VOC Gas Monitoring Technology - Photoionization PID sensor

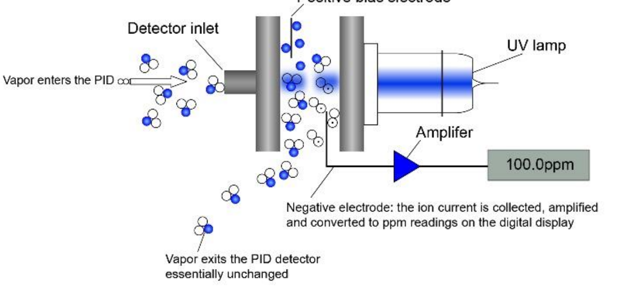
Governments worldwide have established a range of standards and specifications for VOC (volatile organic compounds) monitoring, utilizing methods such as gas chromatography, flame ionization detectors (FID), and photoionization detectors (PID). These are the primary techniques for monitoring VOCs in ambient air and pollution sources.

The PID gas sensor, with its high sensitivity, can detect extremely low concentrations of VOCs and other toxic gases. This makes it indispensable in industries such as petroleum, petrochemicals, and environmental protection monitoring.

1 Types of gases detected by the PID sensor

The PID (Photoionization Detector) sensor uses an ultraviolet light source to excite and ionize the target gas, producing positive and negative ions. The detector amplifies the current generated by these ionized particles and displays the gas concentration in parts per million (ppm) on the meter. The ions pass through the electrodes and quickly recombine to form the original organic molecules, without causing any damage to them during this process.

A key advantage of the PID is that it does not "burn out" and does not require frequent replacement of calibration gases, allowing the tested gas to still be collected for further analysis.



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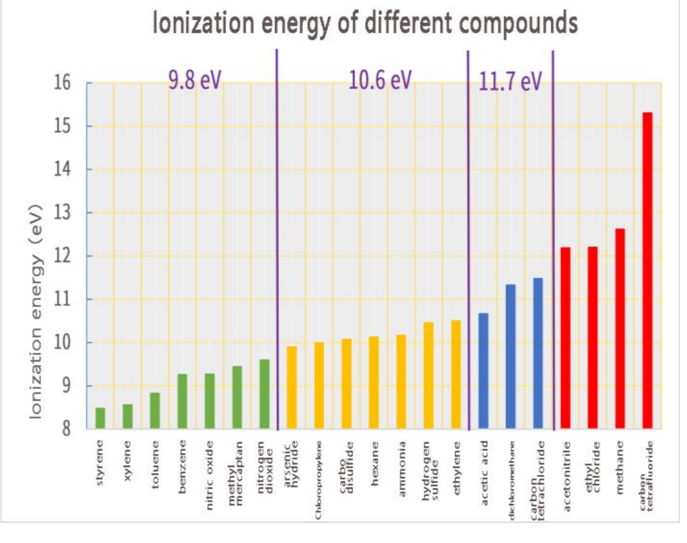
The PID detector can detect hundreds of compounds, but each compound has a different ionization energy. Therefore, the ultraviolet lamp in the PID detector must be chosen based on the ionization energy of the target compound. Currently, commercial PID detectors are available in three specifications: 9.8 eV, 10.6 eV, and 11.7 eV. Compounds with ionization energies higher than 11.7 eV cannot be detected by commercial PID detectors at this time.



Volatile organic compounds (VOCs) refer to a range of organic compounds with boiling points between 50°C and 260°C at room temperature. These compounds are mainly characterized by their volatility and organic nature. Common VOCs include benzene derivatives, organochlorides, freons, organic ketones, amines, alcohols, ethers, esters, acids, and petroleum hydrocarbons.

VOCs are released both through everyday activities and industrial production processes. In daily life, sources include gasoline vapor from gas stations, the drying of decorative coatings, and alcohol-based disinfectants. In industrial settings, VOC emissions are significant, particularly during processes such as spraying, printing, and cleaning with organic solvents, where large amounts of volatile organic solvents are used.

