GAS SECURE

A Dräger Company

Dräger

GasSecure GS01 – Reliable infrared gas detection with no need for field calibration

Single beam triple wavelength technology – unique to the GS01 gas detector – is the key reason why GasSecure can provide lifetime calibration for their product. In other words, field calibration will never be required for this gas detector.

D-42775-2015_1000

INTRODUCTION

The GasSecure GS01 represents a totally new concept in hydrocarbon gas detection using single-beam triple-wavelength infrared (IR) technology for fast gas detection with extremely low power consumption compared to wired IR gas detectors. This paper explains the detection concept and in particular how this concept enables a lifetime calibration-free detector design.

The GS01 detector utilizes IR absorption spectroscopy. This method for measuring gas concentration is based on the absorption of IR radiation at gas-specific wavelengths in a volume containing the target gas. Specific molecules will absorb light at known wavelengths, and most hydrocarbon gases, including methane and propane, absorb infrared light at approximately 3.3 microns.

The GS01 gas detector compares the amount of light at the wavelength where hydrocarbon molecules absorb light (known as the gas sample wavelength position) with the light intensity in the neighbouring areas of the electromagnetic spectrum where no such absorption occurs (known as the reference wavelength position). Thus, the GS01 calculates gas concentration from the ratio of the intensities at the gas sample wavelength and the reference wavelengths. Note also that in neither wavelength area (gas sample and reference) will other atmospheric constituents such as water vapour, nitrogen, oxygen, or carbon dioxide absorb light. IR absorption spectroscopy is rooted in the principles expressed in the Beer-Lambert Law:

$$T = e^{(-ANL)}$$

where T is the transmission at the specific wavelength, A the absorption coefficient of the particular gas molecule, N the gas concentration, and L the path length the beam travels in the gas volume. Measuring T and knowing A and L (note that L is fixed by design for the GS01), N can be found.

The measurement itself is not particularly challenging, since explosive mixtures of hydrocarbons in air typically absorb more than 10% of the incident light in the spectral band around 3.3 µm for a path length of 13 cm, as applied by the GS01. More challenging is designing a gas detector for harsh environments with virtually no zero and no span drift in a wide operating temperature range. Such a design significantly reduces the cost of ownership, because regular field calibrations are no longer required.

