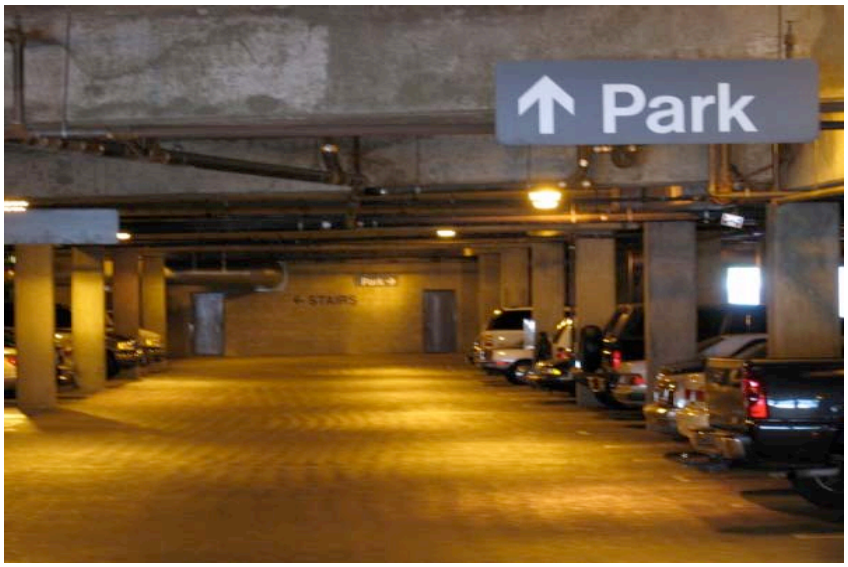
AirTest™
Sensors That Make Buildings Smart!

The Parking Garage Opportunity

An AirTest Guide To Saving Energy
And Improving Air Quality In Enclosed Parking Garages



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AirTest: Understanding The Parking Garage Opportunity

1. Overview

This paper provides a review of the opportunity available in utilizing AirTest products to provide CO based ventilation control in enclosed parking facilities. It also describes the products offered by AirTest and selling tools that can be used to take advantage of this lucrative opportunity for reducing energy in buildings. Also described is a process where AirTest can assist you in the design and layout of the a ventilation system. To date approximately 65% of the enclosed parking garages, both new and existing are not using CO based ventilation systems.

2. The Opportunity

There are thousands of enclosed parking garages throughout the world that by code, require a high level of ventilation during all occupied hours. Typically this ventilation rate is 1.5 cfm/sq ft or greater. Most codes also allow the option to operate fans based on the level of carbon monoxide measured in the space. Since most gas-fueled vehicles emit some CO when they operate, the level of CO can indicate vehicle activity in the space and can be used to activate fans based on demand. In some jurisdictions, because of energy concerns the use of CO sensors for parking garage ventilation control has now become mandatory for all new construction.

Ventilation control using CO sensors usually controls CO to ensure that levels do not exceed 35 ppm (50 ppm in some jurisdictions). This can either be achieved by turning fans off-and-on based on this action level or by modulating the speed of fans using variable speed drives. Typically this type of control strategy can yield a significant reduction in energy usage. For a garage that is most busy at the beginning and end of a day, energy savings can approach 90 to 95%. In most cases the installation of a CO based ventilation system can pay for itself in two years or less, which represents a no-brainer opportunity to most facility operators.

AirTest Case Study 1

Lowes Santa Monica Hotel

Parking Sq Ft	159,500 sq ft
Fan HP	120 hp
AirTest Sensors	23
System Cost	$64,965
$ Saving	$76,311
$ Savings/Sensor	$2,825
KW Saving	545,079
Payback (years)	0.85
Rebate @ $0.16/kW	$64,965
Total User Cost	$0
Payback W Rebate	Immediate
Greenhouse Savings	732,040 lbs CO2

3. Energy Saving Potential

Estimating Savings

The energy savings potential for CO based ventilation will depend highly on the cost of electrical energy in your area. The chart below provides an estimate of the annual cost to ventilate an enclosed parking facility at various $/kWh utility rates, based on a 100,000 square ft garage that will hold 350 to 400 cars[1]. The chart can be used to develop a 'rule of thumb' that can be used to determine the approximate energy usage and savings that might be available to parking facilities in your area based on one of four operating schedules. (AirTest also has a more accurate tool that can be used to estimate specific energy usage and savings for a particular garage that will be explained later).

