



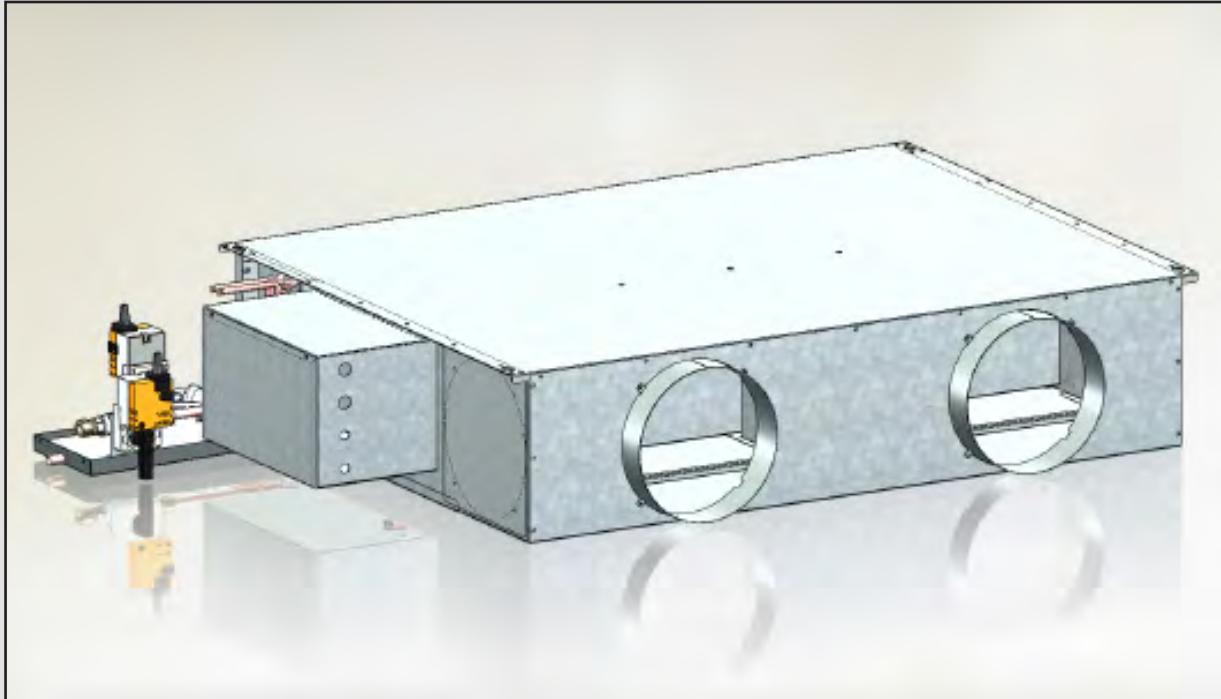
features & configuration

MATRIX



ultimate fan coil system

the matrix solution



The Matrix Solution has evolved from an Ability Fan Coil Unit and in most respects has the external physical characteristic of a fan coil. However, Matrix should not be confused with any ordinary Fan Coil Unit.

