AIRCUITY®
Creating Measurably Better Environments

# Aircuity Technical Paper

## Why Critical Building Systems Require the Use of Centralized Air Sampling Systems instead of Discrete Air Quality Monitors or Sensors

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# *Why Critical Building Systems Require the Use of Centralized Air Sampling*

## Overview

*There are many reasons why after 15 years of successful usage in over 1,000 installations, centralized air quality sensing via an air sampling system as provided by Aircuity is still the only system on the market that is being used in laboratory facilities and other critical applications. This is despite other technologies and companies having provided air quality monitoring for homes and offices for a similar time period. Critical applications have unique requirements that preclude the use of discrete sensors and systems. Some of the reasons for this are mentioned in the following points.*

## Purpose Built Architecture for Control Not Just IAQ Monitoring

The Aircuity system is a purpose built, centralized, multi parameter, demand based control solution designed to solve several problems and flaws with distributed discrete sensors. The system is successfully installed in tens of thousands of critical room environments world-wide dating back almost 15 years and its benefits, savings, and life cycle costs have been validated by some of the most notable and distinguished engineering firms and laboratory clients in the industry. The system was specifically designed to solve known reliability, accuracy, safety, and maintainability issues that would occur by using discrete sensors to not just monitor but to accurately and safely control airflow to save significant amounts of energy.

## Centralized Sensing Cancels Unsafe & Persistent Sensor Drift

One of the reasons that discrete sensing approaches will not work reliably in critical applications is due to pervasive sensor drift (offset errors) that are present in all gas and particle based sensors particularly when exposed to harsh environments. This drift in turn produces issues with reliability of energy savings performance, safety, and maintainability. To be safe and provide real air flow savings, the air flow monitoring and control solutions need to have very accurate and reliable differential TVOC, particulate, CO2, dewpoint, and sometimes CO sensing that will not be affected by the normal or sometimes abnormal levels of supply and return air contaminants. In other words, we need to measure the actual level of contaminants generated in the critical space, not those brought into the mechanical system via return air, since only the return air contaminants can be eliminated by dilution ventilation and more outside air.

Thus, to achieve safe and accurate control we must sense both the supply, return, and outside air contaminant concentrations and take the difference to determine the amount of contaminant in the return that is from internal contaminants.

As such if we were to use individual or discrete sensors it would need three sensors: one for the supply duct one for the return duct, and one for outside. However, each sensor will have its own drift error meaning that when the two sensor's signals are subtracted from each other the desired and small difference signal will by definition be in error by up to plus or minus twice the error of a single sensor. In fact, using two discrete sensors, differential signal errors such as those from

offset errors can easily exceed 100% resulting in either no energy savings or unsafe operation!

However, with the Aircuity system only one sensor is used to measure the supply, return, and outside air. Therefore, any offset errors of the sensor will be the same for both measurements since the error will not have changed in the up to 15 minutes between the supply air and room exhaust air measurements. Thus, when the supply and exhaust measurements are subtracted from each other to get the desired differential measurement signal, the offset drift errors cancel resulting in a highly accurate differential signal for accurate airflow control.

Both the unique need for highly accurate differential measurements as well as the also unique ability of a centralized air sampling system like the Aircuity system to provide accurate measurements despite omnipresent drift errors is just one critical reason why discrete sensors are not applicable for critical applications.

## Air Sampling Provides High Quality, Lab Grade Sensors Economically

In order to get an accurate and broad sampling of IEQ parameters, high quality TVOC and particulate sensors are needed. Importantly, these special sensors are not the ones generally used for home and commercial IAQ monitors since they are too expensive for these applications. Specifically, a Photoionization Detector (PID) type of TVOC Sensor is required to get consistent, repeatable, and accurate TVOC measurements covering a wide range of chemical compounds. On the other hand, home and commercial IAQ monitors use the much cheaper and much less accurate Metal Oxide Semiconductor (MOS) TVOC sensors. These sensors work by oxidation, in other words, as the sensors detect chemicals the sensor is oxidized, slowly destroying the sensing element and creating large amounts of sensor drift. In a home or commercial environment that is relatively free of chemical vapors, the sensors can last for several years before drift and sensor element degradation makes the sensor unusable for any application. However, in a critical application which will potentially see several hours a week of significant enough chemical vapor concentrations, these sensors will drift considerably and even fail in a year or less. As such the TVOC sensors used by IAQ monitor manufacturers may be inexpensive but they are totally inappropriate for use in critical environments.