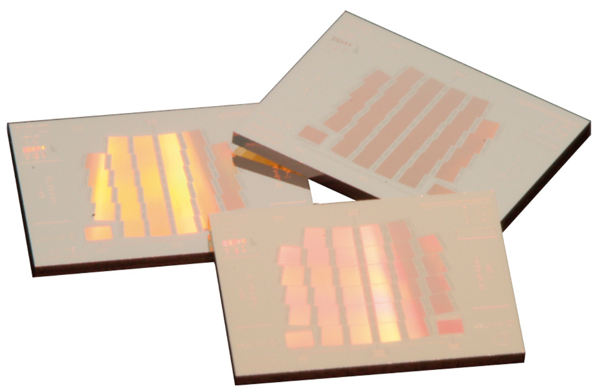

Figure 1: The MEMS chip

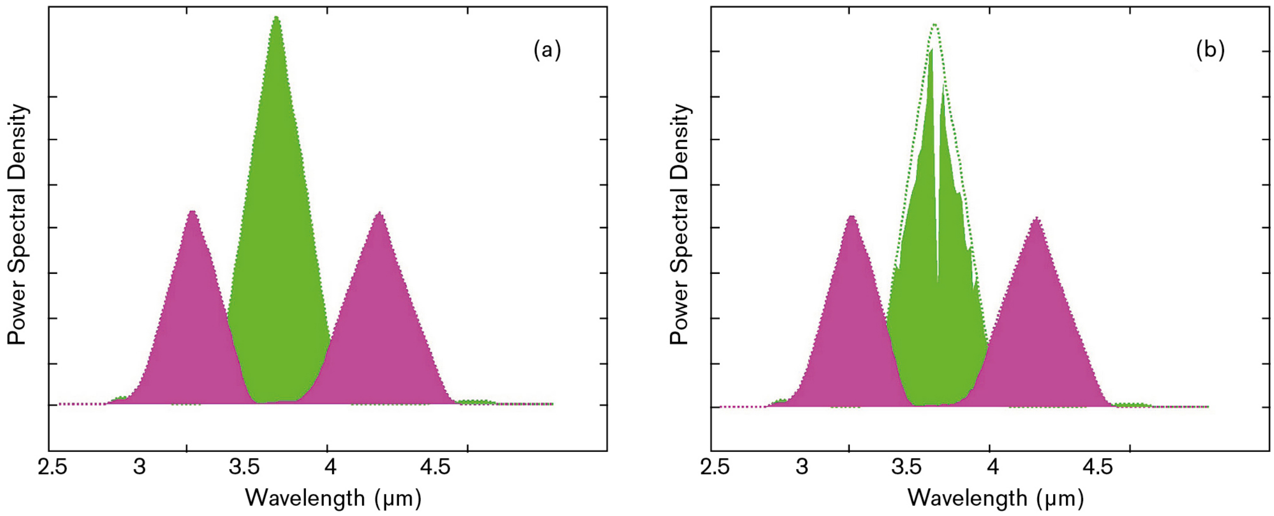

Figure 2: The filter functions used for hydrocarbon detection, corresponding to the two states of the MEMS (green = gas state and purple = reference state), (a) in the absence of hydrocarbon gas and (b) in the presence of Methane.

TRIPLE-WAVELENGTH DETECTION

Although there are variations the principal optical design of traditional IR point detectors comprises broadband light sources, optical filters, a beamsplitter, and solid-state photodetectors. The filters select the correct wavelengths for the gas and reference measurement from the incoming broadband light. The GasSecure approach is different, applying state-of-the-art MEMS (Micro Electro Mechanical System) technology for the optical filtering, which distinguishes the GS01 from all other commercially available IR hydrocarbon point detectors.

The filter is a patented silicon MEMS chip proprietary to GasSecure (See Figure 1) that disperses, focuses, and modulates the incident light. By applying a control voltage to this chip, it is switched between the gas state and the reference state at a frequency of 1 kHz. In the gas state, a wavelength area where hydrocarbons absorb light is focused onto a single photodetector. In the reference state wavelengths, where hydrocarbons do not absorb, are focused onto the same detector.

Note that the reference state is composed of two spectral areas located to the left and right of the gas state wavelength position, hence the term triple-wavelength detection.

Figure 2 shows the respective filter function curves for both states as generated by the MEMS chip (a) in the absence of hydrocarbons and (b) in the presence of Methane. The presence of Methane molecules reduces the amount of light in the gas state, but not in the reference state.

The gas concentration is then calculated from the ratio of the light intensities reaching the photodetector in both states. Therefore, any other influences on optical transmission such as drifting source intensity or fouling of the windows are effectively eliminated, because these influences will equally affect the gas and reference state light intensity and cancel in the ratio of both. This is illustrated schematically in Figure 3. Moreover, working with two reference wavelengths situated on both sides of the hydrocarbon absorption wavelength, will correct for first order wavelength-dependent error sources, primarily a changing emission spectrum of the infrared source. These linear changes of the emission spectrum will increase the light intensity in one sideband, but simultaneously reduce intensity in the opposite sideband.

The sum of both i.e. the strength of the reference signal remains unchanged. Hence, the gas concentration can be measured more reliably. This triple-wavelength detection principle is unique to the GS01 from GasSecure.

SINGLE-BEAM DESIGN

As already stated, the MEMS chip serves a number of purposes namely dispersing and focusing light and switching between two optical states. By applying a control voltage to the chip, the diffracted light is spatially redistributed between the diffraction orders. In the gas state, light with wavelengths where hydrocarbons absorb is focused onto the detector, whereas light with wavelengths where hydrocarbons do not absorb is focused onto the same detector in the reference state.

