Gas Detection Application Note

Point Infrared Gas Detector Buyers Guide

Users of flammable gas detectors are finding that Point-Infrared (PIR) combustible gas detectors generally work well for LEL (lower explosion limit)-range hydrocarbon vapor measurement, and offer a lower cost of ownership than traditional catalytic combustible gas detectors. Evidence of market acceptance can be found in that many traditional fixed and portable gas detector manufacturers are now adding PIR gas detection instruments to their repertoire. However, technical evaluation of PIR gas detectors available on the market today reveals that not all are created equally, and in some cases the use of an improperly and/or hastily-designed PIR gas detector may actually reduce the overall level of safety attained at a hazardous facility or jobsite. The goal of this report is to provide an overview of proper and improper PIR gas detector designs, and other important features to consider when determining which PIR gas detector will best meet your flammable gas detection system requirements.

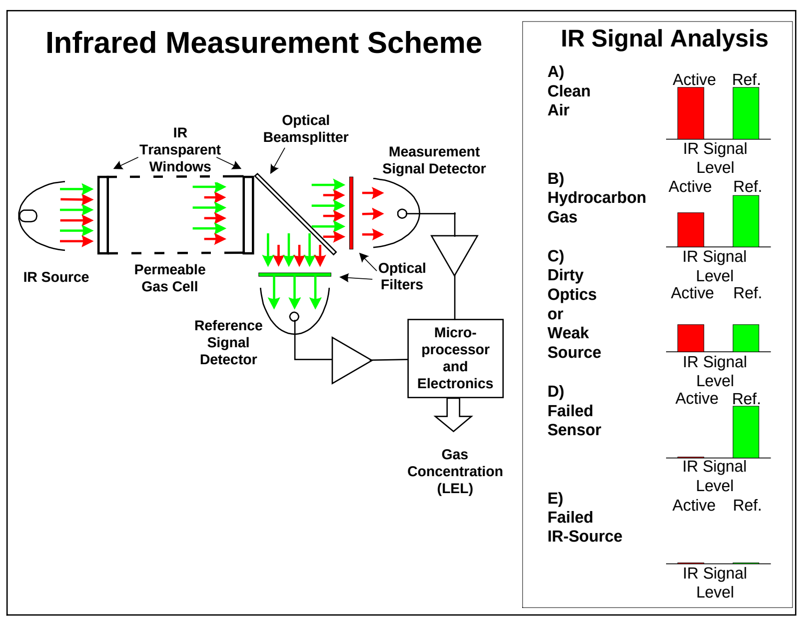
Why Point-Infrared Gas Detectors?

The historical method of detecting combustible gases involved sensors based on catalytic (pellistor) beads. Pellistor-based sensors are susceptible to significant covert (undetected) sources of failure. Primary of these are catalyst poisoning and flame-arrestor plugging, either of which prevent the sensing of gas. It is not difficult to see how a covert pellistor failure could remain undetected for day, or even months, as the only way to detect a catalytic failure is to periodically check the sensor with test gas and check for proper response. The absence of covert failure modes is the intrinsic characteristic of infrared gas detectors that provides a significant advantage over catalytic beads. Other advantages PIR detectors can include reduced calibration requirements, longer service life, and superior resistance to impingement from water, ice, dirt, oil, and other contaminants.

How do Point Infrared Gas Detectors work?

All infrared gas detectors use variations on the basic measurement scheme outlined in the illustration below. An infrared source is used to illuminate a volume of gas that has diffused into a measurement chamber. The gas absorbs some of the infrared wavelengths as the light passes through it, while other wavelengths pass through completely unattenuated. The amount of absorption is related to the concentration of the gas.

The amount of absorption is measured by a set of optical detectors and subsequent electronics. The change in intensity of the absorbed light is measured relative to the intensity of light at a non-absorbed wavelength. The microprocessor computes and reports the gas concentration from the absorption.



