Photoacoustic Infrared Technology
for Detection of Refrigerant Gases

MSA
The Safety Company

Not all infrared refrigerant monitors are created equal.
Photoacoustic Infrared Technology offers: stability, flexibility, sensitivity.

ASHRAE REQUIREMENTS FOR REFRIGERANT MONITORING

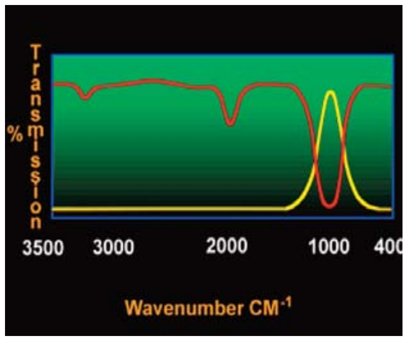
ASHRAE 15-2001 section 8.11.2.1 requires that each machinery room shall contain a refrigerant monitor capable of detecting a leak at a value not greater than the corresponding threshold limit value. For many of the most commonly used refrigerants such as R123 and ammonia, this would require accurate detection below 50 ppm. ASHRAE 147 section 4.8 recommends a more stringent requirement on large refrigerating systems using chlorine-containing refrigerants. HCFC's and CFC's can contribute to depletion of the stratospheric ozone layer and CFC's, HCFC's and HFC's can contribute to global warming. Therefore, a refrigerant monitor capable of detecting refrigerant concentrations of 1ppm or less is to be used on these systems to provide early warning of leaks.

NEWEST METHOD OF GAS DETECTION

When protecting your employees from toxic refrigerant 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. 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.



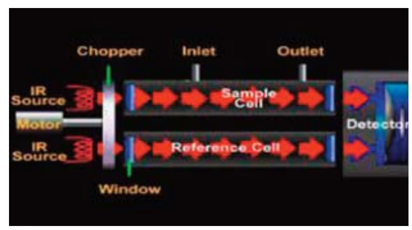
Red *is representative of a typical gas absorption characteristic.*

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

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 a baseline from which to measure light absorption of 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.

Zero stability for absorptive type instruments are a concern due to ambient effects, contamination and normal aging.

1. **Ambient effects-** when zero readings (no refrigerant present) on absorptive units can be affected by changes in temperature and pressure. Thus, a positive or negative shift in the zero reading can be experienced. Auto-zero techniques, which take the unit off-line for a period of time, are sometimes used to mask the zero instability inherent with the technology. Auto-zeroing can require elaborate zeroing schemes or maintenance-intensive filtration.

2. **Normal aging:** – with time, the zero of the absorptive IR unit can drift due to changes in IR source light intensity, detector sensitivity, and/or contamination of the sample cell.

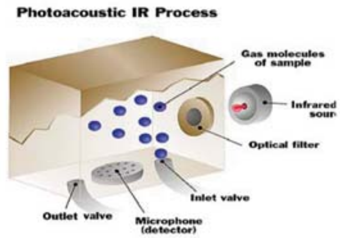
Rezeroing of the refrigerant monitor is needed to maintain the balance between the sample and the reference cell. If the sensor degrades without rezeroing, the unit could become desensitized to the gas of interest.

3. Contamination – any residue due to dust, water or solvents that enters the sample cell can block light from the IR source to the detector. Therefore, theresult will be an imbalance between sample and reference cell signal. This imbalance can create false alarms and compromise the monitor's ability to accurately detect refrigerant gas.

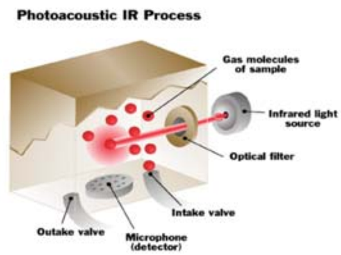
PHOTOACOUSTIC INFRARED TECHNOLOGY

Building upon the success of basic infrared technology for percent level or high ppm detection, 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 upon 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.

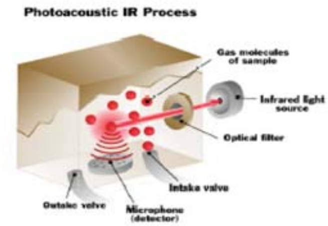
In a photoacoustic infrared instrument, a gas sample is introduced into the measurement chamber of the monitor, and the sample is exposed to a specific wavelength of infrared light. If the sample contains the gas of interest, it will absorb an amount of infrared light proportional to the concentration of gas present in the sample.



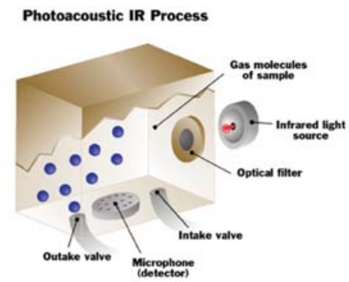
1. Sample gas enters the measuring cell.



2. The gas is irradiated with pulsed infrared energy. The pressure changes, as a result of the heating and cooling of the molecules and is measured by the detector.



3. 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.



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

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 the molecules 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.

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. Therefore, temperature or pressure changes will not change the zero reading on the unit. Additionally, this zero reading will not be affected by aging of the IR source or microphone since the zero is based upon a true zero reading and not the difference between two readings as in absorptive IR. 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 secure a safe working environment. With certain refrigerant 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 percentage 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 ambient effects, normal aging and contamination over time. As was mentioned previously, since 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 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. If autozeroing is used during the rezeroing process, the monitor is not detecting refrigerant gas. Photoacoustic infrared technology offers zero stability because it eliminates the need to adjust for zero drift. There is no zero balacing 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 refrigerant gases. Cross-sensitivity is the ability to differentiate between various gases that may be present within a single sample. When testing for a refrigerant, 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 CO2, 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 FORYOU – THE PHOTOACOUSTIC INFRARED DIFFERENCE

For installations that require detection of a refrigerant 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 100 common industrial gases including refrigerants, carbon monoxide, carbon dioxide, cleaning agents, heat transfer fluids, and a host of common industrial chemicals – with many other applications possible.

Photoacoustic infrared monitoring systems can be expanded to sample 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 itcan solve your gas-detection challenges.

The Safety Company

MSA—**The Safety Company**

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Our Mission

MSA's mission is to see to it that men and women may work in safety and that they, their families, and their communities may live in health throughout the world.

MSA: Because every life has a purpose.

MSA NORTH AMERICA ISO 9001 CERTIFIED Quality System

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