2 Main indicators of PID sensors

Gas concentration range

After identifying the type of gas to be detected, it is also important to assess the concentration of the gas. This involves considering the detection range of the PID sensor, which typically offers products capable of measuring concentrations ranging from a few ppm to tens of thousands of ppm.

Detection resolution

The detection resolution refers to the lowest gas concentration that the sensor can detect. The PID sensor is highly sensitive, and under lower detection ranges, many products can achieve resolution at the ppb level, with some even detecting concentrations below 1 ppb.

Concentration linearity

The PID sensor exhibits excellent linearity, with a linear response over most detection ranges. For most sensor products, concentrations below 5000 ppm can achieve a correlation coefficient of $R^2 > 0.95$, ensuring accurate measurements.

Signal repeatability

The signal generated by the sensor after photoelectric conversion must be output in a stable manner, with minimal absolute deviation, to ensure accurate and consistent performance.

Response time T90

When the sensor comes into contact with the target gas, it generates an electrical signal through photoelectric conversion. The term T90 refers to the time it takes for the sensor to respond and rise from 0 to 90% of the measured gas concentration in the environment. This response time is an important parameter for evaluating the sensor's performance.

Temperature and humidity drift

The PID sensor is sensitive to temperature and humidity, which can cause output value drift and affect the accuracy of the product. As a result, it is difficult to evaluate the exact impact of temperature and humidity on the sensor's performance, posing challenges for consistent usage in varying environmental conditions.

Sensitivity attenuation

The ultraviolet (UV) lamp within the sensor has a limited lifespan, and over time, environmental dust can accumulate on the lamp, leading to reduced performance. As the sensor is used, this gradual decay in UV lamp efficiency can affect the accuracy of the PID sensor. Excessive degradation of the lamp can result in inaccurate gas detection, making maintenance and monitoring of the sensor's condition important for reliable operation.

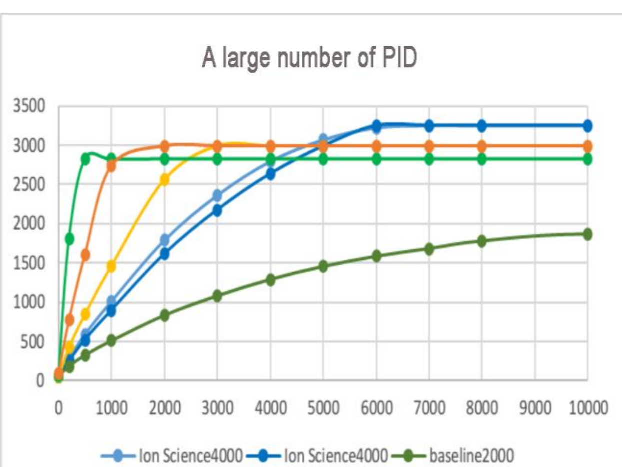
3 Range and resolution

Due to the manufacturing limitations of PID sensors, there is a trade-off between range and accuracy (or resolution). As the detection range increases, the accuracy tends to decrease.

This makes it challenging to achieve both a wide range and high resolution simultaneously. Typically, PID sensors are categorized into ppb-level and ppm-level products, with ppb-level sensors offering higher resolution for lower concentrations and ppm-level sensors covering wider ranges at the cost of some precision.

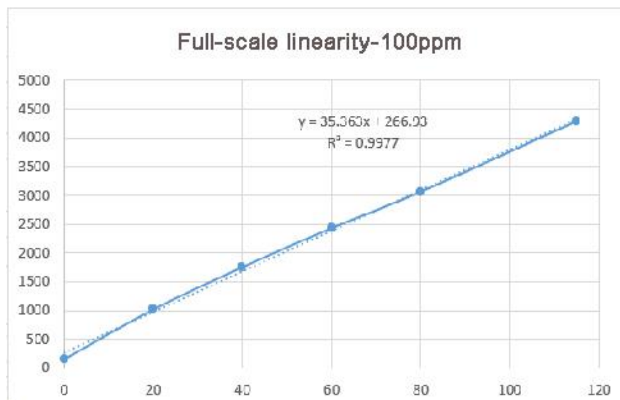
For environments where VOC concentrations are very low but still pose a health risk, a low-range sensor, such as one with a 20 ppm or 50 ppm range, should be selected. These sensors are typically used in leak detection scenarios, where the primary goal is to detect the presence of VOCs. With ppb-level resolution, they offer high accuracy for detecting trace amounts of harmful gases.