This in turn enables a very simple optical design with a minimum number of components: One IR source, mirror and window, MEMS chip, and one photodetector (see Figure 4) Note that Figure 4 shows the instrument in the gas state, because light filtered for the gas state (green line) is focused onto the detector. Upon switching the MEMS chip light filtered for the reference state (purple line) will be focused onto the same detector. The light path and the optical components (lamp, photodetector, MEMS chip, mirror and window) are all the same for the gas and the reference measurement. As the switching between the states is extremely fast (1 kHz), also the environmental conditions (temperature, humidity, pressure) are the same for both states. This design is referred to as single-beam detection, and combined with triple-wavelengths is a unique feature for GasSecure's GS01 gas detector.

Aging of IR light sources or solid-state photodetectors will not affect the GS01 gas concentration calculation, simply because the same components are used for the gas and the reference measurement. Aging effects will affect all optical components equally and therefore cancel in the ratio of both measurements.

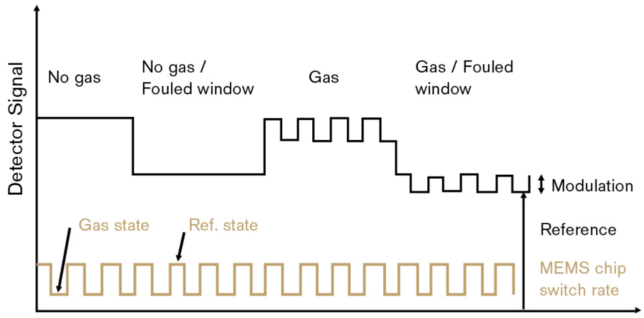

Figure 3: Detector signal in the event of No gas / Gas and Fouled window (the latter representing "other influences" on transmission). Note the ratio used for calculating the gas concentration (Modulation / Reference intensity) remains unchanged.

Moreover, the MEMS chip is a reliable and long-time stable electronic component without conventional moving parts. The crystalline silicon is perfectly elastic, and the forces of gravity, vibration, or acceleration have no influence on the repeatable micrometer-scale movement. The filter functions for gas and reference state (See Figure 2 previous page) are defined by etching patterns in the silicon chip. These patterns are physical surface reliefs with no ageing effects.

Triple-wavelength detection and single-beam design – both unique to the GS01 gas detector – are the key reasons why GasSecure can provide lifetime calibration for their product. In other words, field calibration by the user will never be required for this gas detector.

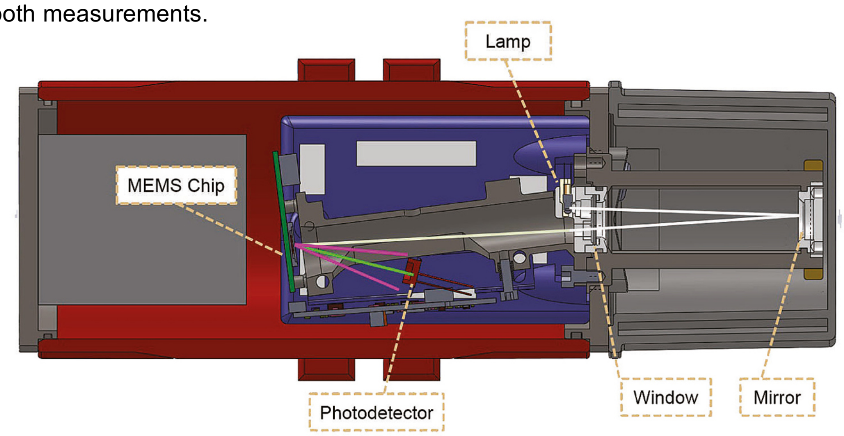

Figure 4: Cross sectional view of the GS01 gas detector showing the main optical components and the light path. The white line represents the incident broadband light from the lamp, whereas the filtered light for gas and reference measurement is represented as green and purple line, respectively.

GAS SECURE
A Dräger Company

Dräger

FIELD TEST DATA

The Norwegian oil company Statoil was one of the first to deploy the GS01 gas detector from GasSecure on an oil and gas production platform offshore, namely Gullfaks C. The wireless gas detectors were manufactured and factory-calibrated in November 2012 and commissioned on the platform in January 2013. In October 2013, one year after factory calibration, GasSecure staff returned to the platform for detector validation.

