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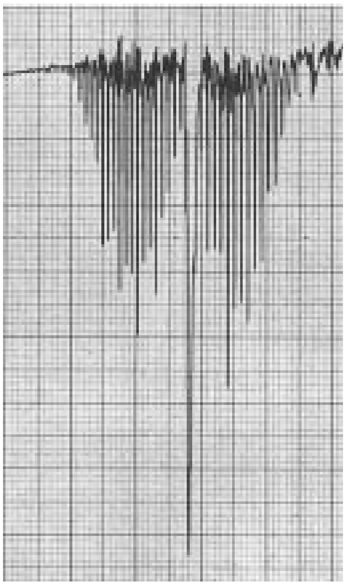
COMPARISON OF OPTICAL DETECTION SYSTEMS

FOR INFRARED HYDROCARBON GAS DETECTION

technical note

Figure 1- IR spectrum of gas phase methane



General Principles

Most molecules absorb light in the infrared region of the electromagnetic spectrum. This light is absorbed by chemical bonds between atoms and the energy of the light absorbed is characteristic of the molecule. Similar molecules absorb light of similar wavelengths, so that most hydrocarbons absorb infrared light at approximately 3.4 microns. See figure 1.
In practice infrared gas detectors compare the amount of light at a wavelength where hydrocarbon molecules absorb light with an area of the electromagnetic spectrum where no such absorption occurs. This absorption wavelength is known as the ***sample*** wavelength and the wavelength at which no absorption is expected is known as the ***reference*** wavelength. The measurement made is a ratiometric change in intensity at the two wavelengths of light.

To make such measurements a source of infra red light, a light sensitive detector and a method of excluding light of wavelengths other than sample and reference is required.

The choice of sample and reference wavelengths depend in part upon the gas species to be detected. Also to be considered is the likelihood of other gasses present that can absorb at the sample or reference wavelengths. Finally the strength of absorption must be considered, a weak absorption requires a long path length through the gas. In practice for a point detector, with a path length of a few centimetres, a sample wavelength of 3.4 microns might be used with a reference wavelength of 3 microns. This gives a good absorption at the

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sample wavelength and avoids absorption at the reference by water vapour and carbon dioxide. However liquid water is almost opaque in this region of the infra red spectrum and must be excluded from the path of the light.

Sources of Instability

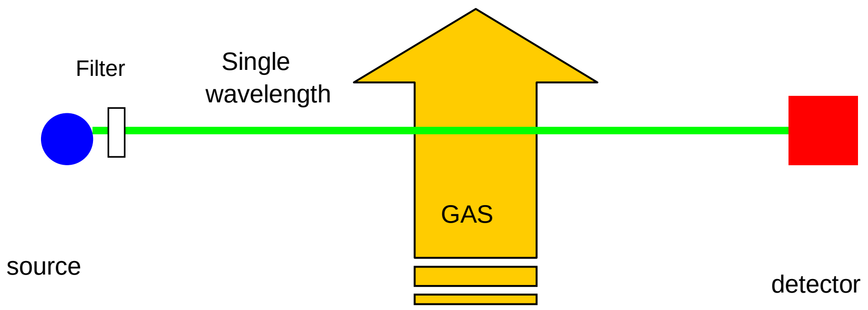
With a point infrared gas detector, one objective is to produce a device that does not require calibration and is resistant to drift in span and zero. This gives the maximum confidence in the operational performance of the detector and reduces the cost of ownership. This is a strong benefit of IR gas detection over pellistor based detectors which require regular calibration due to loss of sensitivity through their operational life. The infrared principle relies on the physical properties of the molecules to be detected and in inherently stable. However in practice there are electronic and mechanical drift issues to overcome to achieve the ultimate stability performance promised by infrared gas detection. This stability is only achieved by a correct choice of the optical system. Software algorithms alone cannot compensate for a poor choice of optical scheme.

