Application Note

ABCLogic Self Calibration Feature

Introduction

Use of CO_2 to control ventilation is one of the fastest growing areas in building control.
A primary reason for this growth is that the technology has now matured to the point where it is inexpensive, easy to use and reliable.
AP leads this trend with a number of unique innovations in its sensor design.

This article explains a key patented feature of the technology called **ABCLogic** that enables CO_2 sensors to automatically calibrate themselves once installed in the field.
This feature eliminates one of the biggest concerns surrounding CO_2 sensing… sensor drift and maintenance. **ABCLogic** is a standard feature of all AP:s commercial CO2 transmitters.
All sensors with **ABCLogic** have a Lifetime Calibration Guarantee where AP will provide a free factory calibration for the sensor if it is found to be out of calibration.

Virtually all gas sensors are subject to some sort of drift.
The degree of drift is partially dependent on the use of quality components and good design.
But even with good components and excellent design a small amount of drift can still occur in the sensor that may ultimately result in the need for a sensor to be recalibrated.

Generally, recalibration involves a maintenance person visiting each sensor in a building and performing a 5 minute to 20 minute recalibration routine using gas bottles and plastic tubing.
The calibration process is simple but it can turn into a significant expense if recalibration is required frequently.
If the wrong choice of sensors is made, the expense of sensor maintenance may wipe out any potential energy savings that could come from CO2 based demand controlled ventilation.

Approximately 15 years ago, the CO_2 sensors developed and patented the concept of a self-calibrating sensor.
The first products manufactured with this feature are still working in the field today and accurately measuring CO2.
Most of these sensors have never been field calibrated.

What Causes Sensor Drift

As discussed before, sensor design and components have a lot to do with drift.
At AP our experience with building five generations of sensors for over ten years has allowed us to select the components and refine the design so that the primary contributor to sensor drift is the normal and unavoidable aging of the infrared light source within the sensor.

In the AP sensor the natural drift of the sensor is very gradual at a few ppm per month with the greatest drift occurring in the first few months of operation.
This drift can be up or down.
AP:s self-calibration feature called **ABCLogic** is designed to correct all sensor drift including aging of the light source.

How It Works

Outside levels of CO_2 are generally very low at around 400 to 500 ppm.
Inside buildings people are the major source of CO_2.
When a building is unoccupied for 4 to 8 hours CO_2 levels will tend to drop to outside background levels.

This is especially the case if the building operational schedule includes a pre-occupancy purge of fresh air into the building prior to the start of the day.
ABCLogic which stands for "Automatic Background Calibration" utilizes the computing power in the sensor's on-board microprocessor to remember the lowest CO_2 concentration that takes place every 24 hours.
The sensor assumes this low point is at outside levels.

The sensor is also smart enough to discount periodic elevated readings that might occur if for example a space was used 24 hours per day over a few days.
Once the sensor has collected 14 days worth of low concentration points it performs a statistical analysis to see if there has been any small changes in the sensor reading over background levels that could be attributable to sensor drift.

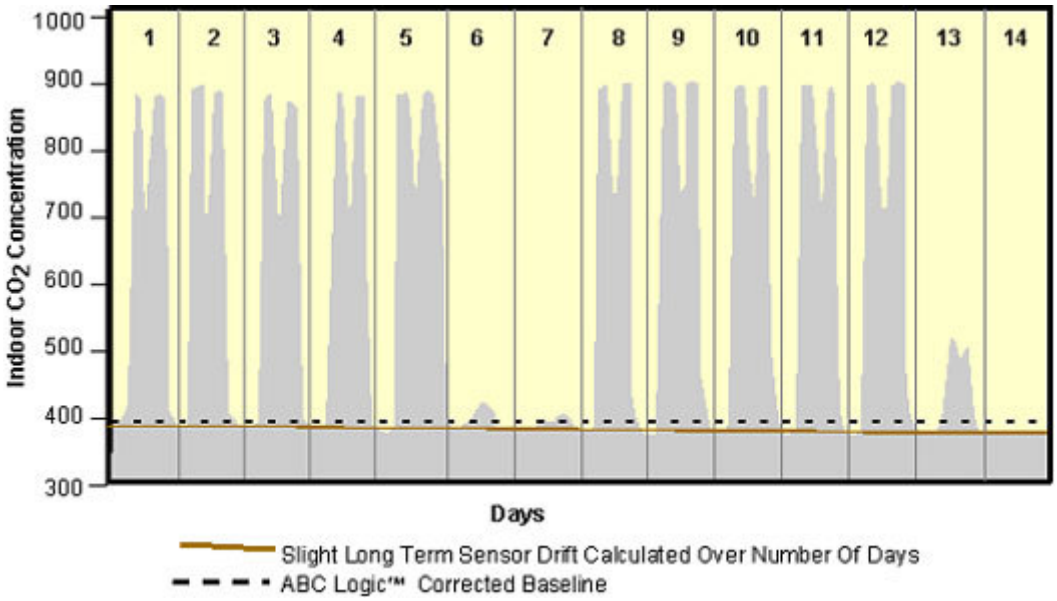
If the analysis concludes there is drift, a small correction factor is made to the sensor calibration to adjust for this change.

