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Conaire Knowledge Series Papers 11

THE BIG LEAP IN DEMAND CONTROLLED VENTILATION

We managed our biggest leap in demand controlled ventilation some time back. Having studied various traditional approaches used in demand controlled ventilation, their evaluation, mainly in the areas of energy efficiency and indoor air quality, we were able to arrive at a blueprint for efficient and intelligent HVAC systems. Systems that monitor the requirements and make adjustments accordingly to affect significant energy efficiencies and at the same time provide optimal ventilation rates. In this article we have discussed the various approaches both traditional and new, with illustrations and outlining their advantages and drawbacks.

A. PRESSURE DEPENDENT VOLUME CONTROL

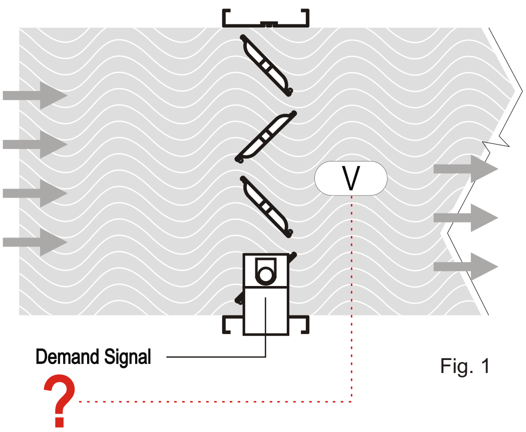

Fig. 1

In this type of control (fig. 1), standard motorised volume control damper without airflow measurement is used. Hence the current airflow is dependent on the fluctuation of the inlet or system pressure. That is the reason it is called pressure dependent volume control.

Variable frequency drives for air handlers in systems using this type of control cannot be used as they can result in imbalance in the complete HVAC system. This makes such a system less energy efficient.

Also, in absence of measurement of the fresh air intake, supply air, etc., optimal ventilation rates cannot be determined and achieved.

B. PRESSURE INDEPENDENT VOLUME CONTROL

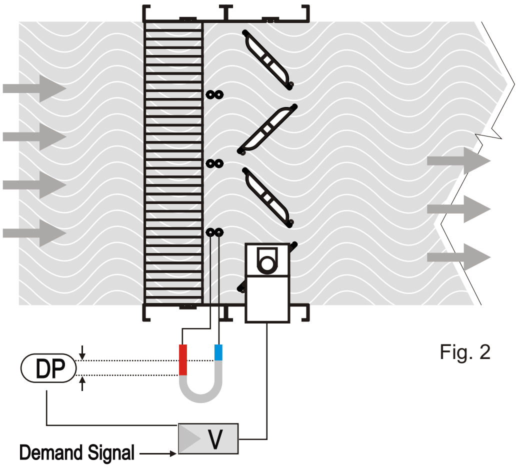

Fig. 2

This control (fig. 2), maintains required flow regardless of fluctuation of the inlet or system pressure. Hence it is termed Pressure independent. Variable frequency drives for air handlers can be used with this type of control as it can automatically balance the complete HVAC system.

Variable air volume boxes can be used in various applications of HVAC control. It is more advisable to use VAQ station instead to provide much effective control and better accuracy in airflow measurements. There are several advantages of using VAQ station over standard VAV boxes discussed in detail

C.
IN MULTIPLE SPACE USING ONE CO_2 SENSOR

Let us now consider a scenario (fig. 3) where a VAQ station is in use for measuring and controlling outdoor air volumes but the problem is still persists until CO_2 levels are measured correctly. A typical approach would be to use one CO_2 sensor in a multiple zone configuration as shown in the figure below.

