode: During the winter months when either the room is unoccupied or the temperature exceeds a preset level, the COOL-PHASE system will re-circulate internal air through the heat exchanger to charge the Thermal Batteries and capture the excess heat. This waste heat can then be used to temper cool fresh air entering the building.

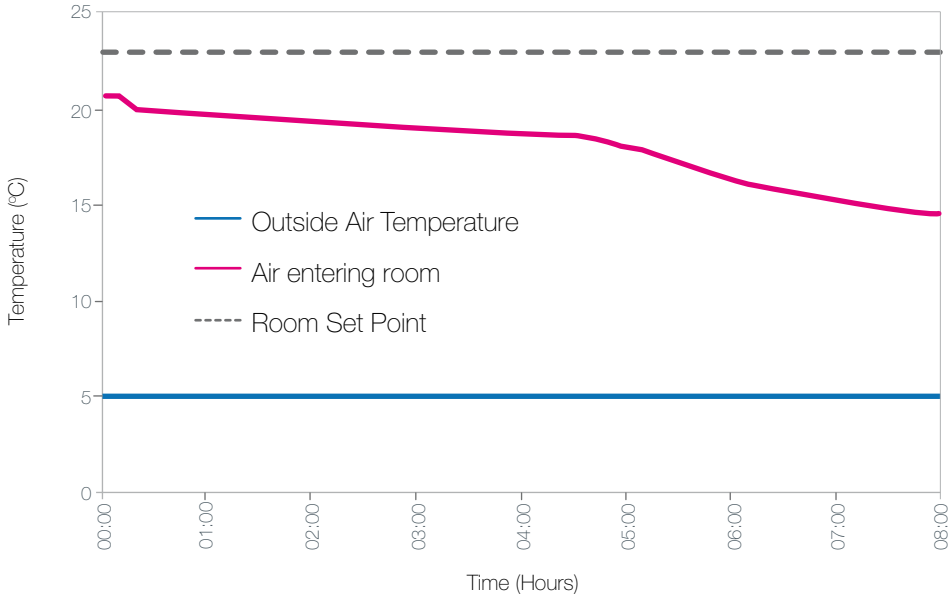
Winter ventilation: The COOL-PHASE system monitors internal CO_2 levels and determines the amount of ventilation that is required. Cool air from outside is warmed by passing it through the heat exchanger. To further reduce the temperature differential between the cool air entering the space and the internal room temperature, external air can be mixed with re-circulated air from within the space.

Comparison to conventional heat recovery systems:

Assuming an outside temperature of 5 °C, an internal room temperature of 23 °C, and a conventional cross flow heat recovery system with an efficiency of 50%, then the resulting temperature entering the room would be 14 °C. If 100 l/s are required to meet the ventilation requirements of the space then the heating loss would be 1.08 kW.

The COOL-PHASE system has a finite capacity to store waste heat and the ability to temper cool air entering the space will vary over the course of the day as the Thermal Batteries discharge. However, assuming that the room and Thermal Batteries are at 23 °C at the start of the day, and 100 l/s of outside air and 100 l/s of re-circulated air are mixed before being passed through the heat exchanger, then the resulting outlet temperature is shown in the graph on the right.

The average temperature of the air entering the space is warmer at 18.2 °C reducing the risk of any cold draughts, while the heating loss due to ventilation is very similar at 1.16 kW.



Case Studies

University of East London

Monodraught COOL-PHASE units were installed in three computer suites at the Stratford Campus to reduce high heat gains from IT equipment and people.

Notre Dame School

Two COOL-PHASE systems were installed in an IT classroom in April 2011. The classroom (approx. 70 m^2) has high internal heat gains through IT equipment and glazing.

Specification

Size (l x h x d):

4000 x 800 x 400 mm (for suspended system supplied with fascias)

Colour:

Powder coated white. Alternative colours available on request.