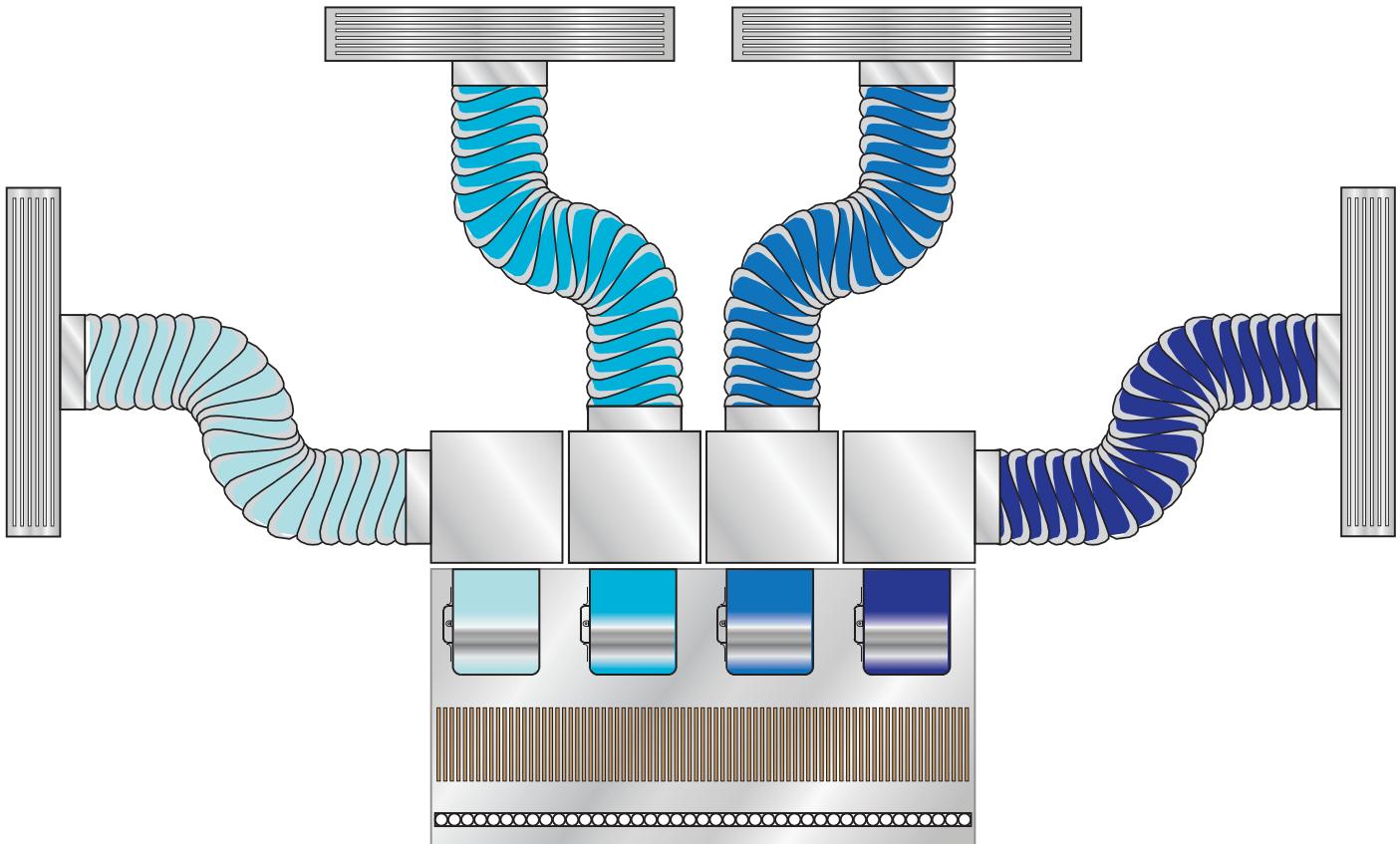
The Matrix Chassis

Matrix units use multiple 'Internal Rotor' fan and motor sets. This means that every fan is directly coupled to its own motor, every fan/motor is an independent entity and every fan/motor has the capability to be individually speed controlled.

The most striking feature of a Matrix unit, in comparison to every other similar product, is that the Matrix discharge plenum is compartmentalised so that each fan and motor assembly supplies air into one sub chamber alone. As each sub chamber has only one spigot connection, which in turn should only serve one grille, this means that each fan (and the air it provides) is delivered solely to one grille location.

Therefore, the air volume to each duct and the balance between ducts is established through controlling the fan speeds alone. This is why a Matrix does not require Volume Control Dampers (VCDs) and does not suffer any of the complications, the noise regeneration and the energy wastage, associated with them.

Matrix units are available from single fan units to units with five fans.



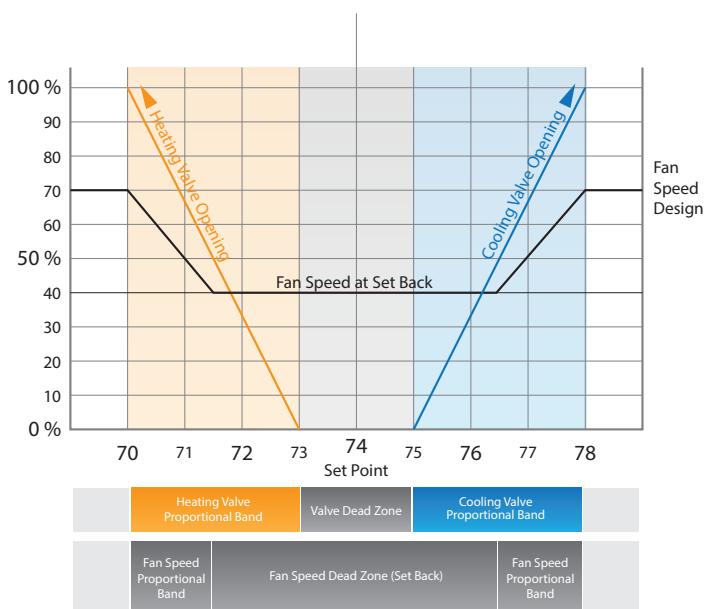
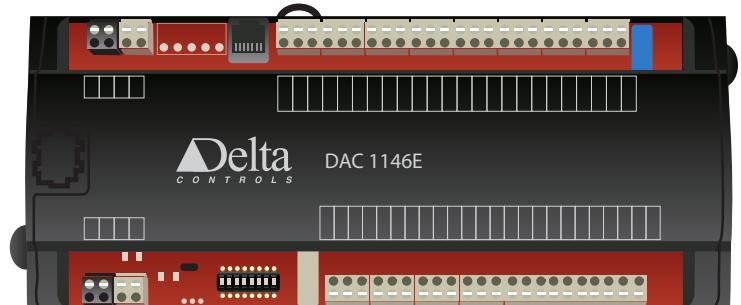
The Essence of Matrix

