# TN-150 TECHNICAL NOTE

# PPBRAE CALIBRATION AND INTERPRETION OF READINGS

## Introduction:

The ppbRAE parts per billion (ppb) Volatile Organic Compound (VOC) Monitor (Model PGM-7240) is the most sensitive Photo-ionization Detector (PID) on the market. The ppbRAE is a broadband detector, and is able to measure a few ppb of VOCs in real-time. Our patented dual-channel sensor and high intensity ultraviolet (UV) lamp make the ppb-level detection practical.

## Dual Channel Sensors Make a Difference

The dual-channel sensor is the most unique design of ppbRAE. Both channels of the sensor are positioned in front of the UV lamp window within the ionization chamber. As VOCs pass by the lamp, they are photo-ionized and the ejected electrons are detected as a current. The first channel current measures only the ionized gases. The second channel measures the same ionized gases, plus a current caused by photo-emission of electrons from the sensor itself. The difference between these two channels gives a signal that is proportional to the UV light intensity. A span gain adjustment is then made to compensate for light variation. Typical factors that cause light intensity to change include short-term lamp fluctuations, long-term lamp aging, dirt accumulation, and UV blocking compounds entering the sensor, such as water vapor and methane. For example, 4% by volume methane reduces the PID response in half on a standard single-channel sensor.

Without the dual-channel sensor, the variations caused by these factors may overwhelm the signal of VOCs at ppb levels.

## Zero and Span Calibration

The ppbRAE requires a supply of ultra-clean air to Zero the sensor. During the zeroing operation, the unit both establishes the zero point for the sensor and measures the lamp intensity for later compensation of lamp drift. The best source of "ultra zero" air is from commercial cylinders with a specification of <50 ppb methane or ethane and <10 ppb of other VOCs (hydrocarbons). Charcoal filters remove most of the VOCs, but cannot guarantee scrubbing of all detectable VOCs, especially when an 11.7 eV lamp is used. The offset and variation of the zero air can be neglected for monitors working at the parts per million (ppm) level, but is very significant if the instrument works down to ppb level. The gas should be supplied directly from the cylinder using the open cup or Tee method. Avoid Tedlar bags or more than a few inches of plastic tubing, as these may contaminate the air with trace amounts of VOCs. A charcoal filter in front of the ppbRAE inlet is the next best alternative if a cylinder of clean air is not available. Outdoor air is another alternative, as it usually contai[illegible] VOCs than in indoor air.

A source of 10 ppm isobutylene is connected to the ppbRAE inlet for the span calibration. Preferably the gas is supplied from a Tedlar bag or of cup or "Tee" to avoid pressure differences. After both zero and span calibration, the ppbRAE is ready for use.

## Why the Ambient Reading Is Not Zero

"Clean" ambient air typically contains a few hundred ppb of VOCs and other UV-ionizable compounds. Therefore, one should not expect a zero reading in ambient air. After connecting a charcoal filter, the reading should drop to less then 100 ppb. By contrast, in a ppm level PID, the ambient is often assumed to be zero during calibration and the normal meter reading means the increase in the gas concentration above this zero reference. For example, if calibrated in an ambient air containing 200 ppb VOC, existing ppm level PID monitors will set 200 ppb as "zero" and all subsequent readings will subtract this 200 ppb from the baseline. Therefore, after a zero calibration, the ambient air usually will read 0.0 ppm. The ppbRAE uses purified zero air as the zero reference (i.e. baseline ). Therefore, even after zero calibration, the ambient may still read a few hundred ppb because the ambient reading is not subtracted during normal readings.

## How To See Incremental Concentration Changes

The "non-zero" ambient reading may be confusing and misleading during normal operation. In ppbRAE, users have an option to read the real-time data as an incremental value from the background reading. The number shown on ppbRAE will be the amount detected, minus the background when the "Cancel Background" feature is selected. A superscript "+" flashes in the measurement display to indicate that the background is cancelled. The background can be reinstated when the "Show Background" is activated. It should be noted that this feature of the "Cancel/Show Background" applies to the display only. The datalog function continues to record values that include the background whether or not it is shown in the instantaneous reading display. This feature will allow the user to see clearly the incremental change of gas concentrations above the ambient background level.

