
Open-Path Infrared Gas Detectors

Direct and Coaxial Optics Design

Open-path infrared gas detection is a proven method for detection of combustible gases. It is used to detect low-level gas concentrations and to alarm when specific hazardous concentration levels are exceeded. The units are specially designed to perform under extreme conditions such as high-speed air flows, humidity, and corrosive gases where point gas detectors may be ineffective. Infrared technology is known for high reliability and simple installation.

Open path infrared gas detectors are extensively used for offshore oil applications due to their ability to operate reliably in extreme weather conditions (fog, rain, snow), in direct or reflected sunlight, near flame, and within other black-body radiation sources.

Proper optical design is a crucial element for dependable operation of an open-path infrared product. There are two generally accepted optical detector designs for open-path infrared units, which will be referred to as "direct optics" and "coaxial optics" in this paper.

In a coaxial optical detector system (see Figure 1), a beam splitter is used to split the infrared light beam between the sample and reference channels. These channels have optical filters that pass light of different wavelengths. The sample side usually passes light of either 2.2-2.3 or 3.3-3.4 micron. The latter exhibits a higher absorption peak for hydrocarbons. The reference is at a wavelength that will not detect hydrocarbons.

With a direct optics configuration (see Figure 2), three lenses are employed: two sample channels for hydrocarbon detection, and a reference channel positioned between the two sample channels. As with a coaxial system, the reference is at a wavelength that will not detect the hydrocarbons. Infrared light from the source enters the detector and strikes all three channels. No beam splitter or additional optical components are required in this configuration.

While both optical designs have been successfully commercialized, several distinct performance differences which occur can influence your choice of instrument. A summary of some of these differences is printed on the next page.

Coaxial Optical System

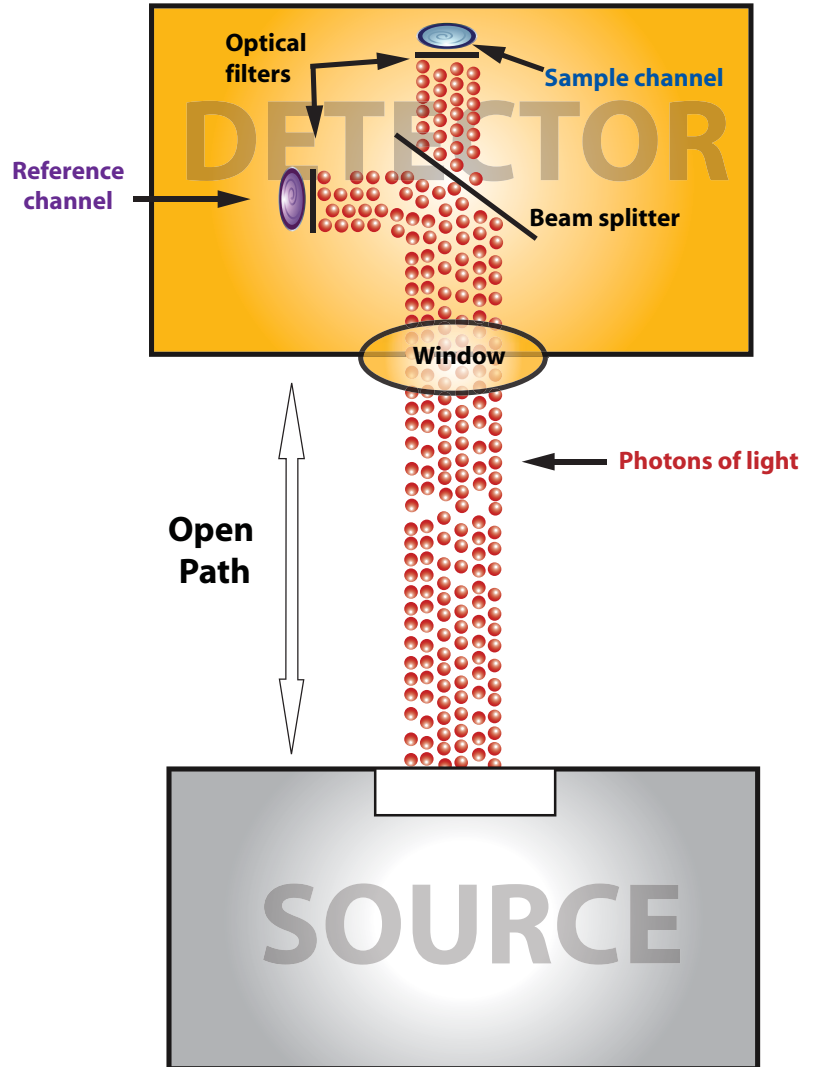


Fig. 1

Advantages of the Direct Optics Design

A direct optics design has certain advantages, the three most significant of which are:

Misalignment Tolerance

After being installed for years in rough environments, the source and detector units might shift from their proper alignment. In some cases, especially on offshore installations, the structure upon which the detectors are installed is somewhat flexible, causing misalignments of a temporary or ongoing nature. Therefore, it is an important advantage for a detector to tolerate a more severe misalignment, in order to be operational for longer periods.