At this point you will see that to take advantage of the Matrix concept requires the capability to individually speed control up to four, sometimes even five fans.

While four or five physical speed controllers are possible, to make the Matrix system 'really fly' demands an altogether smarter solution. This comes in the form of a terminal controller that has sufficient outputs to control each fan individually under the dictates of a specially configured and preloaded control strategy.

This emphasises why a Matrix unit is not simply a fan coil! Matrix units are an integrated solution that include as a minimum, the Matrix chassis and the Matrix controller loaded with the Matrix control strategy.

All the other components part of a Matrix unit, the coils, the filters etc are as you would expect to see on any other terminal air conditioning product.



two fan styles

Imagine

'Self setting and self-compensating air volumes, lower noise levels, no volume control dampers and no wasted energy'

All the fan motors used in Ability Matrix products are EC/DC. These offer a significant energy saving over their previous AC equivalents consuming about 45% of the electrical power at the same duty point.

However, EC/DC motor and fan sets offer even more savings if used under the dictates of an intelligent, intuitive, variable speed strategy. The EC/DC fan and motors Ability use come in two different styles that allow us to provide two speed controlling options on any Matrix package.

Standard EC/DC Fan Option

The 'Standard' EC/DC fans provide a Matrix solution, where the individual fan speed adjustments necessary for air volume setting and duct balancing are made remotely through a laptop with software provided as part of the package.

In this instance, the commissioning team would continue to use a balometer over the grilles but instead of adjusting a physical 'Volume Control Damper' in the ceiling to effect balance, they would access and adjust the fan speed of each fan through the laptop and software supplied; essentially an electronic VCD!

Direct contact with your Matrix units is not necessary; commissioning adjustments can be either communicated from the laptop through a Bluetooth enabled wireless device, or through a wired connection at a single location. This single connection point is what allows settings or adjustments to be made to many units via the network cabling.

No Volume Control Dampers means there is no cost to buy and install them, no noise regeneration over them and no wasted energy because of them.

AVCD Analogy

You do not keep your foot hard on the accelerator of your car and control your speed with the brake; that would be crazy. So why do we use electricity to generate air volume only to throttle it off with a volume control damper, that is crazy too!

EC = Electronically Commutated and DC = Direct Current

The Self Balancing Option

The 'Self Balancing' EC/DC fans provide a Matrix solution, in which the fans self adjust their own speed to deliver the air volumes that have been pre-defined into the control strategy by Ability on your behalf.

The design air volume for every grille on every Matrix is uploaded into each controller / strategy as part of the manufacturing 'end of line' procedures in the Ability factory.

The Ability control strategy converts this volume requirement (litres/sec) into a control signal voltage (Volts) that in operation is fed to each of the individual fans within each Matrix unit.

The inevitable differences in static pressure between the individual ducts on a single Matrix unit are compensated for by a continuously running strategy routine. The strategy stores a database of the relationships between the motor speed, the motor current draw and the speed signal voltage. It evaluates these against the values it is sensing in real time and is therefore able to make any compensatory speed adjustments necessary.

Even after handover, this self-monitoring and self-adjustment continues to operate and so any static pressure changes, perhaps introduced at a 'fit out' rearrangement, will be corrected for automatically.

Actual air volume adjustments that may also be required for any one of a number of reasons, can also be implemented remotely through the Matrix software or the BMS.

NB: Air volume changes (or for that matter any change) made through the Matrix software can be made to a single Matrix, a group of Matrix units or a whole project simultaneously.