The figure below shows CO_2 concentrations as they might occur over 14 days in an office space with peak concentrations occurring in the morning and afternoon of each day.

The dotted line is drawn through all the low points for each day as compared to an assumed background of 400 ppm.

If a statistically relevant change in the data shows a shift above or below background, a slight adjustment is made to sensor calibration as shown by the solid level line.

Every day the sensor looks at the past 14 days worth of data and determines if a calibration adjustment is necessary.
A similar type of approach of nightly calibrations is often used for other HVAC equipment such as VAV boxes.



Measuring Inside-Outside Differential

When using CO_2 to measure and control for ventilation it is most important to consider not the absolute ppm levels but the differential concentration between inside and outside concentrations.
In general terms the higher the differential the lower the ventilation rate.

One of the additional benefits of **ABCLogic** is that the sensor is calibrated to outside levels without having the expense and trouble of placing a sensor in the outside air.
The sensor assumes that the lowest level is 400 ppm.

Any readings above this level are related to the differential.

Applications for ABCLogic

It is important to note that **ABCLogic** is designed for use in applications where spaces are periodically unoccupied for 4 hours per day or more so that indoor concentrations can drop down to typical outside levels.
Use of a pre or post occupancy ventilation purge is recommended as a good engineering practice to deliver proper air quality and can help ensure that the space regularly reaches background conditions.

If a purge is not used it is recommend that the occupancy schedule for the building operate the HVAC system for an hour or so after normal occupancy ends to allow for CO_2 levels to be reduced to background.
Some building operators may also want to use CO_2 as the control parameter for activating the system.

If a AP sensor is being applied in a application that is unlikely to see regular background levels of CO_2 then the **ABCLogic** feature should be deactivated.
The manual that comes with the AP sensor explains how this can be accomplished.
For these applications AP recommends using a Industrial type CDI 24 hours dual beam sensor that uses another slightly more expensive method of maintaining long-term calibration.

Commissioning Sensors with ABCLogic

When first installed CO_2 sensors with **ABCLogic**, the sensors will use the first 14 days of operation to calibrate themselves to local background levels.

Installers or building operators should not be concerned if readings on the sensors appear unusually high or low or if a lack of agreement between sensors is found.

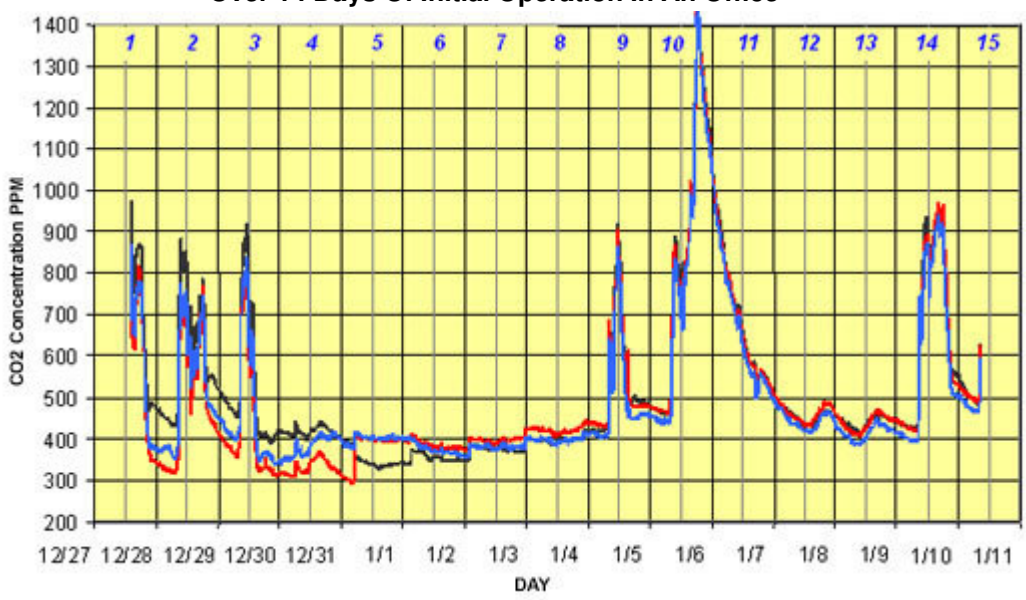
The sensor you receive from AP has gone through a complete quality check and has received a factory calibration that has verified the sensor is working properly.