Performance specification:

- Normal ventilation rate: between 0.1 to 0.25 m^3/s.
- Maximum ventilation rate: 0.35 m^3/s.
- Thermal energy storage: 8 kWh.

System requirements:

- Ventilation requirements: connection to clean outside air source, inlet to be positioned away from sources of pollution and heating, eg. kitchen exhaust or AC compressor.
- Inlet: a suitable roof cowl or minimum 500 x 500 mm wall / window mounted weather proof louvre with bird guard.
- Filtration: G4 300 x 400 x 500 mm bag filter, filter box and access hatch.
- Minimum supply duct size: 400 x 300 mm.
- Exhaust: internal or external grille specified to suit.

Installation requirements:

- Recommended minimum floor to ceiling height: 2.8 m
- Minimum ceiling void (if mounting within void): 500 mm
- Weight: 375 kg

Controls and user interface:

- Wall mounted user controls with room temperature, humidity and CO_2 sensors.
- COOL-PHASE control system including temperature and humidity sensors.
- Master / slave mode to control multiple units in a single zone.
- Optional connections to compatible window, natural ventilation (eg. WINDCATCHER® natural ventilation system) or heating controls.
- Optional ‘traffic light’ indicator for windows.

Wiring requirements:

- Single phase mains with switched 5A fuse spur supply, KLIK PCR2000 socket, positioned within 1 m from AHU footprint.
- CAT 5E network cable between unit and user interface.
- CAT 5E network cable between slave and master units.

BMS Interface:

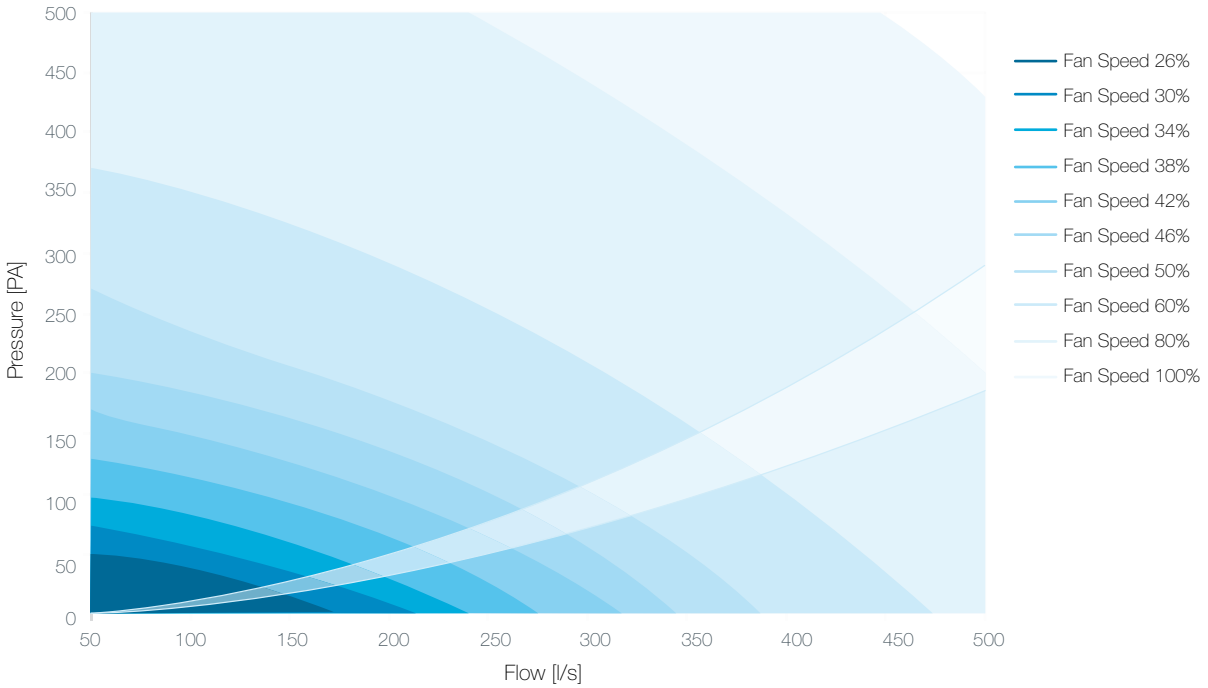
- Single digital on / off input to enable / disable COOL-PHASE system from BMS or Fire Alarm circuit.
- Single digital on / off output to be used in one of the following modes:
  - » Heating – The COOL-PHASE system will signal to the BMS to turn on heating when temperatures fall below a preset level.
  - » Cooling – The COOL-PHASE system will signal to the BMS to turn on a secondary cooling system when temperatures rise above a preset level.
  - » Fault – The COOL-PHASE system will signal to the BMS when there is a fault in the system.

