# Comparison Of Photoionization Detectors (PIDs) And Flame Ionization Detectors (FIDs)

## Comparison of PIDs and FIDs

Photoionization detectors (PIDs) and flame ionization detectors (FIDs) are sensitive low-range gas and vapor instruments that are optimized to detect different gases, typically volatile organic compounds (VOCs). While both can measure in parts per million (ppm), they accomplish the measurements in different ways. This is similar to measuring distance using a tape measure instead of a yardstick (you get the same reading in feet using a different tool). By better understanding the strengths and weaknesses of each technology, the most appropriate type of monitor can be chosen for a particular application. In general, PIDs are smaller, lighter and simpler to use, and therefore are preferred for portable applications, where possible.

## How do PIDs and FIDs Work?

A PID uses an ultraviolet (UV) light source (*photo*) to *ionize* a gas sample and *detect* its concentration. Ionization occurs when a molecule absorbs the high-energy UV light, ejecting a negatively charged electron and forming of positively charged molecular ion. The gas becomes electrically charged. These charged particles produce a current that is easily measured at the sensor electrodes. Only a small fraction of the VOC molecules are ionized. Therefore, PID measurements are non-destructive and samples can be bagged and used for further analysis.

An FID uses a hydrogen-air *flame* to *ionize* the sample gas and *detect* its concentration. Ionization occurs when electrons are ejected from VOC molecules in the hot combustion flame. These ions are electrically charged and produce a current that is easily measured at the sensor electrodes. The VOCs in the sample stream are completely combusted. Therefore, FIDs are destructive and effluent samples are not suitable for further analysis.

## Why doesn't a PID read the same as an FID?

PIDs and FIDs have different sensitivities and are calibrated with different gases.

**PID Order of Sensitivity**:
Aromatics, iodine compounds >
Olefins, ketones, ethers, amines, sulfur compounds > Esters, aldehydes, alcohols, aliphatics > Chlorinated aliphatics, ethane > methane (no response)

**FID Order of Sensitivity:**
Aromatics, long-chain compounds >
Short-chain compounds (methane) >
Chlorine, bromine and iodine compounds

Therefore, they will not give the same readings on the same gas stream.

In broad terms, PIDs respond to functional groups, whereas FIDs respond to carbon chain length. Thus, an FID has similar response to propane, isopropanol and acetone, because all three have three carbon atoms, whereas a PID is very sensitive to acetone, moderately sensitive to isopropanol, and has the lowest sensitivity to propane. In addition, various types of PID lamps have greatly different sensitivities. For example, for butanol the relative response for 9.8 eV, 10.6 eV, and 11.7 eV lamps is 1, 15, and 50, respectively. Moreover, most field-portable FIDs use a flame-arresting sampling frit to make the sensor explosion-proof. This slows diffusion of heavier vapors to the sensor and tends to equalize response to smaller and larger compounds. Thus, FIDs have relatively even response to a broad range of compounds, whereas PIDs can be made to be either very selective by using a low-energy lamp (e.g., 9.8 eV) or broad-band using a high-energy lamp (e.g., 11.7 eV).

## Response to and Interference by Methane

An FID is often calibrated with methane, but a PID cannot detect methane at all. The high Ionization Energy of 12.6 eV for methane prevents the UV light source in any PID from ionizing methane, so it can't be seen by a PID. Thus, an FID is useful for measuring natural gas, which consists predominantly of methane. On the other hand, a PID is more useful for measuring toxic VOCs in landfills, where non-toxic methane can interfere in the measurement when using an FID.



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### Detection Limit, Range and Linearity

FIDs typically have a range of 1 to 50,000 ppm. PIDs can have ranges from 1 ppb to 4,000 ppm or 0.1 to 10,000 ppm. PIDs can detect much lower levels than FIDs, while FIDs are more linear in the high concentration range (>1000 ppm).

### High Humidity

FIDs are generally free from humidity effects, except if water condenses in the sensor, the flame can be extinguished. PIDs have slightly reduced response as humidity increases and can have false-positive humidity response at very high humidities. The latter effect can be avoided by maintaining a clean sensor.

### Inert Gas Matrix

PIDs can be used to measure VOCs directly in an inert gas matrix containing no oxygen, such as nitrogen or argon. The response is typically unaffected or slightly increases in the inert gas. FIDs require oxygen to sustain the flame required for measurement. In portable FIDs, the oxygen usually comes from the sample air itself. Therefore, if measurements need to be made in an inerted pipeline or vessel, some method is required for sample dilution to bring in ambient oxygen.

### EPA Method 21 Fugitive Emissions Analysis

According to EPA Method 21, both PID and FID are suitable for fugitive emissions monitoring. Refer to Technical Note TN-122 for more information.

### Ease of Use

PIDs tend to be smaller, lighter and less complicated than FIDs. PIDs are available as light as 6 ounces, whereas FIDs typically weigh a few to several pounds. FIDs require the use of hydrogen, thus needing more handling to exchange cartridges and possible safety hazards when transported. Flame-out on FIDs can occur, requiring restarting the instrument. PIDs may need lamp and sensor cleaning when used in heavily contaminated areas.

**PID/FID Comparison**

| Parameter | PID | FID |
|---|---|---|
| Ease of Use; Size and Weight | Handheld, lightweight | Bulky, heavy, requires hydrogen cartridges |
| Linearity | Better at lower concentrations | Good linearity throughout range |
| Range | 0.005 (5 ppb) to 10,000 ppm (parts per million) | 1 to 50,000 ppm |
| Compound Detection | Measures organic vapors and gases; measures some inorganic gases | Measures organic vapors and gases; measures a few inorganic gases |
| Compound Selectivity | Selectivity can be increased with lower energy lamps and decreased with higher energy lamps | Broad sensitivity |
| Inert Matrix Gas | Can measure directly in an inert gas matrix such as argon or nitrogen | Requires oxygen presence; for inert gas measurements, requires dilution with air |
| Sample collection | Non-destructive: allows sample collection with complete sample integrity | Destructive: sample is “burned” as it is ionized |
| Use | Personnel monitoring and Fugitive emissions | Fugitive emissions, too bulky for personnel monitoring |
| Reliability | Reliable, low cost, long life lamp | Frequent “flame-out” issues and hydrogen cylinder replacement |
| Intrinsic Safety | Intrinsically safe with cold operation | Explosionproof using flame arrestor to isolate hot flame; not desirable for some extremely hazardous environments |
| Cost | Low cost | High cost |



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