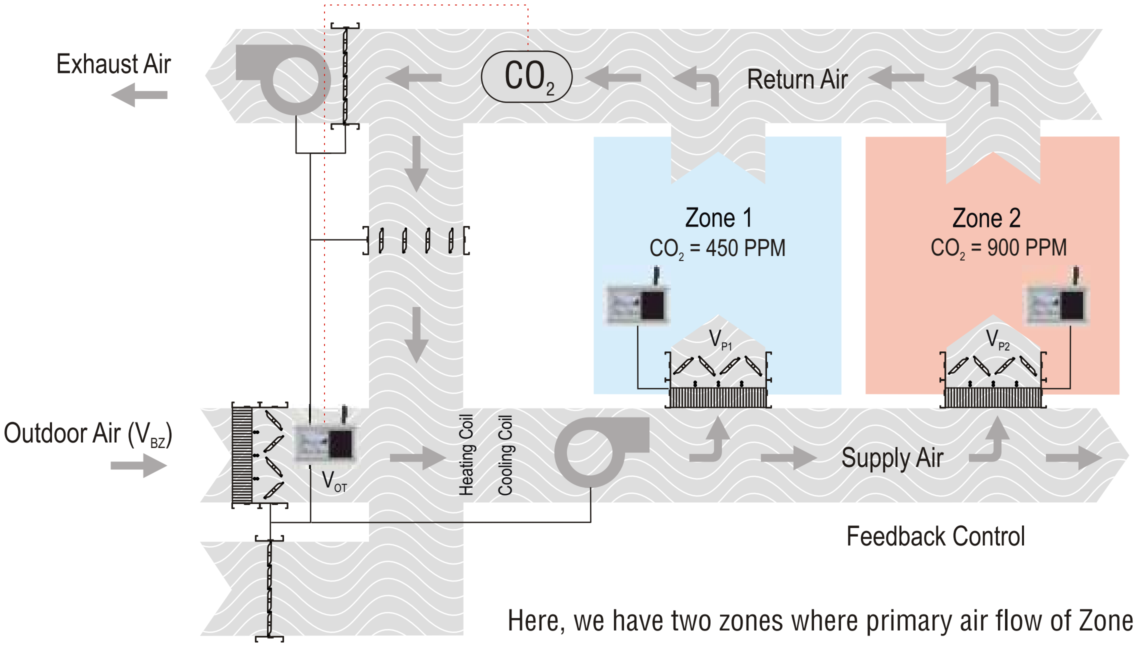

Fig. 3

Here, we have two zones where primary air flow of Zone 1 is equal to Zone 2. At present Zone1 CO_2 concentration is 450ppm & Zone 2 CO_2 concentration is 900ppm, thus using one CO_2 sensor at the common duct of the two we merely measure the average of the two, i.e. 675 ppm and we command outdoor air damper to bring outdoor air for the dilution of 675 ppm of CO_2. This means that on one hand we are over ventilating Zone 1, while the critical Zone 2 still remains under ventilated.

HOW TO ACHIEVE OPTIMAL VENTILATION ?

Having discussed commonly used traditional approaches for demand controlled ventilation & their disadvantages, the question arises as to how optimal ventilation can be achieved.

First and foremost is to use VAQ stations to measure the amount of outdoor air coming into a building. And then, Reset intake air flow by applying demand signal to VAQ station in response to variations in zone population and ventilation efficiency both. Which we will now discuss in detail hereinafter.

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CALCULATING OUTDOOR AIR REQUIRED FOR A SINGLE SPACE

$$\frac{R_A \times A_Z}{E_Z} \rightarrow V_{OZ\,(min)}$$

$$\frac{R_A \times A_Z}{E_Z} + \frac{R_P \times P_Z}{E_Z} \rightarrow V_{OZ\,(max)}$$

E_z is the zone distribution efficiency, which determines how effectively outdoor air distributes in the zone.

It depends upon the type of distribution system and varies from 0.5 to 1. Refer Table 6-2 in ASHRAE standard 62.1

where,

- R_A is required outdoor air cfm per square feet area, it ranges from 0.06 to 0.48, depends upon nature of occupancy
- A_Z is the zone area in square feet
- R_P is required outdoor air cfm per person, it ranges from 5 to 20, depends upon nature of occupancy.
- P_Z is the designed maximum population. Refer table 6-1 in ASHRAE standard 62.1

Hence we get required minimum and maximum outdoor air for a individual space. Using mass balance we can correlate these fresh air levels with CO_2 levels and demand control ventilation can be strategised.