An interesting scenario - An owner wants the air volumes lowered by 10% on 1000 Matrix units he has bought because his new tenant has lower occupancy levels than expected.

While with conventional fan coils this would be impractical, with Matrix, this change should take no more than an hour or so using the laptop connected to the BMS network at a single position; the ceiling void would not need to be accessed.

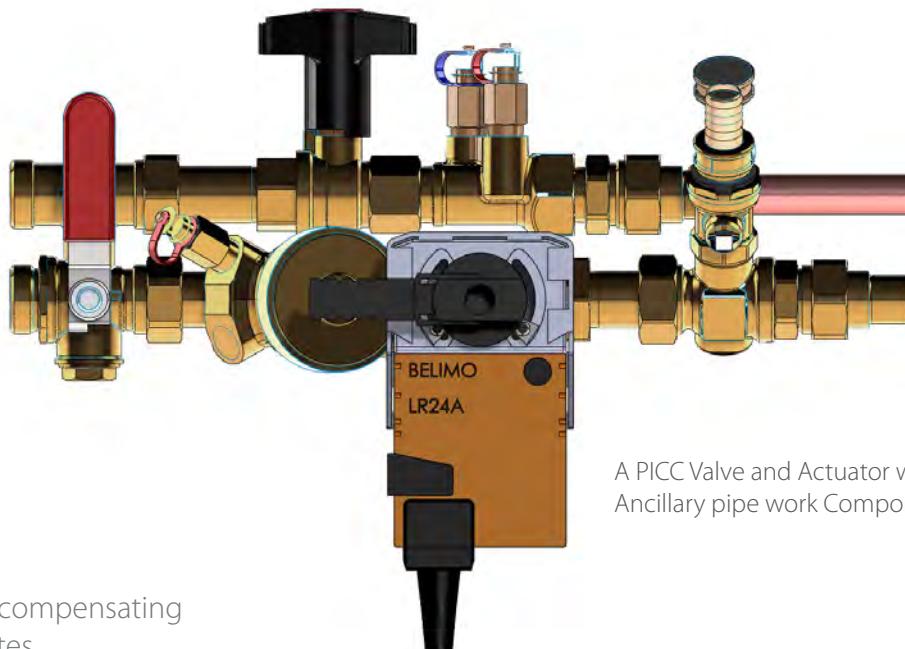
Specific Fan Power

The specific fan power (SFP) of the Matrix range betters the requirement of the 2010 UK building regulations. These limit fan coil styled products to 0.6 W/(l/s). Under design conditions Matrix SFP will be lower than 0.3 W/(l/s) (0.14 W/cfm) and as low as 0.1 W/(l/s) (0.048 W/cfm) at setback.

UK 0.6 W/(l/s) = 0.285 W/cfm USA



PICC valves



A PICC Valve and Actuator with Ancillary pipe work Components

Imagine

Self-setting and self-compensating design water flow rates

Whilst most valve manufacturers have a pressure independent valve solution, not many have a characterised pressure independent valve with a remote adjustment capability. The primary purpose of the valve is of course, to provide modulating flow control of the chilled and hot water to the heat exchange coils and provide a comfortable conditioned space - that is taken as read. However, in common with everything else Matrix does, Matrix does not stop there!

Pressure independence - The PI bit!

Each valve incorporates a pressure cartridge that regulates (normalises) the pressure to the back of the rotating ball within the valve irrespective of the varying hydraulic pressures imposed on the valves at different points within the pipework system.

This means that the relationship between valve position and water flow will be the same (normalised) for all the valves within the building.

Characterised Control - The CC bit!

When a ball valve begins to open, water will start to flow. However, the amount of water passed per degree of ball valve rotation is not a linear relationship.

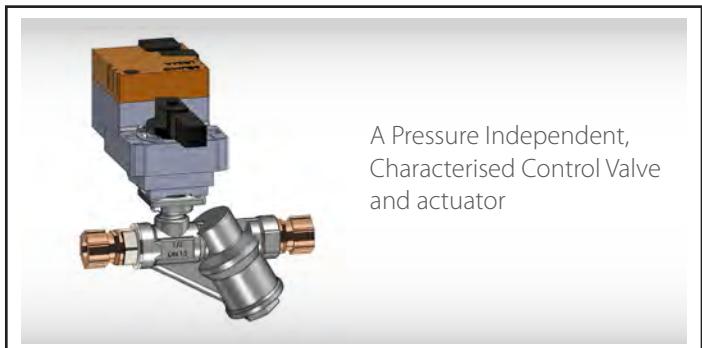
A normal valve naturally lets by more water per degree of rotation when it initially opens than it does per degree of rotation when it is near the end of its travel. The characterisation devices employed in the Matrix valves is a means to smooth out that variation and to give a more linear water flow characteristic over the 90 degrees of the ball valve action.

