Photoacoustic Infrared Technology

Not All Infrared Monitors Are Created Equal

Photoacoustic Infrared Technology Offers:

Stability, Flexibility, Sensitivity

Allan Roczko
Product Line Manager
Instrument Division

Newest Method of Gas Detection

When protecting your employees and operational processes from toxic and combustible gases, it's critical to choose a gas detector that provides the most accurate and reliable monitoring possible. With so much at stake, using the most advanced technology possible is your best—and sometimes only—choice.

Since there are so many types of facilities, gas-detection needs can vary greatly. Some facilities require monitors to identify gases at the lowest possible levels. Other facilities are exposed to gases or compounds that can complicate the ability to detect the gas in question. This is a concept referred to as cross-sensitivity, which will be discussed in more detail later. Still other facilities use combustible gases that require explosion-proof monitors.

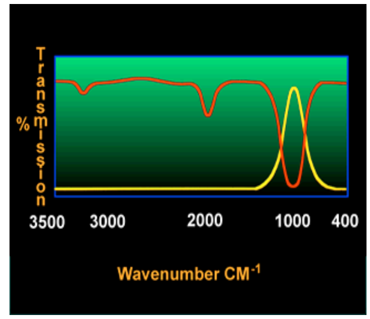
It is now possible to utilize a single gas-detection monitor for all of the challenges mentioned above—one that utilizes *photoacoustic infrared technology*.

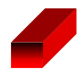
Photoacoustic infrared technology is the newest method of gas detection. It enables gases to be detected at extremely low levels due to its inherent stability and reduced cross-sensitivity.

Infrared Technology in General

To understand how photoacoustic infrared technology works, it is important to understand how traditional infrared technology works.

Infrared detection uses infrared light to detect the presence of gas. When a gas is exposed to the infrared light, it absorbs some of the light's energy. Specific gases absorb light at specific wavelengths, allowing gases to be identified by measuring the absorption of light at these wavelengths. Optical filters are used to pass only the particular band of wavelengths for the gas of interest.





Red is representative of a typical gas absorption characteristic.

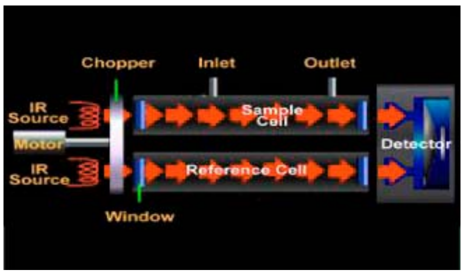
Yellow is an infrared wavelength that would be used to detect this specific gas.

Infrared technology has been used for many years with great success for ambient gas level detection.

Absorptive Infrared Technology

Historically, one of the most commonly used forms of infrared detection has been *absorptive infrared technology*. In an absorptive infrared monitor, a sample of the gas in question is introduced into the measurement chamber of the monitor and is exposed to infrared light. Simultaneously, a sample of an inert gas (usually nitrogen) is present in a separate measurement chamber within the same monitor and is known as the *reference gas*. By using an inert gas, one ensures that no absorption takes place and that all the infrared light passes through the chamber. This provides an accurate baseline from which to measure light absorption by the gas in question.

The detector compares the amount of light transmitted through the sample and the reference cells. The monitor can determine the concentration of gas present in the sample by the ratio of light that is transmitted by the sample gas to the light that is transmitted by the reference gas. For example, if the amount of light transmitted through both cells is equal, then the sample cell does not contain the gas of interest. Conversely, the difference between the amount of light transmitted through the sample and reference cells can be used to quantitatively determine the concentration of gas in the sample cell.

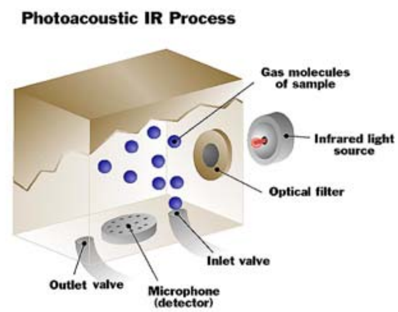


Absorptive infrared detection uses technology based on separate Sample and Reference cells.

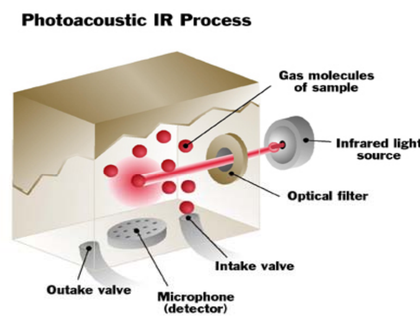
Photoacoustic Infrared Technology

Building upon the success of basic infrared technology, the latest innovation for ambient gas monitoring is *photoacoustic infrared technology*. This technology also exposes the gas sample to infrared light. However, unlike absorptive infrared, the reading is based on what happens to the gas *after* it absorbs the infrared light. With this method, a comparison to a reference sample is not required, so a direct gas reading is obtained.