In environments with high concentrations of pollutants, where the focus is on measuring the VOC concentration, ppm-level sensors are more suitable. For instance, in the case of online VOC emissions monitoring, a sensor with a 5000 ppm range is recommended. These sensors have lower accuracy compared to ppb-level sensors, with resolution typically in the ppm range, making them ideal for high-concentration detection.

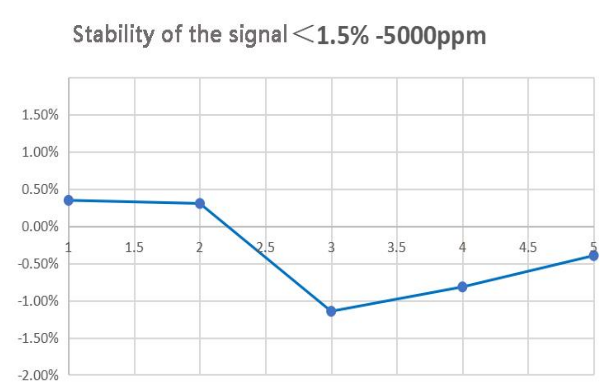


4 Concentration linearity and signal repeatability

The linearity of a sensor refers to how closely the actual relationship between its output and input matches a straight line. The smaller the deviation from this straight line, the higher the linearity. A sensor with good linearity will accurately reflect changes in gas concentration across the entire detection range, providing a reliable response to varying levels of the measured gas.

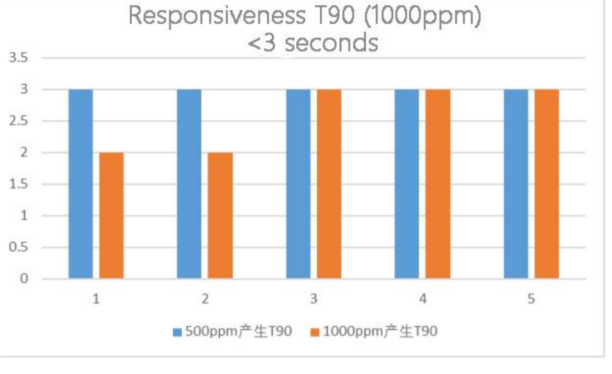


The repeatability of a sensor reflects the degree of variation in its output curve when the input is tested multiple times in the same direction at full scale. The more closely the output characteristic curves align under identical input conditions, the better the repeatability and the smaller the margin of error.



5. Response time T90

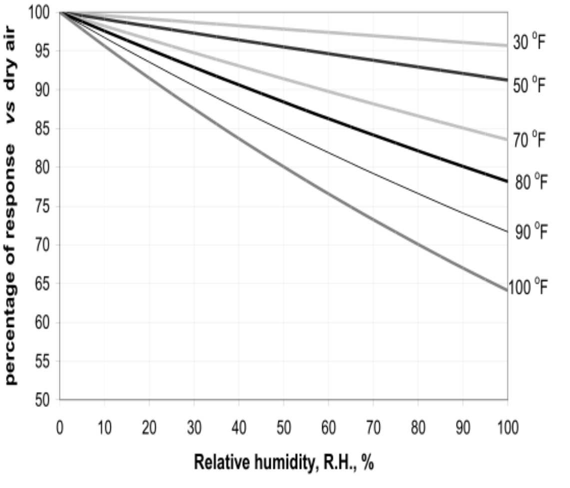
Response time T90
Upon entering a VOC gas environment, the PID sensor responds very quickly, typically within 5 seconds (T90). Similarly, it returns to zero rapidly after leaving the VOC gas environment.
The nominal response time of the PID sensor is usually defined by its T90 time, which represents the time it takes for the sensor’ s output to reach a specified percentage (generally 70% or 90%) of the stable value when exposed to a sudden change in gas concentration, referred to as the T70 or T90 response time.