Unlike most pressure independent valves, which utilise a dial or similar, the valves Ability employ have no physical way to set the design flow rate into the valve itself.

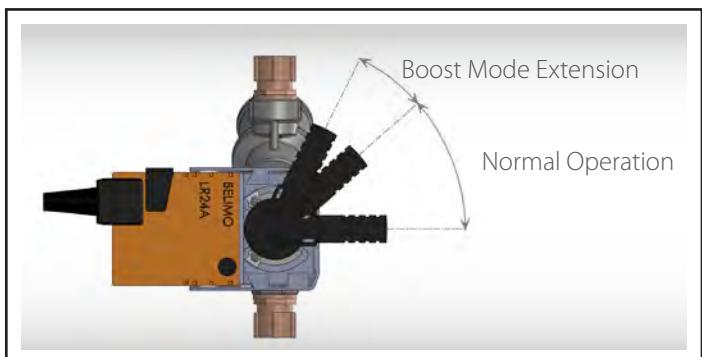
Controlling maximum design water flow

In common with the fans, Ability upload during the 'end of line' testing routines the unit specific design water flow rates for both heating and cooling.

Uniquely, each Ability valve is set by assigning a rotational limit beyond which the valve is not allowed to travel. This rotational limit is coincident with the design water flow rate for that valve on that unit and while the valve modulates as any other valve would, it never travels beyond this point.



Actuator and Valve Type	Heating Valve	Cooling Valve
	BELIMO 000	BELIMO 35
Design Flow	0.045 l/s	
Trim factor	100%	AV203 0.045 l/s SET
Branch Trim Factor	100%	100%
Current Position	0%	107.7%
Open Output	OFF	OFF
Close Output	OFF	OFF
Motor Time for Design flow	40 sec	56.1 sec



The unique advantage of the Ability Matrix system is that water flow rate changes can be made remotely and at any time. This is because the design water flow rate limit position is defined by a value in the strategy and this value, like any other value can be changed simply through a few keystrokes on the laptop or other setting devices.

An interesting scenario - An occupier wants to undertake a re-assignment of the chilled water to better reflect the loads he now has in all his offices after occupation. With Matrix, through the software tools alone, the demands made of all the units can be evaluated and the water flow rates can be re-apportioned to suit the new occupancy pattern.

The Matrix Boost Mode

The Boost Mode feature is one of the smallest strategy routines but is probably the most revolutionary. This feature, within each Matrix strategy, keeps an ever watchful eye on the space temperature relative to the set point and dead zones set. It recognises any unit that is struggling for whatever reason, a water temperature fluctuation or possibly a subtle shortfall in water quantity, and will temporarily adjust the valve maximum flow position until the problem passes.

Consider

Matrix not only controls the environment within predefined boundaries, but it also keeps a watchful eye on the tools it has to do the job, water and air. If it senses there is any problem, it will temporarily adjust its own commissioned values to ensure the occupants remain happy. After the problem passes, it resets back to normal running. Matrix offers substantial reductions in commissioning times and removes the need for conventional flow regulating valves.





the control strategies



Overview

Ability download into every Matrix terminal controller one of a number of Matrix control strategies - the choice depends upon the solution required. These strategies are the result of thousands of hours of development, testing and refinement.

Every design value input into the controller, such as dead bands, set points and fan volumes, can all be changed through the software that comes, if requested, as part of the Matrix package.

Changes to the base strategies can be made to accommodate individual requirements if required. For instance, you might want a Matrix project to interface with light sensors and a motorised shading system. While this routine does not exist in the standard strategy, given a clear definition of the requirement, this could be specially incorporated for your project.

Energy Savings

To recap, EC/DC motors consume approximately 45% of the energy their AC counterparts would use at the same duty point. However, certain EC/DC motor strategies allow the savings to be increased yet further.

The relationship between power consumed (VA) and speed (RPM) on a EC/DC Matrix motor is not linear. Therefore, substantial additional energy savings are there to be had if a variable fan speed strategy is employed.

All Matrix strategies exploit the fact that most fan coil type products, at most times, do not need to deliver anywhere near their design air volume to maintain the desired space condition. So, for most of the time, Matrix units run slower, run quieter and conserve power.