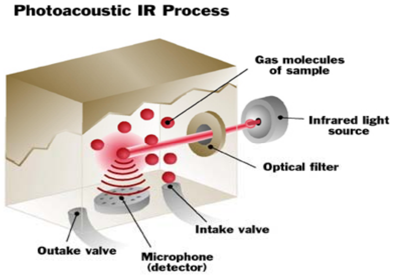
In a photoacoustic infrared instrument, a gas sample is introduced into the measurement chamber of the monitor, and the sample is exposed to a specific wavelength of infrared light. If the sample contains the gas of interest, it will absorb an amount of infrared light proportional to the concentration of gas present in the sample. However, photoacoustic infrared analysis extends beyond simply measuring how much infrared light is absorbed. Photoacoustic infrared technology observes what happens to the gas once it has absorbed the infrared light. The molecules of any gas are always in motion, and as they move around inside the measurement chamber, they generate pressure. When a gas absorbs infrared light, the molecules' temperatures rise, and they begin to move more rapidly. As a result, the pressure inside the measurement chamber increases. This pressure creates an audible pulse that can be detected by an extremely sensitive microphone located inside the photoacoustic infrared monitor.



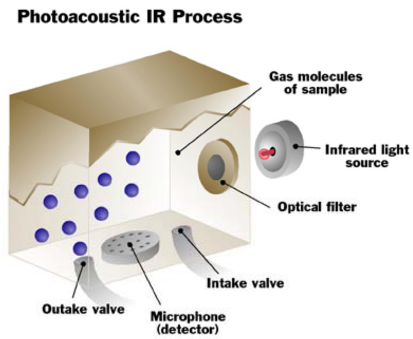
Sample gas enters the measuring cell.



The gas is irradiated with pulsed infrared energy.



The gas molecules heat and cool as they absorb the infrared energy. The pressure changes, as a result of the heating and cooling of the molecules measured by the detector.



The gas is exhausted and a fresh sample enters the cell. This sampling process is continuously repeated.

Because the optical filter will only pass the particular wavelength of light for the gas in question, a pressure pulse indicates that the gas is present. If no pressure pulse occurs, then no gas is present.

The magnitude of the pressure pulse indicates the concentration of the gas present. The stronger the pressure pulse, the more gas that is present. The sensitive microphone inside the monitor can detect the smallest of pressure pulses, enabling it to detect even the lowest levels of gas.

The Need for Low-Level Detection

The term Threshold Limit Value (TLV) refers to the concentration of airborne substances under which workers can be repeatedly exposed without adverse health effects. The purpose of gas-detection instruments is to ensure that gases are identified at concentrations equal to or lower than the TLV, to ensure a safe working environment. With certain gases, the TLV can be extremely low, requiring a detection method that can identify that gas at a very low level. The higher an instrument's sensitivity, the lower levels of gases it can detect.

Absorptive infrared monitors can easily detect gases in the percent by volume or high part-per-million (ppm) levels. But, the detection limits for many absorptive infrared monitors can be well above the TLV of many gases. In order to achieve the required ppm level of detection, these instruments need to have longer sample chambers, increasing the overall size of the monitor, as well as the cost.

Photoacoustic infrared monitors can detect gases at low ppm, and even part-per-billion (ppb), levels due to the high sensitivity and stability of the microphone that measures the pressure pulses. This microphone can detect small pressure pulses, allowing photoacoustic infrared monitors to detect the presence of a toxic compound, before the concentration reaches the TLV, for a wide variety of gases.

The Need for Zero Stability

Zero stability or maintaining a stable baseline is very important for low ppm detection. Instability can compromise low-level detection by causing inaccuracy, false alarms and limited detection levels. A common problem with absorptive infrared monitors is the fact that the zero derived from the sample to reference ratio has a tendency to drift based on a number of factors. These include use, age, variability of the light source and physical changes in the detector over time.

Because the absorptive-infrared-monitor reading compares the readings of the sample gas to the reference gas, it's critical that the balance between the cells is maintained. If this balance is not maintained, the monitor must be calibrated, or re-zeroed, to ensure that the zero point is correct. Otherwise, the monitor may present a false alarm or, worse, become unable to detect the gas in question at low concentrations. Another downfall to this technology is that the re-zeroing process takes time away from the sampling process.