To see a case study of a garage we recently completed in the Los Angeles area click on the link below. This project had a total cost of $160,000 and delivered savings of $200,000 annually.
Link: https://www.airtesttechnologies.com/support/reference/AirTestParkingCaseStudy-Sunset.pdf

[1] Assumptions include a required ventilation rate of 1.5 cfm/sq ft, a ventilation system static pressure of 1.6 in WC , and a fan efficiency of 65%. Contact AirTest if you would like a copy of this excel based estimation tool.

To develop the 'rule of thumb' for your area, please take the following steps.

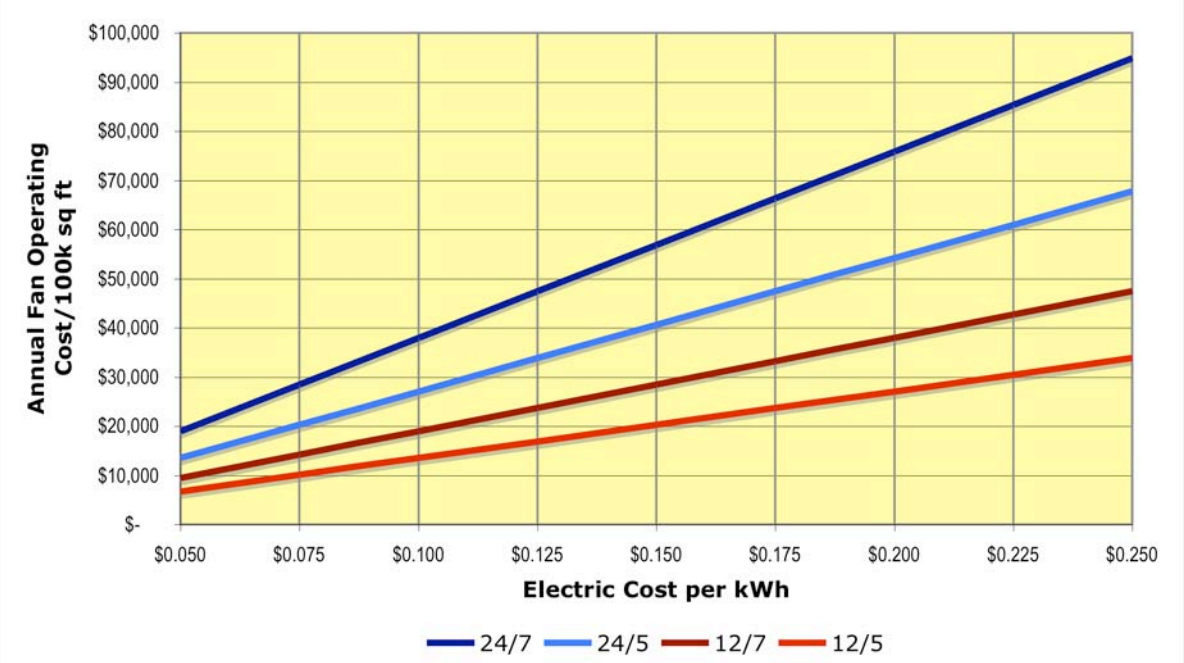
1. Determine what the typical commercial electrical utility rate is for your area by talking to local building owners or utility representatives.
2. Based on the utility rate use the chart in Figure 1 to find the point where the utility rate (from the bottom axis) intersects with the four diagonal lines which represent different operating schedules (hours per day/days per week).
3. Trace the intersection point to the vertical axis on the chart to determine typical annual fan operating cost.
4. You now have four cost figures that can be used to estimate the ventilation cost per 100,000 square feet based on the relevant operating schedule. With this information you can make a general cost estimate for a garage of any size. For example if a garage is 250,000 sq feet, you can multiply the ventilation cost by 2.5.
5. Savings typically will be in the 80% to 95% of the annual fan operating cost. With more details on your ventilation fans we can customize a calculation for a facility (at no cost).