CALCULATING COMBINED OUTDOOR AIR REQUIRED FOR MULTIPLE SPACE

		Zone 1	Zone 2		Zone N
V_{OZ}	Required Outdoor Airflow	V_{OZ1}	V_{OZ2}	....	V_{OZN}
V_{PZ}	Required Supply Airflow	V_{PZ1}	V_{PZ2}	....	V_{PZN}
Z	Outdoor Air Fraction	$\frac{V_{OZ1}}{V_{PZ1}}$	$\frac{V_{OZ2}}{V_{PZ2}}$	....	$\frac{V_{OZN}}{V_{PZN}}$
Z_D	Critical Outdoor Air Fraction	Maximum $(Z_1, Z_2, \ldots Z_N,)$			
V_{OZT}	Total Uncorrected Outdoor Airflow	$V_{OZ1} + V_{OZ2} + \ldots V_{OZN}$			
V_{PZT}	Total Supply Airflow	$V_{PZ1} + V_{PZ2} + \ldots V_{PZN}$			
X	Total Outdoor Air Fraction	$\frac{V_{OZT}}{V_{PZT}}$			
V_{OT}	Total Corrected Outdoor Airflow	$\frac{V_{OZT}}{1+X Z_D}$			

CALCULATING SUPPLY AIR REQUIRED FOR INDIVIDUAL SPACE

Before a selection can be made, the design airflow rate must be determined from load calculations. Caution should be taken to determine these loads accurately as VAQ station/VAV box oversizing can lead to significant energy penalties. The controllable minimum shall be determined by cross-sectional area of VAQ station/VAV Terminal, which is 120 cfm per square feet area.

1. DCV - SINGLE ZONE CO_2 BASED

In an application where the ventilation system delivers fresh outdoor air to a single zone (fig. 4), the CO_2 sensor typically is installed on the wall in the breathing zone, just like the thermostat. It's usually expedient to assume that the outdoor CO_2 concentration is constant, so the indoor concentration (rather than the outdoors) is measured and used to modulate the position of the outdoor-air damper and thereby provide the space with the proper amount of ventilation air on a per-person basis.

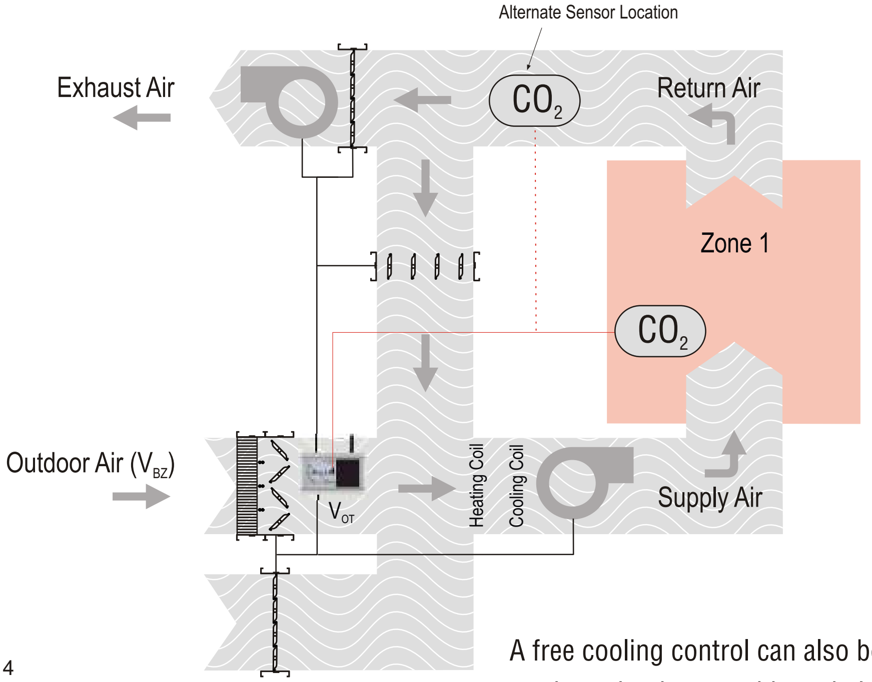

Fig. 4

A free cooling control can also be integrated to provide complete outdoor air when outside enthalpy is low as shown below (fig. 5).