The source of light, normally an incandescent lamp, may drift in two ways. Firstly, the absolute intensity of the light may increase, decrease or even fluctuate. This must be distinguished from signal changes due to absorption by gas. Secondly, the emission spectrum of the source may change with time. This is known as a change in the colour temperature of the source. This change in colour temperature results in a relative change in intensity of the sample and reference wavelengths. This must not be confused with gas or “negative gas”.

The infrared detectors may change in sensitivity with time and temperature. This must not be confused with a slow increase in background gas, nor must a slow increase in background gas be mistaken for a change in detector sensitivity.

Optical Configurations

There are a number of possible optical configurations that can be used, single source single detector, dual source single detector, dual detector single source and dual source dual detector, with either the light filters at the source or at the detectors.

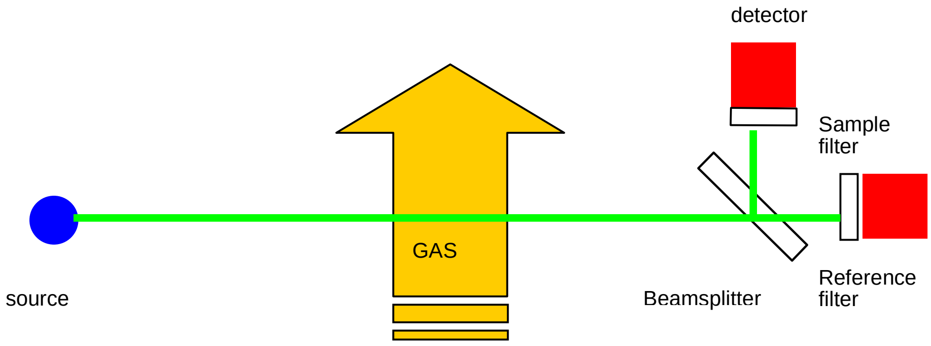


SCHEME 1 - single source, single detector

Only the sample wavelength is selected and measured at the detector. If the intensity of the source changes through source ageing then this can be interpreted as a positive or negative gas reading depending on the direction of change.

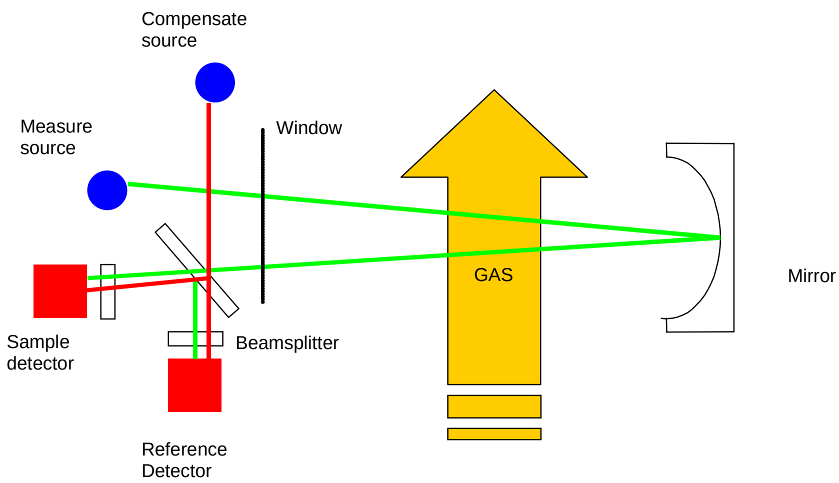
Changes in detector sensitivity will also result in an upscale or down scale drift. Furthermore there is no discrimination between drift in sensitivity and blockage of the light path and so dirt or moisture on an optical surface can be mistaken for gas.

These types of systems are only suitable for applications where calibration and operational checks are carried out on a daily basis such as in a portable gas detector and where the operating conditions are benign.