AirTest Case Study 2

9601 Wilshire Blvd

Parking Sq Ft	284,160 sq ft
Fan HP	121 hp
AirTest Sensors	40
System Cost	$79,933
$ Saving	$23,606
$ Savings/Sensor	$1,998
KW Saving	168,614
Payback (years)	3.39
Rebate @ $0.16/kW	$26,978
Total User Cost	$52,955
Payback W Rebate	2.2
Greenhouse Savings	226,450 lbs CO2

Figure 1
Annual Fan Energy Cost For Parking Garages Based on



Utility Cost and Operating Schedule

Demand Charge Savings

Another area of potential savings is related to reduction of demand charges. Demand charges are charges incurred by facility operators based on their peak use of electricity. Usually the charge is leveled on a per-kilowatt charge, based on the peak energy usage in a month. The demand charge is usually based on specific energy usage within a certain time period where over all energy use is highest for the region. In some cases utilities may have different charges for summer and winter seasons.

Ventilation control strategies that turn fans on and off based on a target level of CO (say 35 ppm) generally will not impact demand charges, because the fans may operate at full load during the high use time period. Demand charges can be impacted if a variable frequency drive (VFD) is used to control the fan speed based on the CO level in the space. A variable frequency drive can be used on most fans to modulate the amount of air delivered by the fan. An added bonus to the use of VFD's, is that the energy cost per cfm decreases as the speed/airflow volume of the fan is reduced. Figure 2 shows the typical relationship between energy usage and airflow reduction using a VFD. In this example running the fans at a 20% capacity will yield over a 90% reduction in energy usage.

AirTest Case Study 3

8484 Wilshire Blvd

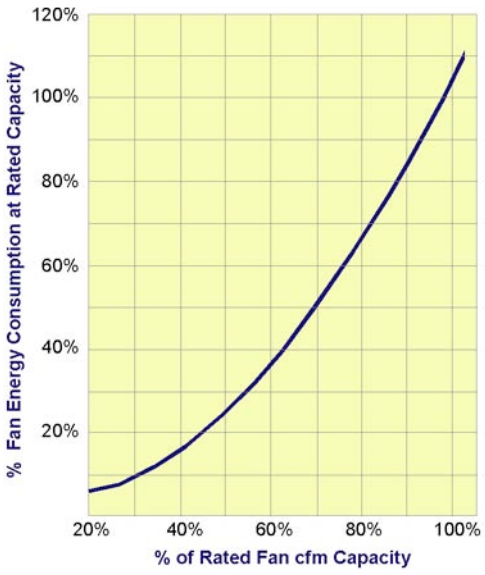
Parking Sq Ft	192,000 sq ft
Fan HP	80 hp
AirTest Sensors	35
System Cost	$82,924
$ Saving	$125,578
$ Savings/Sensor	$2,369
KW Saving	896,986
Payback (years)	0.66
Rebate @ $0.16/kW	$82,924
Total User Cost	$0
Payback W Rebate	Immediate
Greenhouse Savings	1,204,650 lbs CO2

When using VFD control of fans with a CO control strategy the fans are set to run at a minimum level of, say 20%, during all hours of use. This continuous ventilation rate has a number of advantages:

- Continuously operating fans at a low level will yield a significant energy savings.
- Other vehicle related odors, not related to CO are kept at a low level as to not bother garage visitors. Also, for individuals working in the garage, such as parking valets, the temperature and environment may be more comfortable with continuous ventilation.
- A reservoir of fresh outside air is always available in the garage to help absorb CO levels when peak traffic times occur.

As CO levels begin to rise over 10 ppm. the VFD is used to increase the speed of the fan proportionately until the fan is at full speed at the target level of 35 ppm. However the reality of this control strategy is that the continuous low level of ventilation will help control CO levels so that they never approach 35 ppm and so the fans will never ramp up to full capacity. While all garages are different, chances are fan speed will rarely, if ever, exceed 50-70% capacity. The use of VFD's will result in a peak demand reduction of 50% or more of the fan's rated power consumption.