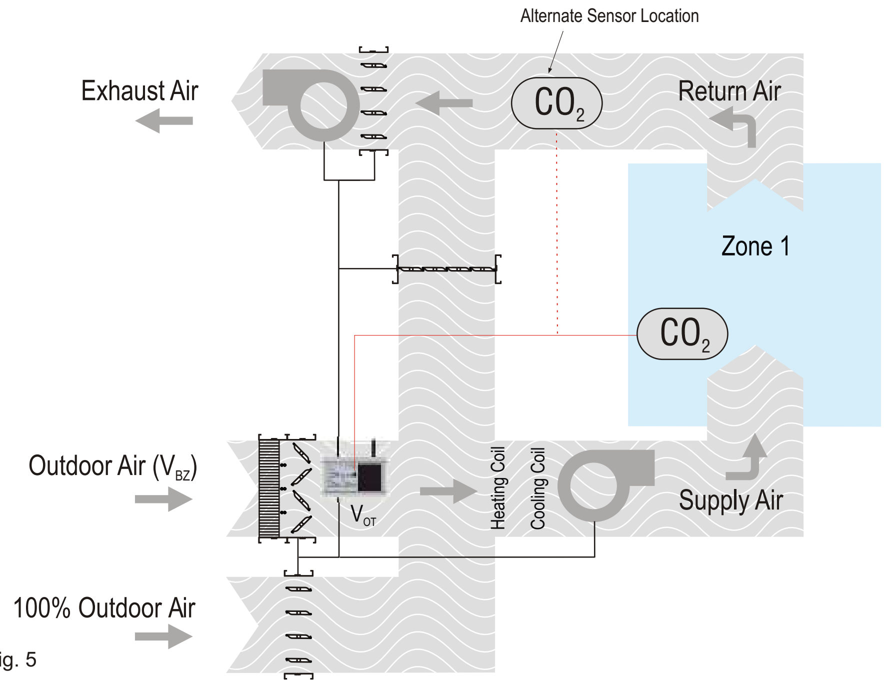

Fig. 5

2.
DCV - MULTIPLE ZONE CO_2 BASED

Multiple Zone System is the system where the ventilation system delivers fresh outdoor air combined with return air to a several multiple zone (fig. 6). One approach for implementing CO_2-based DCV in multiple-zone VAV system is to install a CO_2 sensor in every zone which determines how much outdoor air must be brought in at the air handler to satisfy the critical zone(and thus over-ventilate all other zones), and then repositions the outdoor air damper accordingly.

A free cooling control can also be integrated with same.

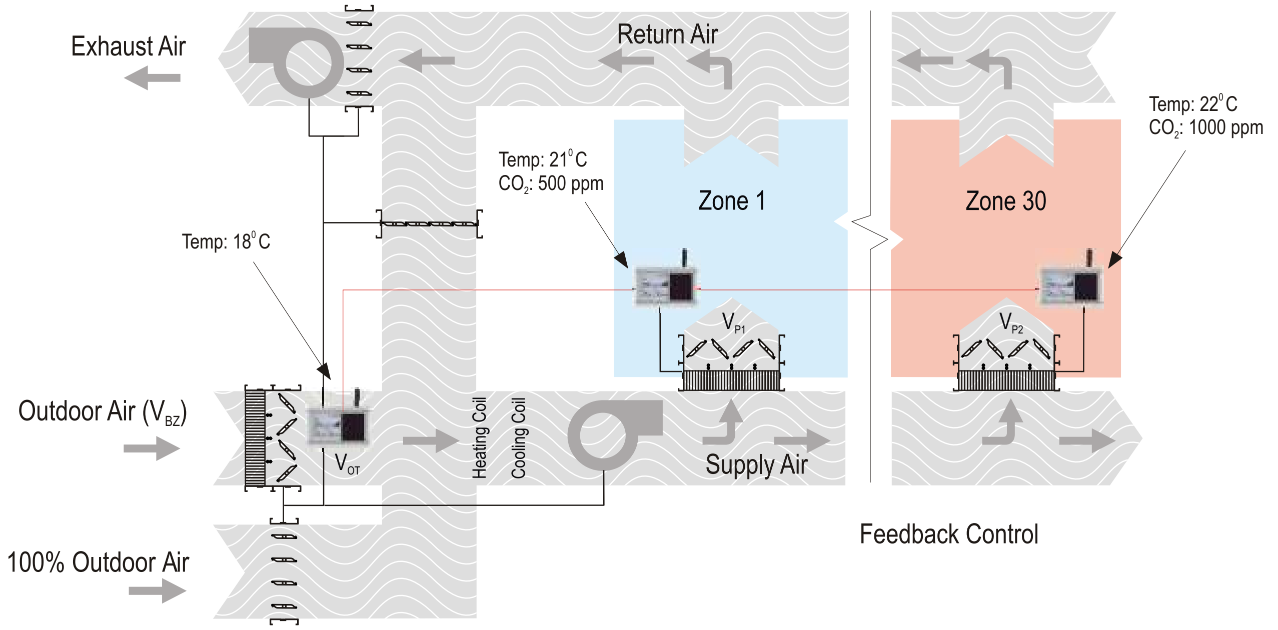

Fig. 6

3. DCV - MULTIPLE ZONE CO_2 BASED WITH VENTILATION RESET

In most multiple-zone systems, the best approach often combines CO_2-based DCV with ventilation reset (fig. 7). Using this strategy, CO_2 sensors are installed only in those zones (conference rooms, for example) that are densely occupied and experience widely varying patterns of occupancy to reset the ventilation requirement for their respective zones. The other zones which either are not densely occupied or do not experience significant variations in occupancy are assumed to require their design ventilation rates whenever they're occupied.

