

MiniPID 2 HS Sensor Deployment Guidelines



Introduction

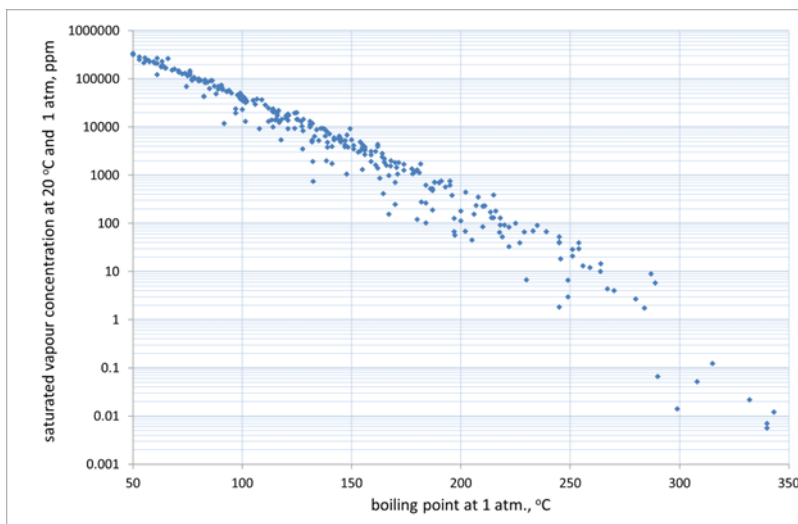
Photoionisation detection (PID) sensors enable measurements of a wide range of organic volatiles in air at concentrations ranging from parts per billion to low percentages. The full range of the HS MiniPID sensor is only 3000 ppb (3 ppm) isobutylene. Isobutylene is universally used as a PID calibration gas. In this document unspecified PID responses in ppb refer to an ppb isobutylene equivalent response calculated by frequent calibration of sensors with 2 ppm isobutylene.

PID responses greater than ~3000 ppb cause a saturated HS MiniPID signal. VOC readings >3000 ppb can be expected in some commonly encountered environments, for example:

- Near heavy traffic, exacerbated by weather conditions or roadway architecture (eg urban canyons), and at sites of unsealed refuelling and fuel spillage (eg station forecourts).
- In industrial facilities where volatiles are routinely used in coatings and paint preparations, or as a solvent.
- In clean rooms and heavily conditioned or refrigerated environments where volatiles accumulate due to low air turnover.
- In unventillated rooms and enclosed spaces where VOC's have been allowed to accumulate.
- In domestic environments on occasion of heavy release of volatiles, such as from paints and varnishes, use of certain cleaning fluids or during cooking.

By contrast, clean rural air delivers a PID response of less than 100 ppb. In reasonably ventilated interior spaces at 20 to 25 oC (68 to 77 o F), 200 to 400 ppb is typical. However, these ambient levels increase significantly in the absence of ventilation and at higher temperatures.

The problem of semi-volatile compounds and VOC outgas



The maximum concentration of an organic volatile in ambient air – its saturated vapour - at room temperature decreases with boiling point, as shown in the graph. Many authorities define VOCs as having boiling points lower than 250 °C, 482 °F. As can be seen from the graph, for VOC's higher boiling points, saturated vapour concentrations tend to fall off. This is due to them forming particulates in air. However, compounds of boiling point 250 °C, have a saturated vapour concentration of 2 to 40 ppm in air. So headspace vapour from these compounds would all saturate the MiniPID HS!

We shall refer to compounds of higher boiling point than 250 °C as semivolatiles. Examples of semivolatiles are plasticisers, machining oils, lubricants, components of varnishes and rosins.

Semivolatiles are ubiquitous in ambient air, not least as they volatilise relatively slowly. If the liquids are spilt or condense on a porous or VOC permeable surface, they may take many weeks or even years to completely volatilise. Semivolatiles are also prone to chromatographic retention on solid surfaces. Therefore, PID response to semivolatiles is slow and often apparent as sensor drift. The vapour pressure of any VOC approximately doubles between 20 and 30 °C, and often the sensor drift is therefore seen to closely follow diurnal changes in temperature.