Figure 2
Relationship Between Fan Energy Consumption And Flow Rate Using VFDs.



For a 100,000 sq ft garage using the same assumptions used for the chart in Figure 1, a 58 horsepower fan is necessary. Energy consumption of a fan motor is determined by multiplying fan horsepower times 0.746. This means a 58 horsepower fan consumes 43 kW in an hour. If we can ensure the power consumption is 50% or less during all operating hours using a VFD, we can reduce peak demand by 21.5 kWh or more each month. Demand charges can range from a few dollars to $40-$50/kW per month in some jurisdictions. In many cases the demand charge savings will justify the cost of the VFD's. The most efficient use of VFD's comes when a few high capacity fans are used to ventilate the garage. If a number of fans are used that are 10 hp or less, the cost of VFD control may be difficult to justify.

Rebates

Because of the significant energy savings potential of CO based ventilation control systems many utilities may offer lucrative rebates or other incentives for installing these systems. Separate rebates may also be offered for VFD equipment. Be sure to check with your local utility to see what kind of incentives they offer for these systems. In some cases rebates may pay for a significant portion of the system installed cost.

Figure 3
Variable Fan Operation Vs On/Off Control

	On/Off Control	VFD Control
Method	Fans are turned off and on based on CO level (usually 35 ppm CO)	Fan speed is varied based on CO level. Fan always runs at approx 25-30% speed. Speed ramps up as levels approach 35 ppm.
Operational Savings	Typically 80-95% energy reduction Vs continuous operation as required by code.	Typically 80-95% energy reduction Vs continuous operation as required by code.
		Operating a VFD at 25% speed consumes about 3-5% of the energy used at full speed.
Peak Energy Reduction (Demand Charges)	None	Typically50% or more reduction in kW demand charges.
Issues	Least expensive first cost control method.	Some added installation and equipment cost (10 to 30% typically). Much superior life cycle cost.
	On/off control means that a negative pressure is not maintianed in the garage at all times. CO may enter the building above.	Continuious VFD operation maintains a negative pressure in the garage to ensure CO does not enter the building above.
	On/off cycling of fan may negatively affect motor life	VFD initiates a soft start, and modulates fan speed with little impact on fan life.
	Unpleasant odors and temperature may buildup in garages during the off cycle. This may lead to employee/tenant complaints.	Continuous level of ventilation provided by operating the VFD at low levels ensure a supply of fresh air that controls odors and general vehicle activity. Perceived comfort is enhanced by continuous air movement.
	For retrofit, a change in operating mode of fans may accelerate failure of motors that are 20 years old or more.	For retrofit, a change in operating mode of fans may accelerate failure of motors that are 20 years old or more.

4. Installation Considerations

Requirements For Additional Gas Sensing Capability

In some jurisdictions it is required or desired that other gases be measured in addition to carbon monoxide in enclosed parking facilities. These gases include:

- ***Nitrogen Dioxide (NO_2):*** Since diesel powered vehicles produce very little CO, NO2 is used as a ventilation trigger for diesel vehicles. Action levels are typically around 1 or 2 ppm due to the highly toxic nature of NO2.
- ***Combustible Gases:*** In areas where alternative fuel vehicles are used, or where seepage of naturally occurring gases like methane are present, a combustible sensor can be used to activate fans and alarms if levels of combustible gases are too high. Typical control levels are around 20% LEL (lower explosive limit).
- ***Carbon Dioxide (CO_2):*** Carbon dioxide is a principal byproduct of all types of combustion. As a result CO_2 can be used to control ventilation where the concern is a build up of combustion related odors that may not correspond to an elevated level of a particular contaminant like CO or NO_2. Typically, maintaining CO_2 levels below 800 ppm will control most contaminants.