Specific fan power

Ventilation rate [l/s]	Ventilation rate [m^3/h]	Fan power [W]	SFP [W/l/s]
320	1152	87	0.27
286	1030	72	0.25
250	900	58	0.23
227	817	46	0.20
200	720	35	0.18
170	612	26	0.15
125	450	19	0.15

Ventilation and specific fan power calculated for air passing through heat exchanger, direct ventilation rates will be higher and therefore correspond with improved specific fan power ratings.

Fan curve



System: *6 m duct run, 90° bend, 2 x PCM modules, 300 x 400 mm G4 bag filter, 450 x 450 mm weather louvre.*

Accreditation & Modelling

BREEAM

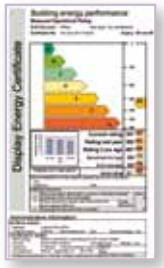
BREEAM is an environmental assessment method which is supported by the UK Government as a means to ensure the optimal environmental performance of buildings.
The COOL-PHASE system can help achieve an excellent or outstanding rating due to its energy efficiency, the creation of a comfortable and healthy environment, and through the use of responsibly sourced materials.

Building Regulations Part F – Ventilation

Ventilation must be provided and be capable of providing a minimum amount of fresh air per person. As a ventilation system, COOL-PHASE is able to meet these requirements when correctly sized and specified for the given application.

Building Regulations Part L - Conservation of Fuel and Power

Part L of the Building Regulations provides requirements for CO_2 emissions that buildings must meet in order to conserve energy. The COOL-PHASE system provides a method for achieving thermal comfort and ventilation requirements while meeting the targets for energy efficiency.



Display Energy Certificate (DEC)

A Display Energy Certificate applies to public authorities and institutions providing public services to a large number of persons with a total useful floor area greater than 1000 m^2.
A DEC shows the actual energy used by the building and can highlight poor energy management with items such as portable air conditioning equipment and over cooling of spaces affecting the rating.

National Calculation Methodology

The National Calculation Methodology is the approved process by which the energy performance of a building is assessed and the energy certificate awarded. This includes Simplified Building Energy Model (SBEM) and approved Dynamic Simulation Models (DSM). The COOL-PHASE system is currently undergoing accreditation for use with both these methodologies.

Energy Performance Certificate (EPC)

The EPC demonstrates to potential buyers or tenants the energy efficiency and performance of a building. The rating given is increasingly being linked to the rental and capital value of the building, therefore increasing the energy efficiency of the building can provide a real and rapid payback on the initial investment. It includes the efficiency of systems that provide heating, ventilation and cooling and therefore COOL-PHASE can help improve the rating given to a building.

BB101 - Ventilation of School Buildings

BB101 provides criteria for air quality and avoidance of overheating. This ensures that during the summer there are no more than **120 hrs** where the temperature **exceeds 28 °C**, the internal temperature should not be more than 5 °C higher than the external temperature on average, and the internal temperature should not exceed 32 °C. The average concentration of Carbon Dioxide should not exceed 1500 ppm. The COOL-PHASE system allows classrooms to meet the requirements of BB101 even in tough scenarios.