Then the ventilation reset equations mention earlier in Table no 1 are used to determine how much outdoor air must be brought in at the air handler to satisfy all of the zones served.

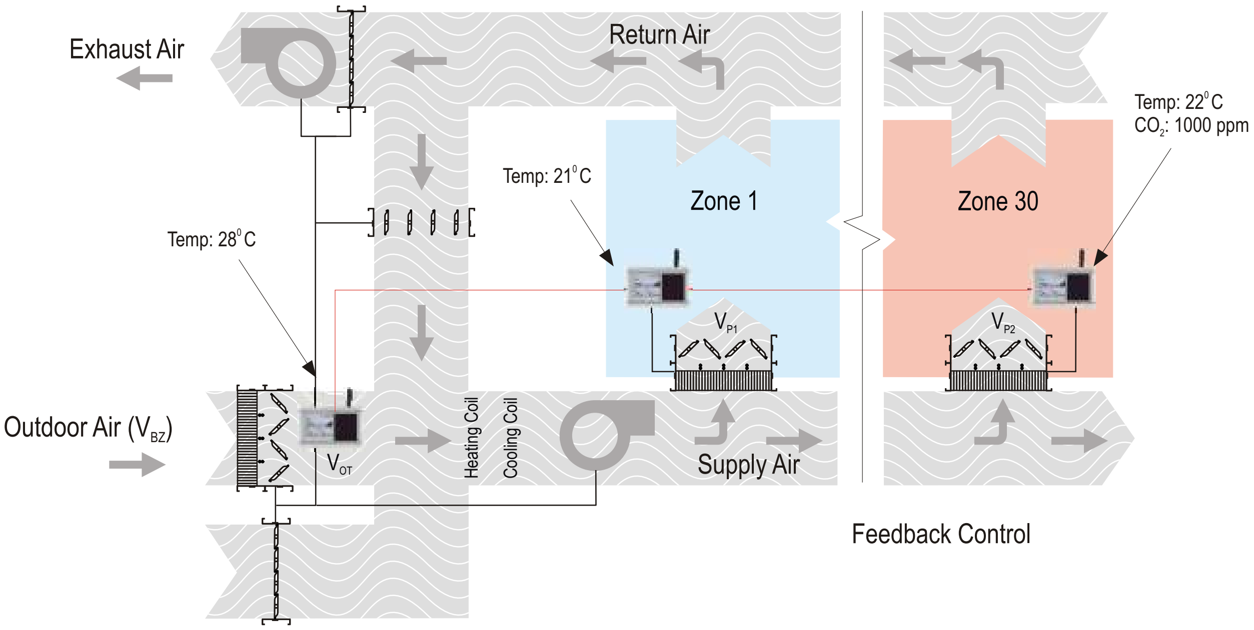

Fig. 7

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BENEFITS OF USING A VAQ STATION OVER A VAV BOX IN SUPPLY AIR APPLICATION