How is "no undisclosed failure" sensing operation attained?
One method of providing "no undisclosed failures" is shown in the illustration above. Signals from (infrared) IR detectors in panels A and B show the normal state of operation of the detector. When there is no gas present the signals for the reference and active channel sensors are balanced. When there is combustible gas present, there is a predictable drop in the output from active channel sensor because the gas is absorbing light.
A fault condition is illustrated in panel C for the signal levels encountered in the case of dirty optics or a weak and failing light source. The former scenario is a trigger to perform routine maintenance and the latter is an indicator that preventive maintenance should be scheduled. In either case, the instrument continues to faithfully measure gas concentration up until the situation degrades to an untenably low signal level. These maintenance situations are easily flagged with modern digital field communication and any number of asset management and predictive maintenance programs. Panel D and E illustrate the situation with failed components in the measurement loop. If a sensor fails or light source fails, signals on one or both sensor channels will fall to zero.
This arrangement is typical of a properly-designed PIR detector. Other sensing designs exist that do not deliver failure diagnostics and status information.

What are the most common failure modes and/or weaknesses of Point IR gas detectors?
The most common failure mode of all infrared gas detectors is insensitivity and/or drifting caused by the effects of water and water vapor. Water absorbs all monitored IR wavelengths within most Point IR gas detectors, and therefore the device designer must control the effects of water and water vapor on the device optics. The most effective designs to control water/water vapor effects include:

- Heated optics. This feature helps control effects of condensation
- No sintered metal/ceramic flame arrestors or frites. These filters are prone to blockage and water-lensing, and generally can not be cleaned, especially if fouled with oil. Avoid designs that use these elements.
- Self-draining optics protection. This ensures that even after exposure to wind-blown rain, water will not accumulate and impede operation. In addition, most "heavier than air" gas hazards require detector installation at grade level to enable early detection. Low installation elevation will result in increased exposure to deflected rainwater, and even partial flooding, in many outdoor settings.

Why is optics protection so important? How can I tell a good design from a poor design?
Of all Point-Infrared gas detector design characteristics, the effectiveness of the optics protection system is most likely to impact the user life-cycle cost of ownership. The simple reason is that a poor design is likely to result in increased routine inspections and optics cleaning, where a superior design is likely to reduce the number of inspections and service requirements. When most users consider IR gas detection, an intrinsic goal is to reduce the cost of gas detection system ownership. A proper optics protection design supports this goal.

A good optics protection design will withstand direct exposure to high pressure water without device failure or fault In addition, the optical protection system should be easily removed, inspected, and cleaned if necessary. A good design will offer a multi-layer baffle to achieve a labyrinth chamber protection package. A good design will **not** use a sintered metal or ceramic flame arrestor as a means of protecting the optics.

Are two IR lamps better than one?
No. In mean time between failure (MTBF) terms, the IR source lamp is the weakest link in a Point Infrared detector design. In addition, as incandescent lamps age, some spectral output drifting is normal, meaning that a device that utilizes 2 IR source lamps should utilize a lamp drift compensation routine to ensure long-term performance of the device is not compromised. The most common symptom of lamp drifting is instability across temperature, and signal drift at zero and span gas conditions.

Are two sensors better than one?
Theoretically, yes. In practice, no. A single sensor eliminates the need to test and match sensors for identical performance characteristics. However, testing has shown the using dual sensors offers generally superior device MTBF over devices employing dual IR lamps within most industrial installations.

Do all PIR detectors deliver the same sensitivity?
No, they do not. Generally, there is a relationship in optics design where the longer the optical path, the better the sensitivity. For this reason, folded-path PIR optical designs are useful in that the measurement path can be close to double that of the overall length of the instrument. This design requires a set of mirrors, which if implemented properly, offer effective and robust performance in challenging environments. Generally look for sapphire-coated mirrors for maximum resistance to mirror surface degradation.