SCHEME 2 Two filtered detectors, single source

Here the two detectors are filtered for sample and reference wavelengths of light. The source is susceptible to colour changes which will can be mistaken for zero drift or gas, however the two detectors will discriminate between overall changes in source intensity (both detectors change). Any detector drift can be interpreted as a ratio change and generate a spurious alarm or fault.



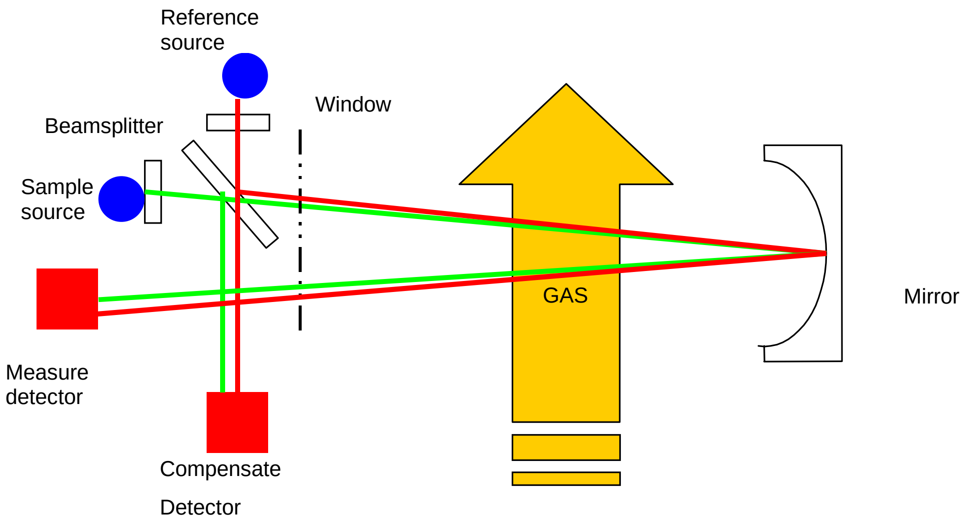
SCHEME 3 Two filtered detectors, two sources.

Here one source provides an external path and falls on both detectors whilst the second source forms a path within the instrument and falls on both detectors. The two sources are modulated at different frequencies and the signals on the detectors are demodulated to determine which source contributes what amount of signal measured on the detector.

Here there is good understanding of atmospheric effects as there is a comparison between internal and external paths. The external path gives a raw ratio change between the sample and reference wavelengths. This is compared with the internal path. This is used to ensure that the detector has not changed in sensitivity.

There is an attempt at compensating for source drift, but this relies on the two sources drifting, or changing colour, at the same rate. In practice this cannot be expected and so the source drift compensation is inadequate for all conditions of change.

The two detectors experience light from both sources and so compensation for detector changes in sensitivity can be adequately made.



SCHEME 4 Two detectors, two filtered sources.

Here both sources have an external and internal path and light at both reference and sample wavelengths fall on both detectors. The two sources are modulated at different frequencies and the signals on the detectors are demodulated to determine which source contributes what amount of signal measured on the detector. As only one source provides one wavelength a change in colour is seen as a change in intensity. As a change in intensity is detected by both the internal and external path this can be detected and eliminated through comparing ratio change on the internal path (never gas) and that on the external path (possibility of gas). Changing source intensity is detected in the same manner.

A change in detector sensitivity is equally compensated for. The detector experiences light at both wavelengths, and an equal proportional drop in both is a zero ratio change and so has no “gas” effects.

This double compensation scheme most fully compensates for changes in source and detector performance caused by lifetime changes.

SUMMARY TABLE

Dual filtered source dual detector.	**Double compensation. Compensates fully for first order effects**	
Dual source dual filtered detectors.	**Does not compensate for source drift. Compensates for detector drift.**	
Single source dual filtered detector.	**Source drift not compensated for. Does not compensate for changes in source colour temperature.**	
Single source single filtered detector	**Not compensated, susceptible to drift, faults and alarms**	**Increasing stability**

NOTES

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