Sensor Placement

General industry practice dictates that one sensor be used for every 5,000 to 7,000 square feet of floor area. This requirement is not related to the sensing capability of a particular sensor but rather relates to ensuring a reasonable coverage and response time to elevated levels. Sensors, other than combustibles, should be placed at breathing level. AirTest has a number of applications specialists on hand that can assist you in determining the best placement of sensors for a particular floor plan.

Control Strategy Considerations

In additional to on/off and VFD fan control, it may also be possible to stage fan operation or operate fans on a zone basis. Where multiple zones use a common shaft, back draft dampers may facilitate a zoning approach. In some cases, parking facilities may also have both exhaust and supply fans that must be controlled. Most systems also incorporate a high level alarm where additional ventilation, horns and/or strobes can be activated if an unusually high concentration of the target gas is measured.

AirTest also can help you determine the best control strategy for a particular job. We can either provide stand-alone control panels, or have the sensors integrate with existing building management control systems. We also now have LonWorks® communicating options for all garage sensing products.

AirTest Can Assist With System Design And Energy Analysis

AirTest can also provide design assistance in putting together a garage ventilation system and estimating energy savings possible. Please contact us for a checklist of the things to look for. There is no charge for this service if you are using AirTest provided equipment. Generally we can turn around a design in 2 to 7 days depending on it's complexity. As part of the design we can also provide a scope of work you can provide to an installing contractor to obtain installation quotes. Information we will require include:

- Floor plan layout of facility including indication of location of major structural elements, fans, support columns and dimensions (Note detailed blueprints are not necessary, just a to-scale drawing in a 8.5 X 11 format)
- Fan motor horsepower(s), voltage, approximate age, is it inverter rated (on metal label on motor), also if the fan is an exhaust or supply fan. Also note if the fan uses a dedicated ventilation shaft or shares a shaft with other fans.
- Typical operating occupancy schedule of the garage for a 7 day period
- Electrical utility rates in $/kWh, and demand charges the facility may be paying. You can also provide a sample electrical bill for your facility and we can figure this out. It is best if we see a bill for a summer and a winter month. Also please let us know who your electrical utility is.
- Identification if a existing CO system is being replaced, and if so the make and model numbers. We often replace non-working systems, or upgrade systems to operate fans on VFD control. In many cases existing conduit can be used.
- Are the floors of the garage constructed of pre-stressed, or post-tension concrete (this is very important).

AirTest Case Study 4

Wilshire-Rodeo

Parking Sq Ft	202,500 sq ft
Fan HP	135 hp
AirTest Sensors	26
System Cost	$86,420
$ Saving	$93,772
$ Savings/Sensor	$3,324
KW Saving	669,800
Payback (years)	0.92
Rebate @ $0.16/kW	$93,772
Total User Cost	$0
Payback W Rebate	Immediate
Greenhouse Savings	899,540 lbs CO2

AirTest Case Study 5

First Federal Bank

Parking Sq Ft	218,500 sq ft
Fan HP	160 hp
AirTest Sensors	30
System Cost	$100,498
$ Saving	$34,000
$ Savings/Sensor	$3,350
KW Saving	242,857
Payback (years)	2.96
Rebate @ $0.16/kW	$50,249
Total User Cost	$50,249
Payback W Rebate	1.5
Greenhouse Savings	326,150 lbs CO2

AirTest Case Study 6

Westwood Plaza

Parking Sq Ft	140,000 sq ft
Fan HP	30 hp
AirTest Sensors	26
System Cost	$24,450
$ Saving	$16,969
$ Savings/Sensor	$940
KW Saving	121,207
Payback (years)	1.44
Rebate @ $0.16/kW	$16,969
Total User Cost	$7,481
Payback W Rebate	0.4
Greenhouse Savings	162,780 lbs CO2

5. AirTest Gas Sensing Solutions

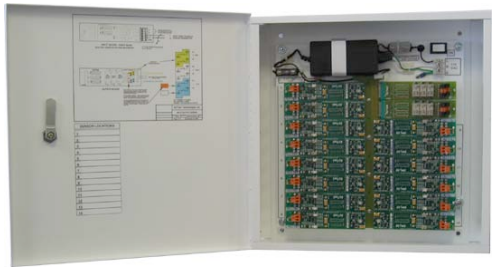
AirTest has a broad range of cost effective gas measurement and control solutions available for parking garage applications. A summary of our offering is provided below. You can also visit our web site to see all these products. Datasheets and installation manuals are also available on the web site as well as a variety of application articles.