	VAQ STATION	VAV BOX
FLEXIBILITY IN SIZE	Comes with a flexibility of site specific customised sizes going down to duct size as low as 200 mm from any practical size.	Available in distinct set of sizes, which may or may not ducting size.
CFM RANGE	Can be calibrated as per airflow need going down to very low airflow quantity (120 cfm per sq. ft.) from any possible flow range.	Comes in sets of fixed CFM ranges and corresponding fixed sizes, therefore resulting in oversizing the requirement. e.g. a certain manufacturer has a specific range of 500-1000 CFM of VAV but lets say the requirement is 300-700 CFM so a model of VAV of higher range is pushed, which goes against the original concept of using a VAV at the same time compromising energy savings and comfort conditions.
CONSTRUCTION	Comes with a honey comb pattern air flow straightener which provides laminar flow for accurate measurement of airflow. Uses a rapid average pitot tube for measuring air flow at various points and then averaging it (As recommended in Ashrae handbook) It contains extruded aluminium multiblade low leakage airofoil design volume control damper for modulation of air. This allows us to achieve very low resistance to flow and effective volume control and restrict the air leakages to mimimum possible as per AMCA 500D. It comes in a standard depth of 230 mm for any size or CFM. It comes in aluminium extruded 1.5 mm nominal thickness low leakage assembly.	No such straightener present so the airflow is turbulent and special care needs to be taken while placing it. Multi point measuring system is present but does not follow the Ashrae's handbook guidelines. Contains circular single butterfly blade damper which will not provide effective performance as compared to former in all parameters. Its standard depth varies from one model to other. It is made out of 22 gauge galvanized sheet.
SOUND ATTENUATORS	There is no requirement of sound attenuators as these are manufactured of size of duct so they are operating at same velocity of duct only. As no sound attenuators are required so depth remains 230 mm only.	Throttling effect results in increased velocity for measurement across velocity probe hence sound attenuators are required, further increasing the depth of VAV box. The depth can go upto to 2 meters also as for higher CFM long attenuators are required.
TRANSITION PIECE	There is no requirement of transition piece as these are fabricated as per your requirement which eases the installation.	Here transition piece is required as matching duct connection is required, these are generally site fabricated.
PRESSURE DROP	Pressure drop is negligible or we can say slightly higher than a opposed blade airofoil damper.	Pressure drops are comparatively high resulting in selecting AHU fans of higher pressure drop thus causing energy losses.

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LEAKAGE	Its leakage class is class I as per AMCA 500D and since it has simple flange to flange connection with duct so leakage is bare minimum.	Each manufacturer follows different leakage class but the tricky part is the complex circular to rectangular connection of the transition piece, generally of canvas where slightest negligence results in high leakage hence loss of energy and efficiency.
VFD CONTROL	They are intelligent enough and communicate with each to optimize air handler speeds in advance rather than waiting for pressure variation in the duct	A pressure sensor with a controller is used to optimize air handler speed in variation to changing demand of VAV installed at supply air.
AIRFLOW MEASUREMENT	Airflow is made laminar first by using honey comb pattern airflow straightener and then measured at various points using rapid average pitot tube so it's deviation in accuracy is maximum 5%.	Low accuracy in measuring Airflow as it is not done as suggested in Ashrae handbook.
EFFECT OF AIRFLOW MEASUREMENT.	Since basic principle is controlling primary air by running PID algorithm for modulating airflow as per differential of actual and set point temperature.	Since its basic principle is same but measurement of airflow is less accurate so modulation is also proportionally affected and it results is ineffective or less effective solution.
CALIBRATION TECHNIQUES	There are always some non-linearitys present in the system which are considered at the time of calibration so that a much effective operation is provided. Hence it has high accuracy.	It only considers linear variables and ignores all non-linearitys hence it has much chance of failing and even though the VAV might be operational but it will not effective.
LOCATION OF CONTROLLER	The controller and thermostat can be clubbed together and in single module and placed inside the zone for easy access.	Controller is mounted on VAV box so accessing it is a tough task. One has to take false ceiling clearance, etc.
INDOOR AIR QUALITY	VAQ stations at supply air with CO2, and rH sensors communicate with VAQ stations at outdoor air and optimize outdoor air with help of a multiple space equation as mentioned in ASHRAE standard 62.1 and provide proper ventilation in each and every space.	No such provision.
TRAP DOOR SIZE	The size of VAQ is compact comparatively so the trap door is very small making it an architects favourite.	Huge size of trap door is required.
LOCATION OF CO_2 SENSOR.	As per LEED requirement, the location of CO2 sensor should be in the zone so we can couple the temperature sensor, controller and CO2 sensor in single module. Which makes it suitable for green building projects.	There is no such provision.

Additional features of CONAIRE VAQ Stations are:-

- *Control fresh air, supply air, return air as well as exhaust air maintaining an economy for the system*
- *Can run enthalpy equations so enabling the use of free cooling for a building in an automated manner*
- *Can modulate air to any unconventional algorithm and conditions*
- *Can also be used for CAV application as a motorised CAV as well as communicable*
- *Was awarded first prize at ACREX 2011 held in Delhi for indoor Air Quality.*

We seek your feedback on this series of knowledge papers from Conaire. Please write in with your suggestions at: feedback@conaire.in

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