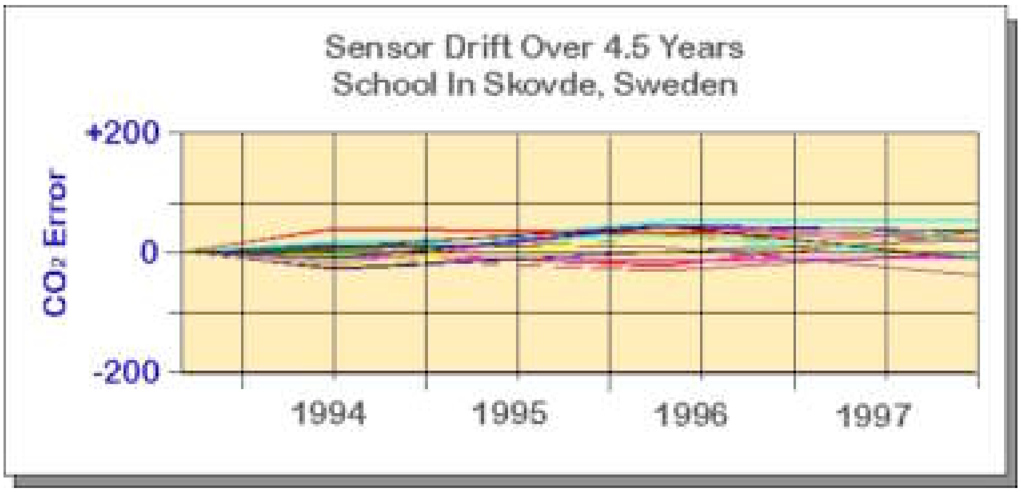
The AirTest Self Calibration CO_2 Sensor Algorithm Explained

Overview

The self-calibration algorithm used in all AirTest CO_2 sensors targeted for ventilation control in buildings has been used extensively since 1993. This algorithm is called "ABC", which stands for Automatic Background Calibration. The figure below shows the initial use of the ABC algorithm by 32 sensors installed in a school in Sweden. For a period of 4.5 years, the sensors where checked every 6 months by flowing a known concentration of CO_2 to each sensor. As the chart shows all the sensors remained within 50 ppm of the known value over the evaluation period (±50 ppm is equivalent to approximately ±0.5 cfm per person of ventilation).