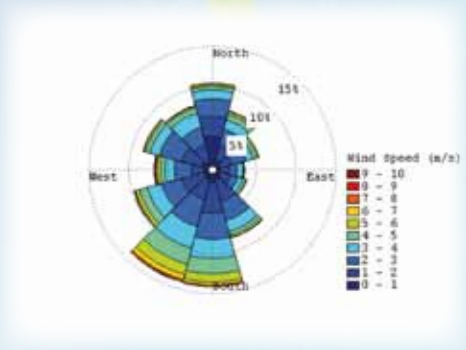
Modelling

NAVENSYS allows Monodraught's Design Engineers to apply weather data from almost any weather station in the world, scale it appropriately, and to input the type and geometry of a building and zone, the constituent parts of its envelope, fabric and the patterns of occupancy.

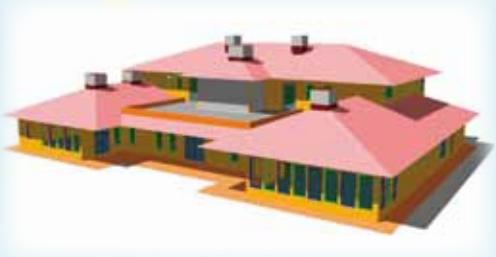
The results determine if statutory requirements or guidelines, such as Part L of Building Regulations or BREEAM, for ventilation rates, internal air temperatures and carbon dioxide concentrations are likely to be met.

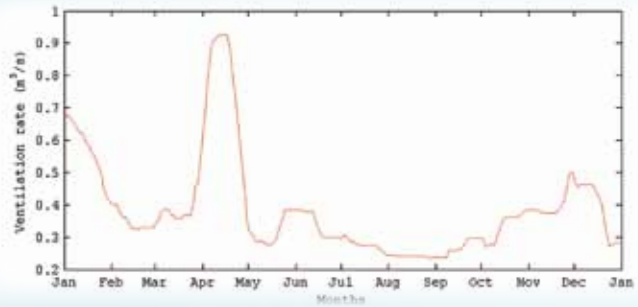
All Monodraught design teams utilise IES VR Studio to model complex building geometry and bespoke control algorithms.

Please contact us for "How to" modelling guidance on both IES and TAS building simulation software.



Weather rose showing wind speed and direction as a percentage, using Data acquired from CIBSE





Estimated ventilation rate over time

European Seasonal Energy Efficiency Ratio (ESEER)

The European Seasonal Energy Efficiency Ratio (ESEER) means the ratio of the total amount of cooling energy provided divided by the total energy input to the cooling plant (one or more cooling units) summed over a year. SEER may be estimated from the EER measured at partial load for the proposed building: SEER = a x E_{25} + b x E_{50} + c x E_{75} + d x E_{100}

The ESEER value for cooling products is also used for part of the Building Regulations Part L calculations, and are used in the production of Energy Performance Certificates (EPC) for new buildings within the UK and the European Union; both as part of the European directive on the energy performance of buildings (EPBD).

	EER_{25}	EER_{50}	EER_{75}	EER_{100}	ESEER
Daytime ventilation (discharge)	13.4	14.2	16.4	17.3	15.1
Night-time ventilation (charging)	6.0	7.6	7.5	8.1	7.3

By comparison an ESEER value of 4 is typical for a modern split AC system. The higher the rating, the more energy efficient the equipment is.

Benefits:

- Very low running costs
- No external units are required
- Highly energy efficient system
- Long life and a warranty of 5 years
- Modular, scalable and adaptable design
- Creates a healthy and productive environment
- High performance ventilation and cooling system
- Environmentally friendly and sustainable solution that uses no refrigerants

Halifax House
Cressex Business Park
High Wycombe
Buckinghamshire
HP12 3SE

Tel: 01494 897700
Fax:01494 532465
email: info@monodraught.com
www.cool-phase.com
www.monodraught.com

January 2012