Each sensor will calibrate itself to its environment over the first 14 days of operation.
Reasons that sensors in the same building may read differently immediately after installation include:

- Concentrations in each space may be different
- The installer may be blowing into the sensor while working with it
- If a sensor is dropped or jarred in shipment a slight shift in the original factory calibration may occur. **ABCLogic** will correct this shift in 14 days.

The graph below shows the behavior of three AP CO_2 sensors with **ABCLogic** installed in the same space over their first 14 days of operation.
As can be seen in the initial few days the sensor readings where at times quite different and in some cases over 100 ppm apart.
However, by the 10th day all sensors agreed very closely in their readings.
This graph is typical of the behavior of all APsensors that utilize **ABCLogic**.

Readings Of Three Sensors With ABCLogic
Over 14 Days Of Initial Operation In An Office



Long Term Performance of ABCLogic

AP has also conducted long term tests of CO_2 sensors with **ABCLogic**.

The graph below shows almost three years of testing where a gas of a known concentration (980 ppm) was flowed to sensors operating in the ambient air of AP:s test lab.

This test was performed every 7 to 15 days.

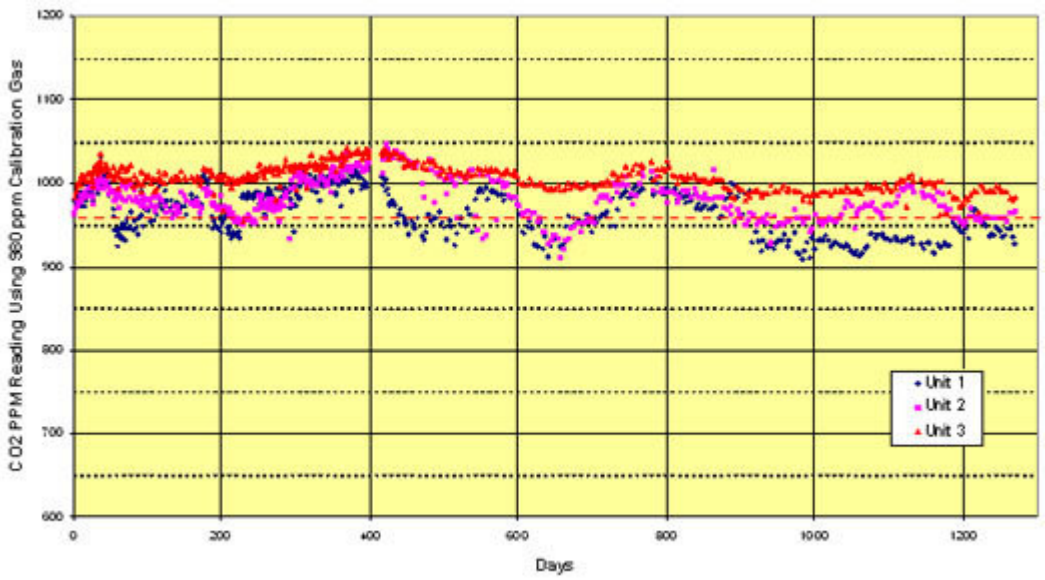
As can be seen from the data, all sensors have maintained calibration relative to a reference gas to well within the ± 75 ppm specification of the sensor throughout the duration of the test period.

This long term testing provides fundamental proof that **ABCLogic** can eliminate the need for calibration over extended periods of time.

Now AP introduce a first in CO_2 sensing, a Lifetime Calibration Guarantee.

Further testing has now confirmed that **ABCLogic** should be able to maintain sensor calibration over the lifetime of the sensor (typically 15 years).

Long Term Calibration Verification Of 3 Sensors With ABCLogic



Lifetime Calibration Guarantee

Based on the results of years of testing of **ABCLogic**, AP now offers a Lifetime Calibration Guarantee on all its CD Commercial wall and duct mount sensors used for CO_2 based ventilation control when operated in an environment that can utilize **ABCLogic**.

If the sensor is found to be out of calibration more than 150 ppm as compared to a calibration gas or recently calibrated reference, AP will provide a free factory calibration of the sensor if returned to AP.

This guarantee only applies if the sensor is operated in an environment where inside levels periodically drop to outside concentrations (i.e. during evenings or weekends when there is no occupancy) as is required by **ABCLogic**.

If a space does not experience a periodic drop to outside levels (e.g. where occupancy is 24 hours, 7 days/week), **ABCLogic** should be deactivated off.

With **ABCLogic** turned deactivated (via keypad or software interface), calibration may be required every 2 to 3 years.