A related issue is VOC content of VOC permeable plastics and coatings. The outgas of VOC's can be very slow, especially from permeable materials that are confined by non-permeable materials, such as occurs when a conformal coating is sprayed as a solution in xylene over a heavily populated printed circuit board. As the xylene volatilises, the remaining xylene is contained in coating within increasingly constrained spaces, causing very slow and prolonged outgas. Outgas of VOCs from permeable materials increases with temperature and is often difficult to distinguish from desorption of condensed semivolatiles as described above. Determination of these effects is often frustrated by the fact that at increased

temperatures, environmental outgas also increases with temperature at much the same rate.

Detector design considerations

From the forgoing considerations it will be clear that detectors containing the sensitive MiniPID HS must be carefully designed so as to prevent the detector from 'sensing itself', especially when the sensor is warm. To avoid this, ensure the sensor is pneumatically isolated from the detector interior. An encapsulated oring which makes a seal around the perimeter of the top face of the sensor is advantageous.

If the MiniPID HS is deployed in a wall mountable detector to sample air under *diffusive* sample gas flow, the sensor is ideally placed as far from the wall mountings as possible, to minimise condensation phenomena caused by the air vs wall temperature disparity. The sensor should be pointing downwards or sideways. Housing for the sensor is preferably made from a metal such as stainless steel or aluminium. The sensor should be maximally exposed to the air as possible. Metallic grids and other protection of the sensor, if deemed essential, should be deployed in the knowledge that they will prolong the response time *and the clear down* of the sensor. Barriers, and housing that in any way encapsulates the sensor will tend to suppress any thermal gradient between the sensor gas inlet and front of the housing. This has deleterious consequences. First, it will suppress convective gas

currents that carry gas from the ambient atmosphere to the sensor mouth – increasing the diffusive path length and hence response time of the sensor. Second, as a consequence of lower convective flow, the effect of any prevailing contamination of the sensor will be less diluted, and more severe.

If the MiniPID HS is deployed in a detector, wall mounted or otherwise, subject to an *impressed* sample gas flow, use gas conduit of minimal VOC permeability. Again, the sensor housing should be preferably made from a metal or low permeability plastic. Gas is best introduced from conduit directed towards the sensor’s gas inlet face. We have found an impressed flow of 100 mL/min is desirable for free fitting sensor housing. As above, an encapsulated oring which pneumatically isolates the gas enclosure is essential, allowing for lower sample flow. However <30 mL/min is not recommended. Flows higher than 200 mL/min are preferentially directed across the gas sensor to lessen gas turbulence which would results in a noisy sensor signal. Exhaust from the gas enclosure should be sufficient to prevent back diffusion of gases

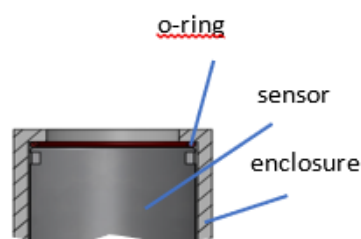
Manufacturing considerations

VOC free sub-components for high sensitivity PID detection should be stored in a VOC free environment, preferably a glass enclosure. Avoid any plastics that are permeable to VOC’s.

Before assembly, components liable to carry semivolatiles (machine oils, mineral oil, slip reagents, etc) should be thoroughly cleaned in a ultrasonic bath containing a suitable light solvent. Dry thoroughly after cleaning. Use a few small aliquots of solvent to ensure maximal cleaning for minimal solvent. After cleaning, store compounds in a VOC free environment.

Components which are subject to uptake of lighter volatiles during cleaning, or other critical steps such as soldering, conformal coating or degreasing should be

which effect the test gas response. The entire pneumatic arrangement should be such as to avoid a pressure in the gas enclosure of >10 mbar more negative than ambient pressure. By placing a pump upstream of a sensor, the gas sensing enclosure can be caused to be at a positive pressure relative to ambient, which is preferable in the event of significant pneumatic leaks, but often introduces VOCs into the test gas stream caused by VOC permeable pump internals.



baked out before assembly. Bake out times depend on the ease of VOC outgas and the outgas temperature. As a rule of thumb, outgas time can be halved for each 10 degC increase in temperature. After conformal coating of PCB’s, at least 60 hr at 70 oC is recommended before incorporation of the PCB into the detector assembly. Outgassed volatiles such as xylene need to be purged from ovens if they are present at concentrations exceeding a few 100 ppm.

When required for assembly the MiniPID HS sensor itself and all cleaned and outgassed pneumatic components should be handled with gloves to prevent transfer of semivolatiles to pneumatically exposed surfaces. Other components should be handled with clean hands. The sensor should be mounted in the detector as near completion of the assembly as possible.



Final burn in and QC testing of detectors containing the HS MiniPID

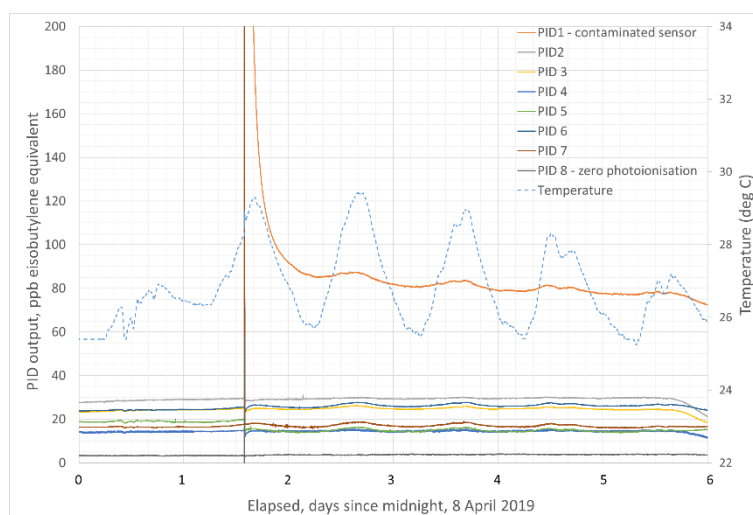
Immediately after manufacture, a high sensitivity VOC detector should be always QC tested to ensure sensor performance congruent with specifications. It is particularly important to verify a low background response to 'zero air'. We have been able to prepare up to 500 mL/min of zero air delivering <20 ppb sensor background from ambient air (200 ppb typical) which is passed through 500 mL dessicant and then through 500 L activated carbon pellets. Similar performance is obtained from 'ultrahigh purity air' ('zero plus') provided in compressed cylinders. For bigger assembly operations, an activated platinum filter can be used, though this can be very expensive. Use VOC free copper or stainless steel in test apparatus to deliver zero gas. A zero gas delivery cradle presented to a diffusive VOC detector should be made of metal.

Although the PID sensor is capable of background <50 ppb (typically <100 mV sensor output), in our experience detectors containing the HS miniPID require at least 12 hr in zero air to provide backgrounds of less than 200 ppb. Further clear-down requires extended burn in. The graph shows placement of a PID (PID 1) in a 50 mL/min clean air stream with six other sensors (PID 2 to 7) presented the same clean air stream for a few months. Prior to testing, PID 1 had been exposed to a moderately contaminated environment for months.

Calibration

Since air may contain semivolatiles which give rise to a significant and slowly moving sensor response, calibration of a high sensitivity VOC detector must

Within 12 hr, the PID 1 signal stabilised to within 5 ppb diurnal drift per day, but would take many days for the PID to reach the low background of the other six sensors Span gas should contain 2 ppm isobutylene in a balance gas of high purity artificial air (80% nitrogen, 20% oxygen). Note oxygen in air generates ozone in the PID photoionisation enclosure which is critical to maintenance of a clean sensor and PID lamp window, as well as causing a slightly suppressed response to the 2 ppm isobutylene. Do not use pure nitrogen as balance gas!



always be undertaken after burn-in using clean air. This will provide the zero point calibration reading. The sensor output with a (masked) lamp delivering zero photoionisation is typically 50 and 55 mV (0 to 5 ppb equivalent – see graph above, PID 8).

No claims, promises or guarantees are made about the accuracy, completeness, or adequacy of the information contained herein.

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