The direct design allows tolerance of any detector misalignment or displacements of up to $\pm 1^\circ$ in any direction, while the coaxial-designed detectors typically tolerate only $\pm 0.5^\circ$ of misalignment. This greater tolerance allows the direct design to be aligned more easily and to maintain that alignment over time.

Sensor Response Validation

Coaxial designs usually include only two sensors: one for "signal" (having a waveband that is absorbed by gas), and the other for reference. The direct design uses one additional "signal" sensor. This allows the detector to identify issues in one sensor by comparing the two signals. Coaxial detectors with only two sensors do not have this self-diagnostic capability.

Beam-Splitter Effects

It is important to note that coaxial designs are not totally immune to gas reading errors, due to optical reasons. Usually, the coaxial nature of optics is obtained using a beam-splitter. The slightest movement of this beam-splitter, due to mechanical shocks or vibrations for example, would lower the reading in one channel and cause a gas reading error. Extreme temperatures might expand, shrink or distort the beam-splitter, causing a similar effect. Gas reading errors due to these effects would go unnoticed in a coaxial detector containing only two sensors, as there is no extra sensor to identify such events.

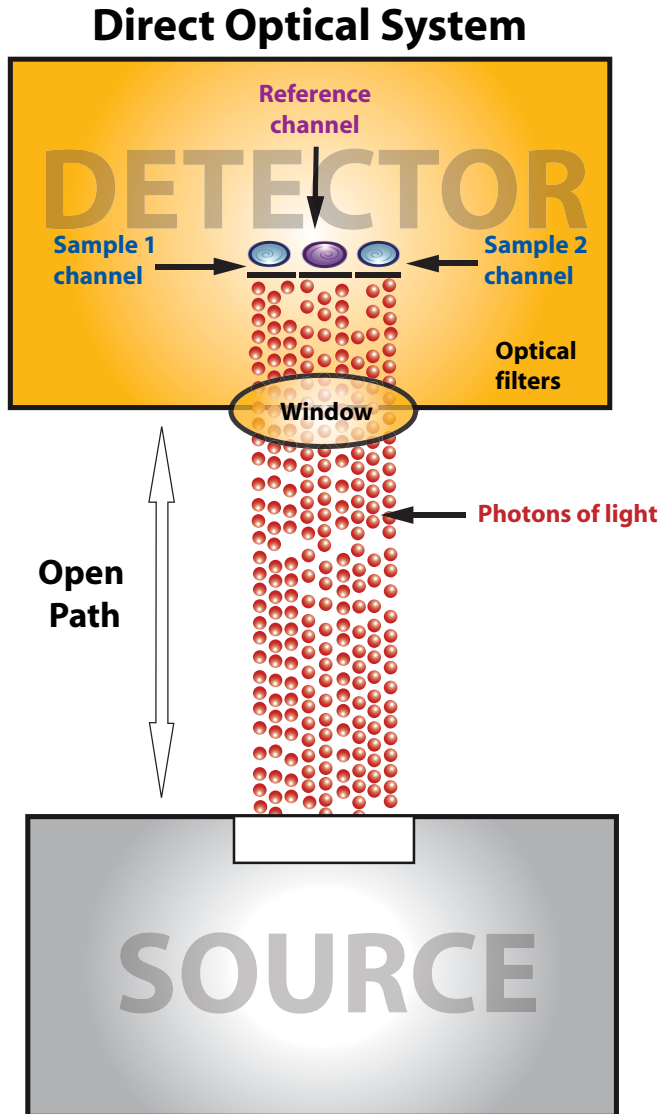


Fig. 2

Effect of Partial Obscurations

One effect worth noting is that of water droplets on detector windows. With the direct optics design, one may argue that water droplets on the window could absorb infrared light and preferentially reduce the amount of light to one sensor. However, this effect can be minimized by closely spacing the optics and by using the two sample channels to verify transmission of infrared light. For a direct optics unit, testing with a methane calibration shows that the water droplet obscuring 15% of the sample or reference channel will only be ~ 10% of full-scale. For all other standard calibrations with heavier hydrocarbons (C2-C8), the effect will be even smaller. Thus, the direct optics unit is fully functional in heavy fog, rain, etc., conditions that result in up to 90% signal obscuration. Experience has shown in North Sea offshore installations with very dense fog, snow, and rain over harsh winter months, that the direct optics units are fully operational at all times.

Other Considerations

Inherent in the design of a direct optics unit is a complex detection algorithm. While the details are not discussed here, an important point should be mentioned: the detector uses its ability to measure the gas sample and reference signals over time to its advantage. Using information about the development over time of all measured signals, the detector makes intelligent decisions regarding the state of possible obscuration and the most effective way to handle it. With the proven optics and the detection algorithm, direct optics open-path infrared units provide a reliable method for detection of hydrocarbons in a multitude of applications.

Summary

When choosing an open-path infrared gas detection provider, it is important to consider the optical design of the detector as well as other traditional decision-making factors (price, service, support, etc.). This paper shows that the direct optics design is a proven method for open-path infrared gas detection and in fact has several key advantages over the coaxial optics design.

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