Photoacoustic infrared technology offers zero stability because it eliminates the need to adjust for zero drift. There is no zero point involved—providing the most accurate and reliable readings.

Considering Cross-Sensitivity

Cross-sensitivity is a key factor to consider when choosing the technology to be used to detect toxic and combustible gases. Cross-sensitivity is the ability to differentiate between various gases that may be present within a single sample. When testing for a specific toxic or combustible gas, it is quite possible that another gas with similar absorption characteristics is present in the chamber. Even ambient air can cause cross-sensitivity problems due to the variability of carbon dioxide or relative humidity in the atmosphere. For example, if a monitor is cross-sensitive to CO_2, mere breathing on the monitor can cause a false reading.

Photoacoustic infrared monitors, like other infrared monitors, are designed to minimize cross-sensitivity through the use of specific optical filters. Given the stability of photoacoustic infrared technology and the use of optical filters, one can achieve the sensitivity and selectivity required for low ppm detection.

Choosing the Right Technology for You – The Photoacoustic Infrared Difference

For installations that require detection of a toxic or combustible gas at a very low level, particularly in an environment where cross-sensitivity is an issue, photoacoustic infrared monitors are the best choice.

Photoacoustic infrared monitors provide precise, low-cost, high-performance monitoring for a variety of gases. The monitors can currently detect more than 60 common industrial gases including carbon monoxide, carbon dioxide, cleaning agents, heat transfer fluids, and a host of common industrial chemicals—with many other applications possible.

Typical Photoacoustic Infrared Monitor Industry-Specific Target Gases		
Agricultural Industry		
Carbon Tetrachloride	Ethylene	N-Pentane
Chloroform	Ethylene Oxide	Phosgene
Dimethylamine	Methyl Formate	Trichloroethane
Ethyl Acetate	N-Hexane	
Automotive Industry		
Cyclopentane	Ethanol	HFE 347E
1,2 Dichloroethane	HFE 7100	CO
Dowtherm J	HFE 7200	
Medical Industry		
Chloroform	Ethylene	Nitrous Oxide
Diethyl Ether	Heptane	Toluene
Ethylene Oxide	Isopropanol	
Petrochemical Industry		
Gasoline (As Propane)	Butane	Xylenes
Diesel Fuel (As Propane)	Pentane	CO_2
Methane	Hexane	Ethylene Oxide
Ethane	Benzene	Isobutane
Propane	Toluene	
Pharmaceutical Industry		
Dimethylamine	Ethanol	Isopropanol
Plastics/Paint Industry		
Chloroform	MIBK	Propanal
Ethyl Acetate	Methyl Methacrylate	Toluene
Ethanol	Methylene Chloride	Trichloroethane
Isopropanol	N-Butanol	Trichloroethylene
Methanol	N-Hexane	Xylenes
MEK	N-Pentane	

Rubber Industry		
Acrylonitrile	Carbon Tetrachloride	Propanal
1,3 Butadiene	Dimethylamine	Propylene Oxide
Styrene	Ethyl Benzene	Toluene
Acetone	Ethylene	Triethylamine
Benzene	Isobutane	Xylenes
Semiconductor Industry		
CO	Methyl Fluoride	Octaflurocyclopentane
Ethanol	Nitrogen Trifluoride	R-32
Hexafluoro 1,3 Butadiene	Nitrous Oxide	Sulfur Hexafluoride
Isopropanol	Octafluorocyclobutane	Carbon Tetrachloride

Photoacoustic infrared monitoring systems can be expanded to observe up to eight separate locations. Additional sensors can be added within the same instrument enclosure to monitor non-infrared detectable gases. Options include a catalytic bead sensor for combustible gas detection and electrochemical sensors for monitoring oxygen, carbon monoxide and other toxic gases.

Choose Wisely

Absorptive infrared monitors are often a suitable choice in gas detection—particularly when higher detection levels are acceptable.

However, when the situation calls for an extremely low-level alarm in the presence of other gases and when reliability is critical, photoacoustic infrared monitors offer the best package of performance and value.

Contact MSA for more information about photoacoustic infrared technology and how it can solve your gas-detection challenges.

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Instrument Division:
P. O. Box 427, Pittsburgh
PA 15230 U.S.A.
http://www.msanet.com

In U.S.:
Phone: 1-800-MSA-INST
Fax: 1-724-776-3280

In Canada:
Phone: 1-800-MSA-INST
Fax: 1-905-238-4155

In Mexico:
Phone: 52 (5) 5 76 64 44
Fax: 52 (5) 3 59 43 30

MSA International
Phone: 412-967-3228
Fax: 412-967-3373

Offices and representatives worldwide

For further information: