A Guide to Accelerant Detection Tools

For Fire & Arson Investigation

Fire investigation, sometimes referred to as origin and cause investigation, is the analysis of fire-related incidents. After firefighters extinguish a fire, an investigation is launched to determine the origin and cause of the fire or explosion. Investigations of such incidents require a systematic approach and knowledge of basic fire science.

Source: Wikipedia

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Sniffer Dogs for Fire & Arson Investigation

The principal goal for fire investigators is figuring out how and where a fire started and where foul play is suspected, specially trained arson detection dogs are amongst their 'tools of the trade'. It is common knowledge that dogs have a keen sense of smell, but the actual degree of sensitivity is amazing.

Smell is a dog's primary sense, and it is 10,000 to 100,000 times more acute than humans. That analogous to being able to see and recognise something 500 meters away, a dog could see and recognize the same object 5000 kilometres away. Or, if you could taste a teaspoon of sugar in your coffee, a dog could taste a teaspoon of sugar in over 3.5 million litres of water.

In terms of detecting the residue of volatile organic compounds (VOC) that may be present at a fire scene from common accelerants such as solvents, gasoline (petrol) or diesel fuel, they have a sensitivity of 0.001 part per million (ppm). That's an incredible 1 part per billion (ppb)!

However, what if a 'sniffer' dog isn't available or the remaining debris does not allow for safe conditions? What if suspected residue is in an area to which the dog doesn't have access e.g. ceilings, small openings? Dogs can also tire and become desensitised.

PIDs for Fire & Arson Investigation

Another proven scientific tool used in forensic fire investigations is the photoionization detector (PID):-

- PIDs are quick, simple to use and accurate for the detection of fire accelerants
- PIDs are very sensitive to commonly found accelerants and will detect hundreds of gasses and vapours in low concentration
- PIDs are non-destructive and will not affect the air sample which can be captured at the same time as the measurement for further lab analysis
- PIDs reduce the quantity and cost of lab samples required to reach a conclusion as to the cause of the fire
- PIDs are portable and battery powered making them ideal fire and arson investigation instruments

Effects of high humidity on PIDs

There are a few important issues to look out for when choosing an instrument.

Like many sensors and measurement instrumentation, traditional PIDs can be affected by the adverse environmental conditions such as those found at fire scenes i.e. dirt, water and humidity. The situation in the immediate aftermath of a fire is therefore not ideal and in particular the presence of high humidity can disrupt PID measurements leading to false low or conversely high readings.

The cause of low readings is because water vapour absorbs the photons normally released by ionisation within the sensor as can be seen in the simplified cross sections of a PID (figure 1).

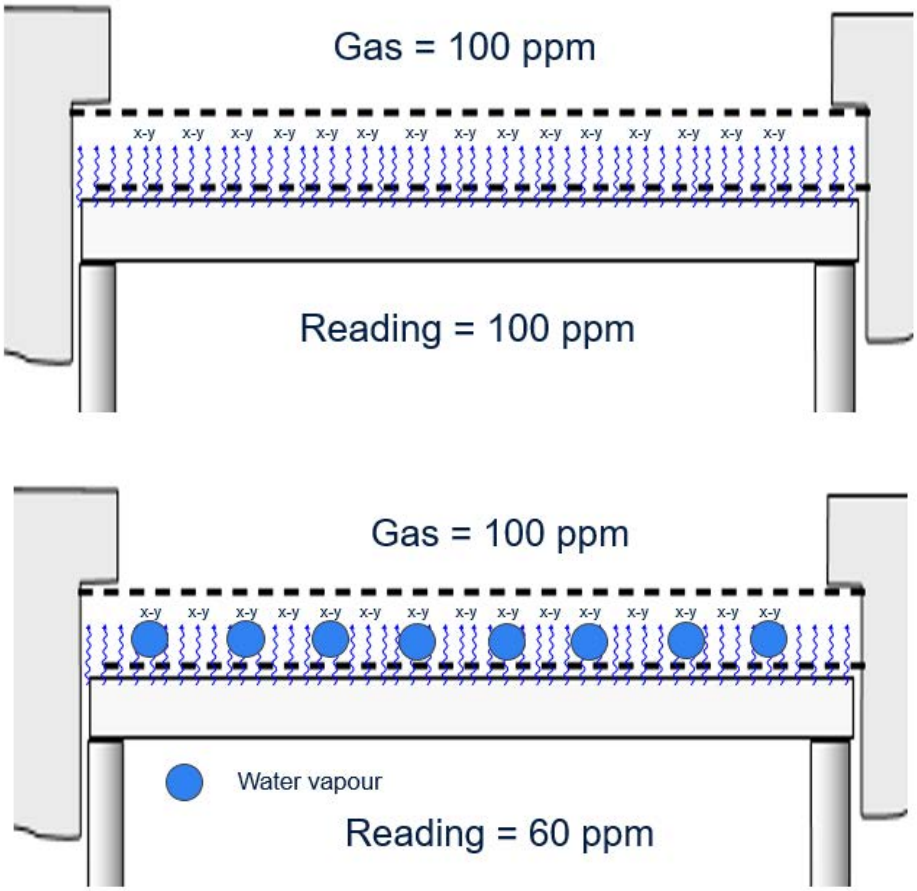

Figure 1: Cross section of a PID sensor with and without water vapour present

The release of photons is what occurs during photoionization, but the issue is that some of these photons are absorbed by water vapour, which worsens as humidity increases.

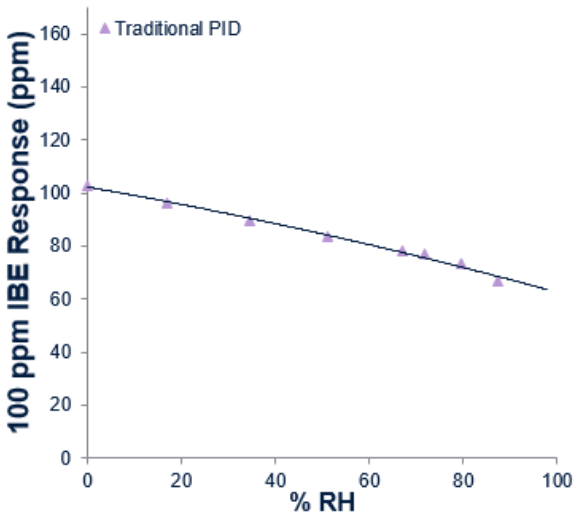

Figure 2: Effect of water vapour absorption

Contamination can also build up between the electrodes effectively short circuiting them, leading to a high, 'false positive' reading at high humidity with no VOC present i.e. > 90% RH (see figure 3).

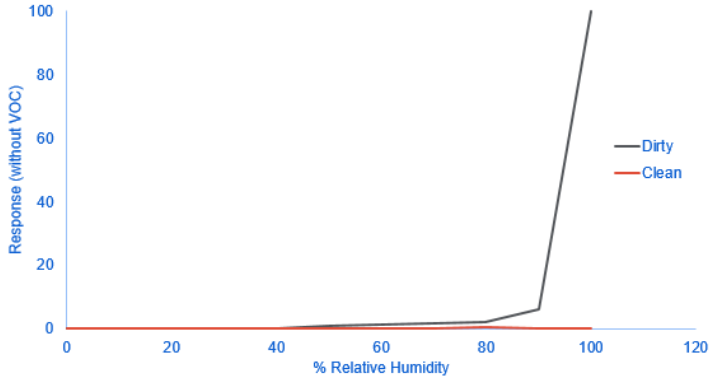

Figure 3: Effect of contamination

Solving the problem of humidity

Conventional PIDs may use humidity suppression/compensation techniques but each of them has disadvantages:

- Humidity sensor – these typically have a slower response than the PID sensor itself which causes a drifting compensation

- Desiccant tube – these both slow the PID response and also reduce it by adsorption plus they need replacing from time to time which adds cost
- Humidify the calibration gas – this only works at one level of humidity and is no longer accurate when the humidity changes

Importantly none of these solutions solves a false positive at high humidity

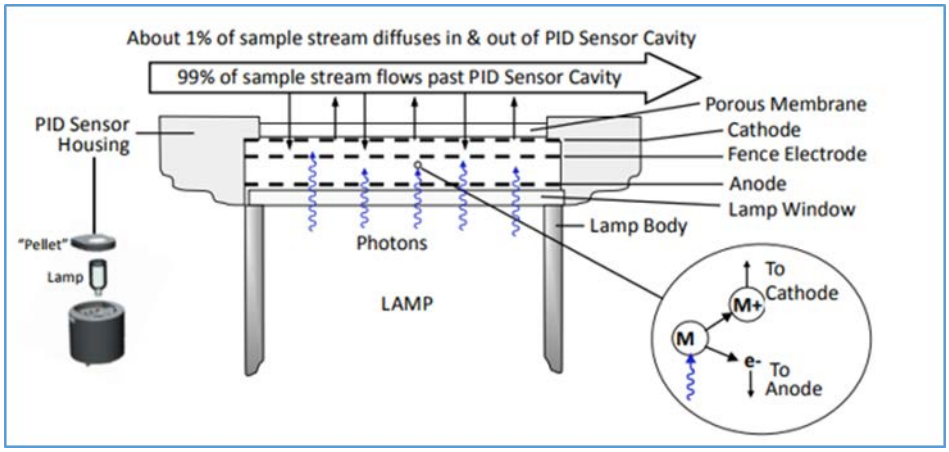

Figure 4: Ion Science Ltd PID sensor design

Looking again at figure 4, the presence of the porous membrane should be noted. It is made from a hydrophobic material which means that it rejects the ingress of water and mitigates the chance of low readings.

To further deal with high humidity, the addition of a third, fence electrode (also shown in figure 4) overcomes the possibility of high readings since it behaves as a conductive break and stops the excess current flow caused by the presence of high humidity and contamination which would otherwise lead to a false positive.

Choosing the right instrument

Manufacturers tend to offer variants of the same instrument differentiated by functionality and/or performance to suit different budgets but here are some important considerations:-

- Battery life – look for at least a 24-hour run time
- Battery type – look for rechargeable but is there a 'dry cell' backup in case of emergency?
- Sensitivity – look for a minimum 0.1 ppm (100 ppb) but ideally 1 ppb, equivalent to that of a sniffer dog
- Fast response and clear down time – this should be around 2 seconds

- Upper range – 20,000 ppm is possible but 5000 ppm will suffice (and save money but look out for compromises that may otherwise be useful)

Ease of calibration & maintenance

To prevent dirt from entering the instrument which can contaminate the PID sensor's lamp, there should be an easily accessible probe filter. Manufacturers normally have a recommended filter life, typically 100 hours use, but because fire scenes can be very dirty, users should be able to visually inspect the filter and change it as required.

During factory calibration and maintenance, the manufacturer should also clean the PID sensor lamp and the electrode stack should be changed prior to factory recalibration which will bring the instrument back to the manufacturer's original specification.

In daily use manufacturers recommend field calibration of their PIDs with Isobutylene, which is an excellent surrogate calibration gas because the response of most VOCs is reasonably close to, and consistent with, this gas. However, fire investigation is a largely a qualitative measurement and a simple 'bump test' using a common VOC source can also be used e.g. the solvent from a highlight pen. This involves exposing the detector to a vapour concentration that checks the sensors' ability to respond and is a simple functional test.

Fire Investigator's Kit

To assist the fire investigator, maximise their 'productivity' and minimise the number of lab samples that need to be taken, a number of useful accessories and spares should be provided:-

- Long, flexible probe, to enable access to awkward spaces and gaps between floorboards and ceilings
- Vehicle adaptor to keep the rechargeable battery topped up plus AA battery pack for 'emergency use'
- Exhaust barb to allow air samples to be captured whilst measuring for subsequent lab analysis if required

- Bump test pen & calibration gas to check functionality and accuracy
- Spare PTFE filters
- Rugged carrying case

Summary

Modern PID sensors are able to ‘compete’ with arson investigation dogs in terms of sensitivity and offer a number of advantages. They are portable and easy to use in the complex aftermath of a fire and can run for many hours, where dogs may otherwise tire or become desensitised. PIDs will increase the productivity of the fire investigator and reduce the number of samples that need to be sent to the lab for analysis. The subsequent cost savings make for an excellent return on investment. PIDs are simple to use and give a continuous read-out for rapid location of residual accelerants at a fire scene.

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About ION Science

Ion Science provide a portfolio of handheld, fixed and portable photoionization (PID) detection instruments for the rapid, accurate detection of volatile organic compounds (VOCs). Find out more about our industry leading range of VOC detection solutions by clicking on the links below.

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