Note that Aircuity does use MOS TVOC sensors in its systems in addition to the PID TVOC sensors but only as a minor backup sensor to measure some relatively large concentrations of a few specific compounds. However, even at that Aircuity would not be able to use these sensors without employing differential measurement with one centralized sensor as mentioned above to cancel out the large offset drift of these sensors and must swap them out every 6 months for a full recalibration. Even with these measures we still have to throw them away after 6 to 12 months.

Similarly, to accurately measure the small (less than 1 micron) smoke and aerosol particles that are a concern in critical environments, a very sensitive, clean room grade laser based particle counter is required. However, again these instruments are expensive and generally not needed for general non-life safety, commercial grade IAQ measurements. Therefore, IAQ monitor manufacturers use the cheaper light obscuration or commercial (not clean room grade) laser particle sensors that may be appropriate for PM2.5 and PM10 measurements but not for making accurate measurements of the smaller 0.3 to 1 micron particles seen from chemical smoke and aerosol vapors that are of specific health concerns.

To provide the quality of contaminant sensors required of critical applications would normally be quite expensive if a sensor was required for each space. However, the Aircuity system can multiplex the use of one sensor over up to 30 rooms reducing the number of sensors required by up to a factor of 30 times making even

relatively expensive sensors very affordable since only one or a few are required for typical control applications. Similarly, the costs of maintaining and replacing these sensors is reduced by thirty-fold.

## Only Aircuity Provides Sensor Calibration & Replacement Economically

Even with cancellation of offset drift, air quality sensors particularly those used in critical environments will drift slowly in other ways such as with gain or linearity changes. As such in our experience over the last 15 years we have found that we need to swap out the sensors every 6 months for a full cleaning, and traceable NIST (National Institute of Standards) calibration, and a checkup of the sensor's "health". We find that many of the sensor elements need to be replaced on a regular basis anywhere from every 6 months to a every few years. As mentioned earlier the MOS TVOC sensors for example will only last 6 months to a year in a typical critical environment. Even with the high quality PID TVOC sensors, the ionization lamps that are the core of these sensors are also only rated for 12 to 18 months of continuous use and therefore must be replaced regularly.

If Aircuity or anyone else tried to employ discreet sensors the cost to maintain these sensors to assure safe and reliable operation would potentially outstrip the operational savings of energy from the system. However, by again reducing the number of sensors that need to be maintained by up to a factor of 30 the cost to maintain and regularly replace the sensors in an Aircuity system is drastically reduced.

## Aircuity Reduces On-site Maintenance Costs Via Remote Sensing

The most safe and effective location for the detection of contaminants in a critical application is in the supply/return duct. This requirement for duct sensing creates a problem for discrete sensors since many of these units are not designed for sensing air in ducts and may actually require locating the entire sensor unit in the exhaust duct where it could easily be corroded and affected by contaminants. Calibration and maintenance of these sensors, that as mentioned above should be done at least every six months, becomes extremely difficult and invasive to operations potentially requiring shut downs while the duct is opened for sensor calibration or replacement. Even when duct mounted sensor probes are available, access to the duct work sensing location may be difficult.

This is not a problem with the Aircuity system since all the sensors are conveniently located in the Sensor Suite enclosure which is typically mounted in an equipment, utility, or mechanical room so access is easy and non-intrusive to operations. The only device mounted at the duct is a simple, totally passive air sampling probe which is used to pull a sample of air from the duct and does not have any items that need to be serviced.

## Air Sampling Improves Sensor Accuracy with Use of HEPA Filtration

One of the factors affecting sensor drift and accuracy is particle buildup in the sensors. The best solution to this is to provide HEPA grade air filtration of the air reaching the sensors (except of course for the particulate sensor!). Although this can be done with discrete sensors the cost of doing this is usually prohibitive and is typically not done with commercial grade sensors. However, since the Aircuity system can sense 30 rooms with only one sensor the cost of HEPA filtering the air reaching the sensor is drastically reduced making it economically possible. With only one filter per sensor suite being required, they can also be easily and economically replaced every six months when the sensors are replaced so the filter will not get clogged up over time.

## About Aircuity

Aircuity is the 20-year leader in optimizing ventilation through its patented indoor air quality (IAQ) platform, improving the air quality for occupants. As a result, commercial, institutional and lab building owners can enhance occupant health, improve employee productivity, lower operating costs, and verifiably reduce energy use by as much as 60 percent.

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aircuity.com • info@aircuity.com