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## Comparing the Readings From Unit To Unit

It is easy to check if the ppbRAE after calibration reads correctly in the ppm range. In the presence of a known concentration of detectable gases, the ppbRAE should display within a specified accuracy of ±20 ppb or ±10% of readings, whichever is greater. For example, the ppbRAE should read between 9 ppm and 11 ppm if a cylinder of 10 ppm isobutylene is used. However, it is more difficult to obtain a consistent ppb level signal for evaluation because no standards are commercially available. The concentration of ambient air varies from area to area, and fluctuates from time to time. Using a charcoal filter is a simple method of generating a fixed concentration of gases at low ppb level (see Figure 3 below). All ppbRAE's you have should read within ±20 ppb if the ambient air passes through the same charcoal filter. For example, with the same charcoal filter and ambient air, units A and B read 80 ppb and 70 ppb, respectively. Therefore, they meet the specification of less than +/-20 ppb error.

## Sample Measurements

The data shown below represent typical performance of ppbRAEs, and should not be treated as the specification.

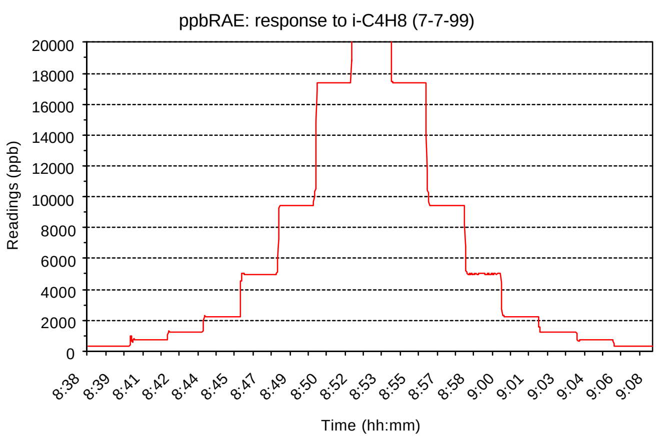


Figure 1 shows the ppbRAE response to various concentrations of isobutylene in increasing and decreasing staircase steps of each concentration for two minutes. The response and recovery time of 90% changes is less than 5 seconds. All measurements are accurate and repeatable within the specification whether switching the gas from low to high concentration or vice versa.

Figure 2 shows that the ppbRAE gives a linear response in the range of 10 ppb to 200 ppm. The ppbRAE was zeroed with a charcoal filter and calibrated with 10 ppm isobutylene diluted from a cylinder of 200 ppm. Various concentrations of isobutylene were diluted from the same setup and cylinder. It should be noted that if different cylinders were used, differences in background impurities from cylinder to cylinder could cause a significant error in this kind of ppb level measurement. Inter-connecting tubing and Tedlar bags can also contribute significant error due to absorption at low ppb levels or release of plasticizers or previously adsorbed compounds. The user needs to be extremely cautious to avoid contamination when experimenting at low ppb levels. An accurate and clean gas distribution and dilution system is recommended when performing this type of evaluation.

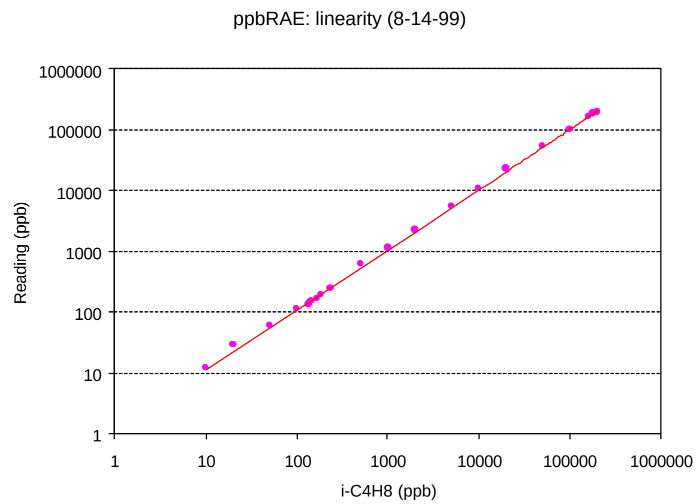


Figure 3 shows the stability of two ppbRAE units continuously running in ambient air for 24 hours. The ambient air has VOCs fluctuating between 150 ppb and 200 ppb, as shown in the upper curve. With charcoal filtering, the reading is very stable, for example 65 ± 5 ppb, as shown in the lower curve.