6. Temperature and humidity drift

PID sensors may encounter moisture during ion capture, which can generate false ions and lead to inaccurately high concentration readings. This issue, caused by humidity interference, is difficult to completely avoid.

To mitigate this, PID sensor instruments and equipment can be calibrated before detection to reduce the effects of temperature and humidity. Ensuring stable sensor performance under varying temperature and humidity conditions will significantly enhance the product's effectiveness in practical use.



7. Attenuation and longevity

In the application of PID sensors, users are particularly concerned about the sensor's service life. Typically, the UV lamp has a nominal lifespan of around 5,000 hours, which means the sensor will require maintenance over time. The associated costs and expenses can be a burden for users. As a result, the service life and rate of performance degradation of the PID sensor are frequently subjects of interest and inquiry.

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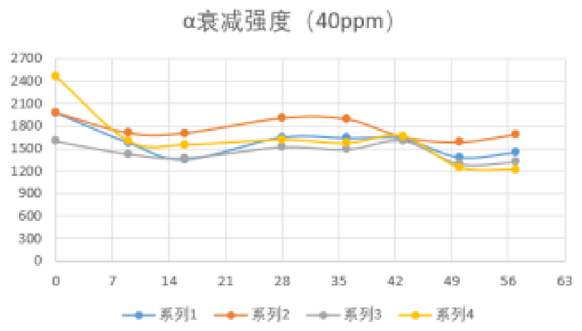
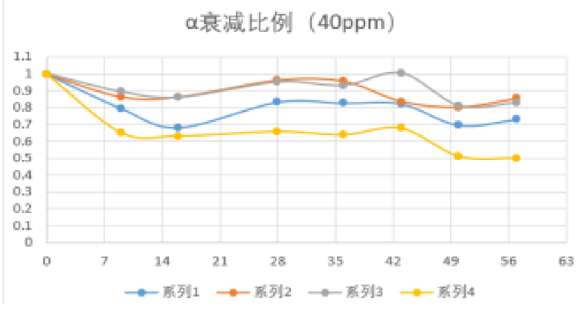


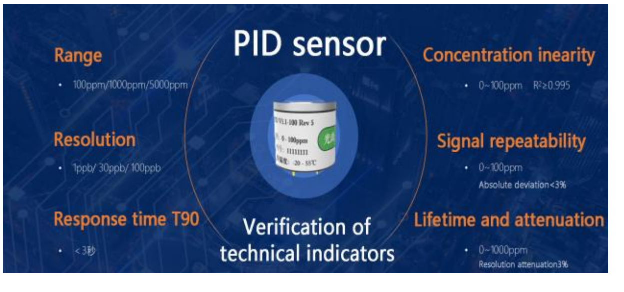


8. Applications of PID photoion-ion sensors

With the rapid growth of the industrial economy, pollution levels are steadily rising, particularly in chemical industry zones, industrial hubs, and their surrounding environments. The environmental pollution burden is increasing, leading to frequent occupational health hazards.

Toxic gas detection plays a crucial role in various areas, including the production process, chemical material leakage, industrial occupational hygiene, indoor air quality monitoring, environmental protection, confined space operations, and emergency accident detection.

Compared to other gas sensor technologies, PID sensors offer several advantages, including fast response times, a wide detection range, quantitative measurement capabilities, high sensitivity, and intrinsic safety. With domestic enterprises making continuous breakthroughs in core technology and industrialization, these sensors are becoming increasingly autonomous and cost-effective to produce. This progress enables broader coverage, more comprehensive monitoring of flammable and explosive gas leaks, enhanced occupational health protection during production processes, and greater value in industrial safety prevention and risk mitigation.



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