AC FCU set at design volume Installed with conventional VCDs - 30Pa	620 cfm	205	195	This illustration is based upon a three fan unit.		
EC/DC FCU set at design volume Installed with conventional VCDs - 30Pa	620 cfm	104	28	Each fan at the design speed is giving approximately 210 cfm producing a duct velocity of 6.5 ft/sec (10" Dia) with a noise level of around NR/NC35 in a contract quality office.		
Matrix set at design volume Installed and set using electronic balance - No VCDs	620 cfm	81	28	The unit would be capable of approximately 12,000 BTU Sensible Cooling.		
Matrix FCU - Electronically balanced - No VCDs - At setback speed reduction of 10%				557 cfm	57	28
Matrix FCU - Electronically balanced - No VCDs - At setback speed reduction of 20%				495 cfm	48	28
Matrix FCU - Electronically balanced - No VCDs - At setback speed reduction of 30%				432 cfm	41	28
	Design Air Volume	Apparent Power (VA)	Watts Motor Heat	Air Volume under set back conditions	Apparent Power (VA)	Watts Motor Heat

Matrix Fan Speed Strategy

Most Fan Coil styled solutions are sized for the hottest day and with the highest potential occupancy level but how often does this really happen – rarely.

The Matrix variable speed (energy saving) strategy works by using two proportional loops that influence the fan speed defining the air volume, the noise level and the power consumed.

The first loop is a simple proportional only control loop which defines that the further the room temperature is from set point the higher the fan speed should be, up to the design maximum.

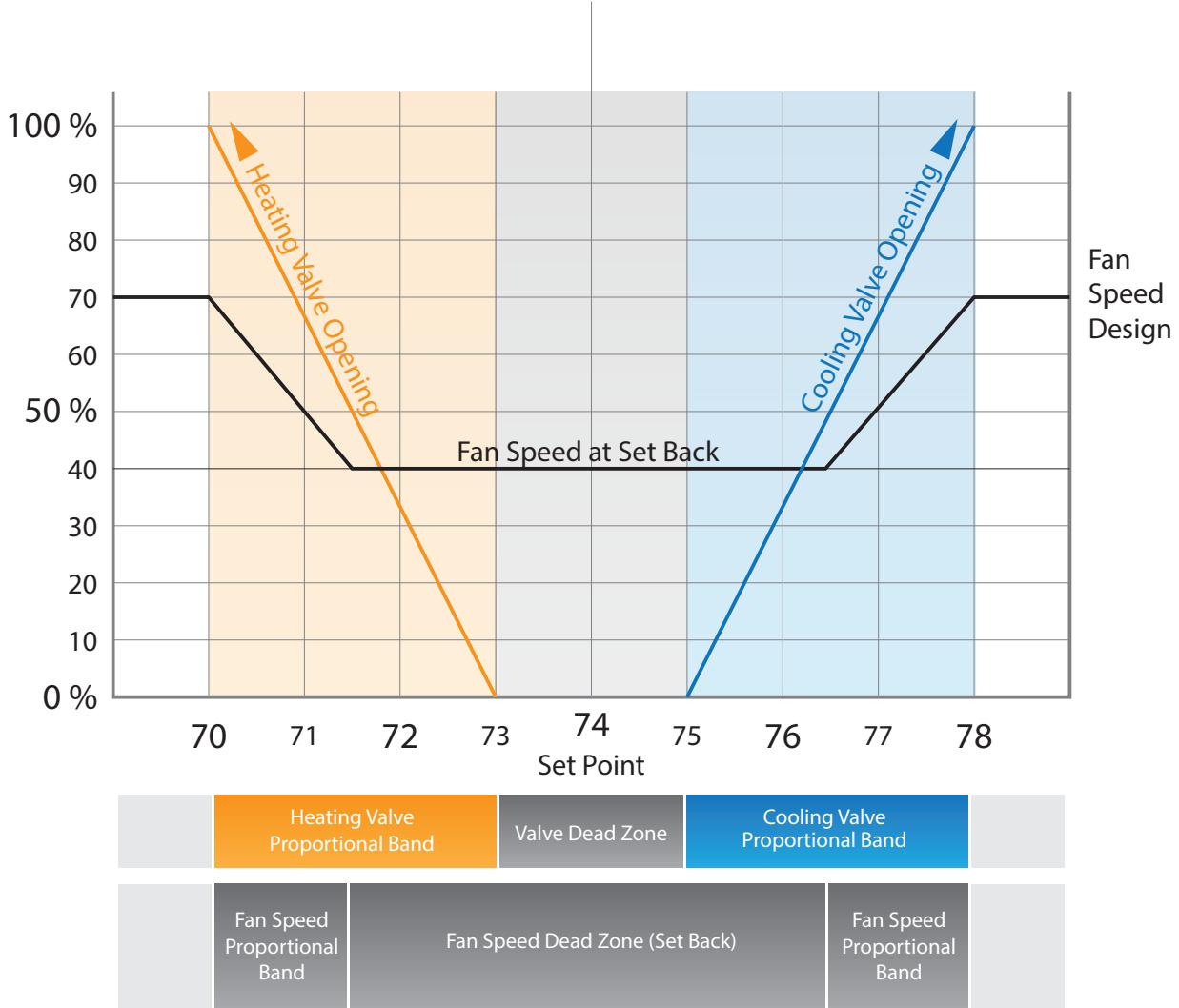
However, while the room is at or around set point the fan is allowed to slow to a lower percentage of design, thus saving energy and reducing noise.