How important is the detector's mechanical design and optics protection system?
The optics protection and mechanical design are critical, as these elements comprise the foundation of value and quality that the device will deliver. A modular mechanical design is recommended to ensure easy installation and service. The device should utilize an optics protection system that protects against heavy rain and hose-directed wash-downs. In addition, the optics protection system should be self-draining in the event that water does penetrate or accumulate within the optical section of the device.
A historical weakness of catalytic sensors is in applications where a low-elevation mounting level of the detector would lead to virtual saturation during a rainstorm, leading to very premature failure. The sintered flame arrestor would allow water to accumulate internally. Any PIR detector that uses a sinter in the optics design has an unmonitored barrier which is an unnecessary carry-over from catalytic sensor protection concepts.
Desirable features provided by top-line PIR detectors include optics heating. This feature helps prevent/limit condensation from forming within the optical section of the device. Thermal compensation is also desirable feature to ensure a wide operating temperature range is offered with good accuracy throughout the range. This feature requires that a thermistor is used within design. Using hydrophobic filters for optics protection has no known downside. Engineering testing proves proper hydrophobic design will not foul, contrary to perception/comparison with sintered flame arrestors. Routine optics cleaning should be unnecessary as this requirement defeats the purpose of moving towards PIR detection.
If life-cycle cost of ownership is important, then optics protection is one of the most significant areas to be evaluated before buying a PIR gas detector. Be aware that all designs are not equal!

Electrical/Electronics design differentiation
Conformal coating of PC boards is not provided by all PIR manufacturers. This is a desirable feature, even within sealed designs as some enclosure breathing is unavoidable, especially in tropical settings. Isolated analog signal output is a desirable feature when the need to separate field device power from computer power is required. Many PIR devices exhibit current consumption surges that match timing of IR lamp activation, and the peak consumption is often not listed, only the average consumption. Be aware that improper power consumption specifications are not uncommon for many PIR detectors. Detector diagnostics should be available to the user on 4-20 signal , HART, and RS-485 outputs of the device. In addition, visual indication should be provided to confirm status information.
Electronic design can be difficult to evaluate without extensive time and effort. Selecting a well-known, name brand can be the best way to avoid electronic design shortcuts and possible problems

Performance differentiation

T60: Time to reach 60 percent of full scale should be confirmed, where beginning with the gas-sensing element in clean air, it shall be suddenly exposed to a prepared mixture of gas-in-air having a concentration corresponding to 100 percent of full-scale gas concentration. From the instant of exposure to this gas mixture, the instrument shall respond to provide an indication of 60 percent of full-scale gas concentration within 12 seconds.

Accuracy: Device accuracy should meet the standard where the sensing head is exposed to five gas concentrations falling in each of the following ranges: 9 to 11 percent, 24 to 26 percent, 49 to 51 percent, 74 to 76 percent, and 98 to 100 percent of the full-scale gas concentration. In each case, the concentration indicated by the meter or output signal shall not vary from the known test gas concentration by more than ±3 percent of full-scale gas concentration or ±10 percent of applied gas concentration, whichever is greater.

Air velocity variation: The instrument shall be calibrated first with the detector head exposed to a static mixture of the initial calibration gas. It shall then be exposed to the initial calibration gas mixture in motion so as to impinge on the detector head with a velocity of 5 ±0.5 m/s (16.4 ±1.6 feet/s). The meter or output indication during exposures to the mixture in motion shall not vary from that observed during exposure to the static gas mixture by more than +10 percent or -5 percent of full-scale gas concentration in the orientation that causes the greatest deviation.

Approvals Certification	ATEX is a global certification that is necessary for world-wide acceptance
Offshore exposure tests:	saltwater, fog, rain, direct solar exposure, freezing conditions
Onshore exposure test:	rain, dirt, dust, oil, direct solar exposure, freezing conditions
Communication tests:	HART, Addressable protocols, RS-485 Modbus

Performance testing requires time and effort to confirm. Ensure all data provided by vendors is backed by 3rd party test report. Ask for a test report copy to confirm performance capabilities of the detector.

Summary

Major differences exist in Point Infrared Gas Detector device design. Top tier and second-tier devices exist, so expect that you will get what you pay for. Be sure to evaluate every applicable challenge that your project presents, and compare these challenges and expectations to the features offered by the candidate detectors. Testing maybe necessary to confirm that the device is capable of delivering the reliability, quality, and value expected by the customer. Call us for additional information on IR gas detectors.