Website: http://www.airtesttechnologies.com/product/parking/index.html

Integrated Sensor & Control Products	
	***CT1000 Single Gas Controller*** The CT1000 combines a solid state CO sensor with a control package that provides three user adjustable, 5A relay activations for low, high and fault indication. Also has adjustable on time delay to prevent short cycling of fans. Multiple units can be daisy chained. Options for 24VAC, 110VAC and 220VAC power. Ideal for small scale projects.
	***CT2100 Dual Gas Controller*** The CT2100 combines the ability to measure and control for two gases in a single control package. It features a high and low 10A relay activation as well as a separate relay for fault indication. The CT2100 also has an adjustable on time delay to prevent short cycling of fans. Can be used with all AirTest gas sensors. Multiple units can be daisy chained.
Gas Transmitters	
	***TR2000 – Carbon Monoxide CO Transmitter*** The TR2000 is a cost effective, long life (5 year), highly accurate electrochemical sensor that is CO specific and immune to interference from other gases including humidity and temperature. Loop powered (4-20 mA output) and LonWorks® versions available. Low cost, plug-in replacement sensor elements are available. Fits in standard single gang receptacle (included). Impact resistant plastic. Ideal for integration with VFD's or BMS systems.
	***TR3210 – Nitrogen Dioxide (NO_2) Transmitter*** The TR3210 is an electrochemical sensor that can reliably measure the low levels of nitrogen dioxide typically required for parking applications. Loop powered (4-20 mA output) and LonWorks® versions available. 18-24 month life. Low cost, plug-in replacement sensor elements available. Fits in standard single gang receptacle (included). Impact resistant plastic. Ideal for integration with VFD's or BMS systems.
	***TR5200 – Combustible Gas Transmitter*** The TR5200 is a highly accurate catalytic bead combustion sensor that can be factory tuned to a variety of combustible gases including methane, natural gas, and propane. Measures LEL concentrations. Loop powered (4-20 mA output) and LonWorks® versions available. Unlike solid state sensors the catalytic bead sensor is sensitive only to combustible gases.
	***TR9223 – Carbon Dioxide (CO_2) Transmitter*** The TR9223 is a self-calibrating, infrared CO_2 sensor intended for the control of combustion related odors in enclosed vehicle facilities. Requires 24VAC power, provides 0-10V or 4-20 mA output. Relay option and LonWorks® output also available.

6. AirTest Control Panel Solutions

AirTest also offers stand-alone control panels that can be used to control one or more fans using a multiple of gas transmitter inputs.

CN9000 Control Panel	CN7216 VFD or On/Off Panel	CN8000 LonWorks® Panel
		
Key Features:		
• For use with AirTest 4-20 mA gas transmitters. Can accommodate two types of sensors e.g TR2000 CO and TR3210 NO2. • Total capacity of 36 inputs/outputs. Customized to user requiement. • Provides on/off control of fans (no time delays). • Each zone relay output includes: Fan On, High Level Alarm, Sensor Fault Indication. • Low voltage relay provided for fan switching. • Status LED's on inside of control panel indicate power, ventilation, alarm and fault for each sensor. • Steel Enclosure, CSA/UL Listed Components, 110VAC or 24 VAC.	• For use with AirTest 4-20 mA gas transmitters. • 2 to 16 outputs. Can accommodate up to two different types of AirTest Sensors. • Can control one zone with multiple fans either via on/off or variable speed drives (must specify when ordering). • Display inside panel indicates gas levels and allows numerous adjustments of the control system. Also simple to set up and troubleshoot.	• For use with AirTest LonWorks® gas sensors. • Custom configured for the customers application. • Two wire networked sensors simplify installation particularly for large jobs. All sensors are preprogrammed and the system is designed as plug and play. • Ideal for applications where there are more than 16 sensors and multiple control zones with VFDs. • Display outside panel indicates gas levels and allows numerous adjustments of the control system. Also simple to set up and troubleshoot.
Control Panel Options:		
• Strobe to indicate sensor or system fault • Horn to indicate high level concentration that indicate system failure	• Strobe to indicate sensor or system fault • Horn to indicate high level concentration that indicate system fault. • Phone dialer for high level alarm and system fault.	• Strobe to indicate sensor or system fault • Horn to indicate high level concentration that indicate system fault.