Air Off Protection Strategy

The second proportional control loop is continually looking at the air temperature leaving the unit and has the authority to override the variable fan speed and raise the air volume should it decide.

This is generally when the 'air off' temperature is potentially becoming too cold and the unit is in danger of dumping cold air from the grilles. In these circumstances this second 'strategy loop' proactively raises the fan speed to elevate the off coil temperature and avoid this undesirable condition.

If for any reason this loop does not correct the problem with fan speed adjustment alone, it will then also gradually start to close the relevant valve and can even send an alarm.



Matrix Valve Control Strategy

The design water flow rates, both heating and cooling, are preloaded into every Matrix controller and the unit will start controlling immediately the unit is put into 'Automatic Mode'.

The valve action in normal operation mirrors that of any other modulating control valve. The strategy incorporates a set point value, a dead zone and a proportional band over which the heating and cooling valves modulate between fully closed and fully open.

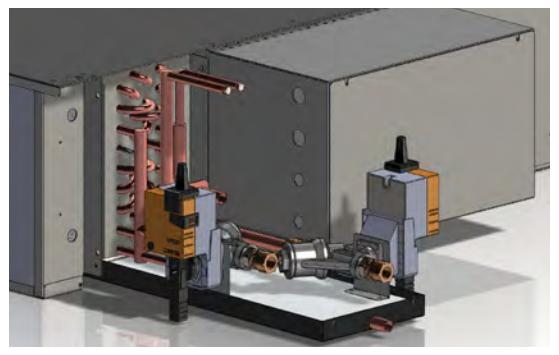
The diagram above shows a typical control strategy with the valve action and the variable fan speed action also shown.

It is worth re-emphasising that all these design parameters are pre loaded as the fan coils are being assembled but remain adjustable through the software.

The action of the valves are shown in orange and blue (orange for heating and blue for cooling) and the variable speed of the fans is shown in black.

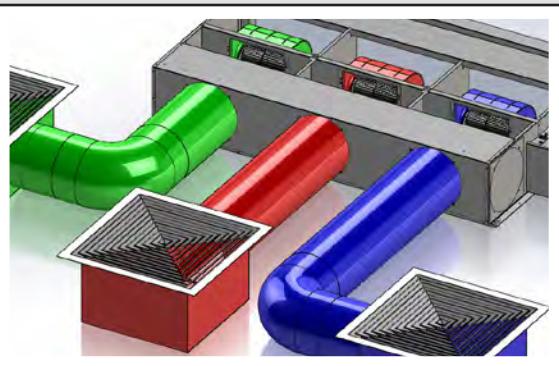
The supply air protection strategies and the boost strategies are not shown. This is because they only come into play to protect against unusual, unpredictable events and so they are almost impossible to plot.

The Four Strategy Loops



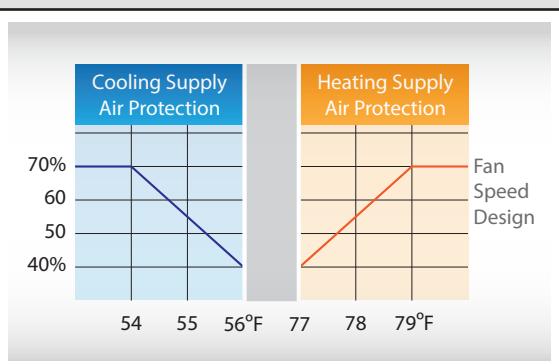
One - Water Flow

The PICC 'Valve Control Strategy'. As with any normal modulating control valve, this Matrix control routine modulates water flow to the heat exchanger coils depending on demand.