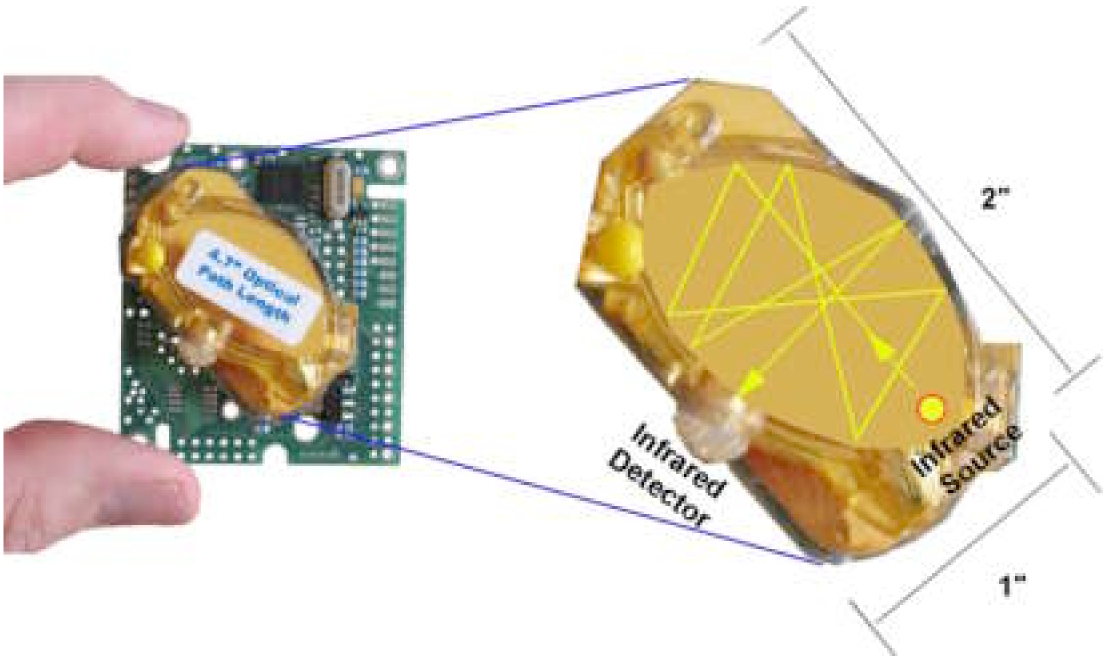


Background On Sensor Drift

All sensors experience drift of some sort. In the case of infrared sensors like the CO_2 sensors offered by AirTest the drift is known to affect only the zero baseline of the calibration curve. This means that the basic sensor will always accurately measure the increments between ppm levels, but the zero point or baseline of the measurement may shift over time. In other words the sensor will always accurately indicate a difference of say 100 ppm in concentrations but base line drift may result in the sensor reading slightly higher or lower than it's original calibration. For example a hand held sensor may indicate outside levels of 400 ppm and inside levels of 900 ppm, a difference of 500 ppm. If the sensor experienced baseline drift of say 50 ppm, outside levels would then be 450 ppm and inside levels would be 950 ppm. Even with baseline drift the sensor would still indicate a difference of 500 ppm. The self-calibration algorithm in the sensor corrects for this baseline shift.

Drift can be caused by many factors depending on the design of the sensor and the components used in assembly of the sensor. The AirTest product integrates carefully selected components that minimize electronic, mechanical and environmental effects on the CO_2 measurement that might cause drift. Inside the sensor durable gold plating is used to ensure a consistent reflective surface over time regardless of environmental effects. Non-gold surfaces, like aluminum, or nickel may tarnish or oxidize over time causing drift through a change in optical characteristics of the sensor.

One of the most critical components of the sensor is the infrared light source used. In most well designed infrared gas sensors, built using consistent quality practices (e.g. ISO-9001 procedures), the light source can be the greatest contributor to sensor drift. As the light source ages, its light output will change and affect sensor accuracy. As part of the ISO-9001 procedure used in the manufacture of the AirTest sensor, infrared source vendors have been carefully selected, incoming products are screened and checked and all light sources are burned in for at least 30 days before they are assembled into a CO_2 sensor. Using these procedures, aging-related changes in lamp output can be minimized but not totally eliminated.



Oval Design Provides Extended Optical Path Length

Using an optical assembly that ensures a strong signal-to-noise ratio also reduces the effect of changes in lamp output on sensor drift. Basically this means that small changes in the system, such as a minor change in light output, will have a small affect on the accuracy of the entire measurement system. This is achieved through of the folded path optical design used in the AirTest sensor (See illustration above). By allowing the light to bounce around many times in the optical sensor an extended sampling path can be compressed into a small package. For example, the small oval optical sensor used on the AirTest CO_2 sensor measures less than 1" by 2" yet it can travel a path through 4.7 inches of CO_2 before it reaches the detector. This offers a significant benefit over traditional straight path sensors (e.g. Telaire, Vaisala) where sampling length is limited by the physical size of package (e.g. wall mount case) it must fit in. For more information on this you can refer to:

http://www.airtest.ca/docs/article/lengthmatters.pdf

How The AirTest Self Calibration Algorithm Works

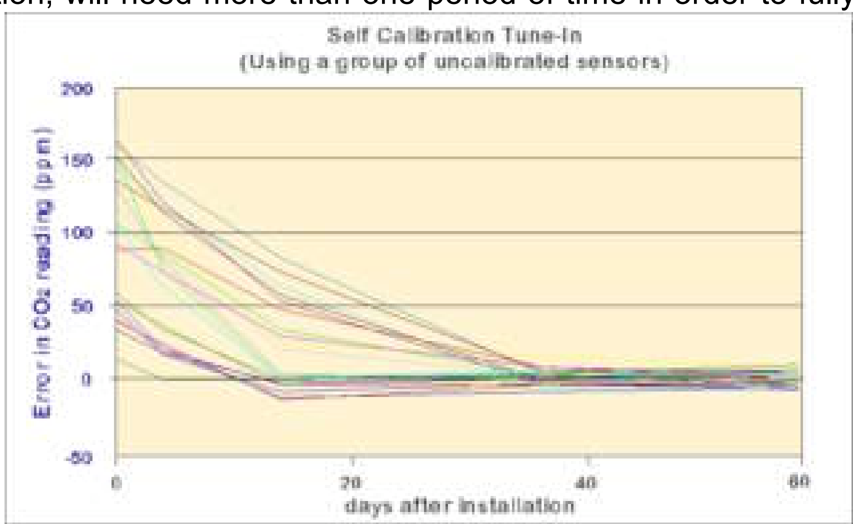
AirTest's CO_2 sensors for fixed installation are factory calibrated and maintenance free. They do not require any further calibration when used in normal indoor air applications. This algorithm takes advantage of the fact that CO_2 levels in buildings when unoccupied on weekday evenings, or weekends will drop to outside baseline levels (typically around 400 ppm). Outside levels tend to be fairly constant year round.