7. AirTest Variable Speed Drive (VFD) Solutions

AirTest can also provide the latest state-of-the art variable speed drives as part of your ventilation control system at a very affordable price. We offer Danfoss drives which are among the most technically advanced drives on the market today. If AirTest is putting together ventilation system for you to operates with VFDs, we can also provide a very competitive and broken out quote on the VFDs. Some of the options to think about when ordering VFDs are listed below. If you have questions about some of these options, AirTest can walk you through the best choices for you application.

- Fan(s) operating Voltage and Horsepower
- Enclosure type: NEMA 1 (Basic), NEMA 12 (Dust Proof), NEMA 3R (Waterproof/Outdoor)
- Electrical connection choices include:
    - Base unit
    - With integrated disconnect
    - With fused integrated disconnect
    - Electronically Controlled Bypass (ECB) with drive fusing and main disconnect
    - Electronically Controlled Bypass (ECB) with main fusing and disconnects (100kA SCCR)
    - Electro Mechanical Bypass (EMB) with drive fusing and main disconnect
    - Electro Mechanical Bypass with main fusing and disconnects (100kA SCCR)
- Extended warranty (standard warranty is 18 months)
- Factory authorized and certified startup is also available (highly recommended)

VFDs For Small Fans Are Now Economical

VFDs have become much less expensive and we are increasingly installing them on smaller fans to reduce energy, energy demand and fan noise. Even fans under 1 horsepower can benefit from use of an inexpensive VFD.

8. System Commissioning

When you purchase a ventilation control system from Airtest, we will also provide you with a commissioning checklist that you can use to ensure the system is all connected and operating properly. It even has a sign off line for your customer. It is important to note that all sensor provided by AirTest are factory calibrated and do not need startup calibration. However, we do recommend flowing gas of at least one concentration to each sensor at startup to verify sensor operation and its factory calibration.

9. System Maintenance

AirTest's ventilation control systems are designed for minimal maintenance. However due to the nature of the gas sensors used, periodic calibration checks, calibration or sensor replacement is recommended. Please check the datasheet for the sensors you are interested in for sensor life and calibration information. Airtest offers calibration kits for all gas sensors we offer. These kits include a zero and span calibration gas along with a flow regulator and fitting for the gas sensor you have. Replacement gas bottles are also available separately. Most sensors can be calibrated and adjusted with a zero and span gas in about 5 to 10 minutes. Calibration can be checked with a span gas in less than a minute.

If you would rather not go though the process of recalibration, we do also offer inexpensive factory reconditioned electronics with new sensors that are inexpensive and easy to replace. In most cases replacement involves undoing a few screws and reconnecting 2 to 4 wires. The whole process takes 2-4 minutes. Rather than recalibrating sensors you could just replace it. This process is ideal if you have limited manpower and time to ensure a technician understands how to properly calibrate the sensor.

TR2000 Factory Reconditioned Replacement Module

10. More Information

AirTest is here to assist you in planning and laying out your parking garage project regardless of whether it is new construction, retrofit or replacing a existing system with state of the art sensors, controls and VFDs. We can help put together a plan, budget and scope of work for installation. Our energy analysis will also allow you to present an accurate assessment of the payback and return on investment on the project. This can all take place in a few days. Regardless if you are a building owner or a contractor focused on helping customers save energy, AirTest can show you how to significantly reduce electrical use and energy demand charges.

For more information please contact one of AirTest's offices or one of our distributors.

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