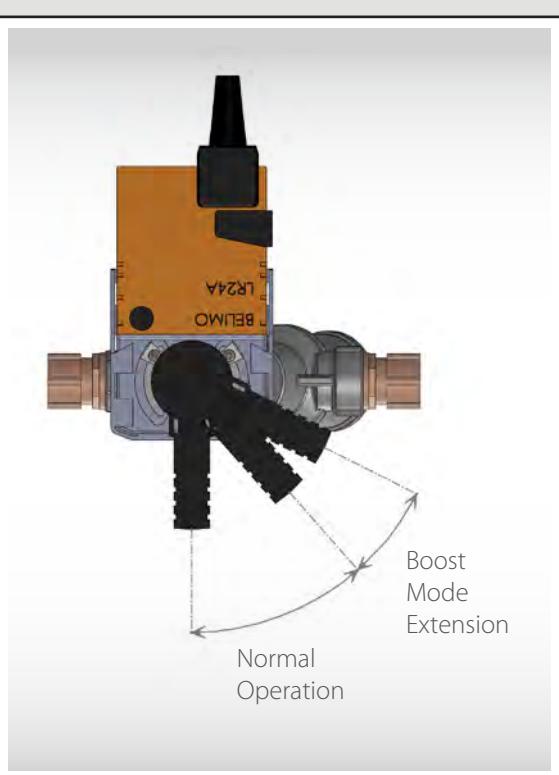
Two - Air Volume

The 'Variable Fan Speed Control Strategy'. This acts in a very similar way to the valve control routine except it modulates the fan speeds to control air flow over the heat exchangers, depending on demand.



Three - Supply Air Protection

The 'Supply Air Protection Loop' ensures that, whatever else happens, the air off condition is always maintained within acceptable limits. This leaves the designer free to experiment with both the fan and valve proportional bands because he will always be guarded against any undesirable situations.



Four - Boost Mode

The 'Boost Protection Loop' ensures that, if despite the best effects of the Matrix unit, the temperature in a space continues to drift, the design flow rate valve position is temporarily relaxed until the room comes back into line.

Consider

Boost Mode effectively means that even though the Matrix unit self sets design water flow at commissioning time, if that setting is ultimately slightly low, the unit will temporarily correct this situation if it needs to in a 'Peak Load' situation. Conversely, if the water flow setting turns out to have been a little high, again it does not matter because the off coil protection loop will spot the problem and again, temporarily correct the situation.

matrix cubed

The final piece of the World beating, Matrix jigsaw -



Matrix Cubed is an optional control device that allows any Matrix unit to monitor its own physical condition, report or alarm on that condition and most importantly save even more power.

Matrix Cubed Features:-

Standby Sentinel - Low power mode

A routine that puts the unit into a low power mode saving energy when any Matrix is not in use.

As Fan coils generally spend more time in a non operational state than they do in their operations state, the amount of power they consume while idle is important and can add up to a substantial proportion of the total running cost.

Ability has engineered a solution that keeps only the bare minimum of components active but sufficient to power up the rest of the unit and controls when required.

No. Fans	Standard Matrix Standby (W)	Matrix Cubed Standby (W)	Saving Watts	Saving %
5	43	11.7	31.3	73%
4	36.3	11.7	24.6	68%
3	30.2	11.7	18.5	61%
2	23.1	11.7	11.4	49%
1	17.9	11.7	6.2	35%



NRG Watch - Energy Monitoring

Most system integrators are now installing Building Energy Management System, BEMS, which as the name suggests are designed to monitor and manage energy usage within a building.

Although not necessarily of billing quality, the Matrix cubed device outputs energy consumption in Amps and Watts. The idea is to provide a better vision than has been previously possible detailing exactly where your fan coil energy is going. This monitoring output can range from simple graphs to league tables for users.

Matrix Health Check

This periodic check on the status of all Matrix units is an additional means to keep an eye on the 'well being' of the units as time passes.

With the units at design volume, the health check routine records several values on the initial BMS enable or power-up of the system. This initial (as new) value is then saved and used as a benchmark to compare against the same values over time. A simple algorithm applied to the growing differences to the 'as new' recording will indicate any unit that has either a fan failure or dirty filter condition and raise an alarm through the Building Management System.

This allows servicing and repairs to be demand based, as opposed to a simplistic (but more costly) time based routine.



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