Long-term sensor drift is eliminated by a digital, intelligent, "low-pass filter", named the ABC algorithm (Automatic Baseline Correction), with configurable time constants ranging from hours to years. This filtering takes place in two steps, before it acts on the zero calibration constants:

The first step is a constant search for the lowest CO_2 value ever found during a period called *ABC_PERIOD.* The lowest reading is stored as the *ABC_SAMPLE.* At the start of a new evaluation period, an *ABC_RESET* is performed.

The second step is when the *ABC_PERIOD* has expired (7.5 days by default). At that time a sensor probe rescaling is performed based on the input *ABC _ SAMPLE,* and the expected background fresh air CO_2 concentration (assumed to be 400 ppm by default).

Following step #2, the sensor calibration is updated accordingly, restricted by a stabilizing procedure limiting the maximum allowed rate of change by the constant *ABC LIMIT* (by default around 25 ppm/week). In this way anomalous events cannot destroy a proper calibrated sensor. On the other hand, any sensor damaged for instance due to bad handling or transportation, will need more than one period of time in order to fully recover. *The figure below* shows a number of sensors that were intentionally mis-calibrated and then installed in a normal office space. As the sensors were exposed to normal evening and weekend baseline levels for a number of days the sensors gradually adjusted their calibration to all achieve the baseline concentration.



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What If Outside/Background Levels Are Greater than 400 ppm?

In some areas, outside levels may be somewhat higher or lower than the 400 ppm assumed by the self-calibration algorithm. This does not mean that the sensor will be inaccurate for ventilation control. CO_2 based ventilation control is based on measuring the difference between inside and outside concentrations. The 400 ppm assumption provides a baseline for comparison. It really does not matter if the absolute outside concentration is 450, the sensor will still accurately measure the difference in ppm's between inside and outside concentrations. The absolute level of CO_2 may matter for some laboratory applications but for ventilation control accurately knowing the difference between the baseline period and the occupied period is enough to provide adequate ventilation control. This algorithm has the same effect as placing a sensor outside to constantly measure the difference between inside and outside CO_2 concentrations.

Ensuring Optimum Operation

ASHRAE Standard 62 recommends that building owners provide a pre-occupancy purge of spaces, to ventilate out contaminants that may have built up over an evening or weekend shutdown period. This practice will also ensure that the sensor always sees the true baseline level in the space. In this case good engineering practice ensures good air quality and a calibrated sensor for ventilation control.

How Long Will The Sensor Maintain Calibration

The sensor will maintain calibration as long as it sees a background level of CO_2 on a periodic basis. The electronics and components in the sensor are rated for a minimum rated 15-year life. The sensor should maintain calibration over its working life.

What If A Space Is Occupied 24 Hours Per Day?

If a space is constantly occupied and there are not periods where outside levels drop to background levels then the ABC algorithm will not work. This is also the case for greenhouse or other agricultural applications where CO_2 levels may be elevated at all times.

For these type of applications user should request that the ABC self-calibration algorithm be deactivated. Without ABC operating the sensor should be calibrated every two to three years. Calibration is a simple process where nitrogen is flowed to the sensor for approximately five minutes at which time a button on the sensor is pressed or the sensor automatically recognizes it is in calibration mode and adjusts itself. Contact AirTest for more information on non-ABC calibration options.

For More Information Contact:

For CO_2 Sensor Engineering Spec: http://www.airtest.ca/docs/co2/co2spec.zip

AirTest Technologies Inc.
888 855-8880
www.AirTestTechnologies.com
info@AirTesttechnologies.com