Table 1 below shows the zero point for 10 detectors, all located in one fire area, when exposed to dry nitrogen from a gas cylinder. All detectors are well within the stated specification of +/- 3 %LEL, confirming a stable zero point one year after factory calibration and without any need for re-calibration in the field.

Table 1: Zero point measurement on GS01 detectors installed on Gullfaks C platform one year after factory calibration.

Device tag	Zero point [%LEL]
DG-M24T-69	0
DG-M24T-70	0.6
DG-M24T-71	0.4
DG-M24T-72	-1
DG-M24T-73	0.7
DG-M24T-74	-0.4
DG-M24T-75	0.1
DG-M24T-76	1.7
DG-M24T-77	0
DG-M24T-78	-0.1

A major oil & gas company in Malaysia selected the GS01 gas detector for a refinery application. The detectors were manufactured and calibrated in March 2013 and commissioning for this project took finally place in April 2014.

As part of the preceding acceptance test all detectors were in March 2014 validated with 2.5 %vol. methane (in synthetic air) providing a nominal reading of 57 %LEL.

Table 2 shows the recorded readings, which are all within GasSecure's specification of +/- 5 %LEL for concentrations greater than 50 %LEL, notably one year after factory calibration and without any re-calibration in the field.

Table 2: Validation of GS01 detectors as part of a customer acceptance test, one year after the initial factory calibration.

Device tag	Reading with test gas
292GDA007	55.8
283GDA002	54.6
283GDA003	53.2
293GDA001	58.2
292GDA008	57.9
291GDA011	57.1
291GDA012	61.8
294DGA011	61.2
294DGA012	52.6
294GDA012	53.6
225GDA021	53.9
225GDA022	55.9

SUMMARY

The GasSecure GS01 gas detector is taking infrared (IR) absorption spectroscopy to the next level using patented MEMS (Micro Electro Mechanical System) optical filters. With this technology, GasSecure has designed a gas detector for harsh environments with no zero and no span drift in a wide operating temperature range. Three wavelengths are utilized for the gas and reference measurement and this triple-wavelength detection provides a more reliable quantification of the gas concentration.

The MEMS filter also enables a true single-beam design i.e. the light path and all optical components are the same for the gas and the reference measurement. With this design any long-term aging effects, primarily source intensity and detector sensitivity changes, are effectively eliminated.

In conclusion, the GS01 creates value for the customer with reliable infrared operation and a calibration-free design.

CORPORATE HEADQUARTERS
Drägerwerk AG & Co. KGaA
Moislinger Allee 53–55
23558 Lübeck, Germany

www.draeger.com

MANUFACTURER
GasSecure
Hoffsveien 70 C
0377 Oslo, Norway
post@gassecure.com
www.gassecure.com

REGION DACH
Dräger Safety AG & Co. KGaA
Revalstraße 1
23560 Lübeck, Germany
Tel +49 451 882 0
Fax+49 451 882 2080
info@draeger.com

REGION EUROPE
Dräger Safety AG & Co. KGaA
Revalstraße 1
23560 Lübeck, Germany
Tel +49 451 882 0
Fax+49 451 882 2080
info@draeger.com

REGION MIDDLE EAST, AFRICA
Dräger Safety AG & Co. KGaA
Branch Office
P.O. Box 505108
Dubai, United Arab Emirates
Tel +971 4 4294 600
Fax+971 4 4294 699
contactuae@draeger.com

REGION ASIA PACIFIC
Draeger Safety Asia Pte Ltd
25 International Business Park
#04-20/21 German Centre
Singapore 609916
Tel +65 6308 9400
Fax +65 6308 9401
asia.pacific@draeger.com

REGION CENTRAL AND SOUTH AMERICA
Dräger Panama S. de R.L.
Complejo Business Park,
V tower, 10th floor
Panama City
Tel +507 377-9100
Fax +507 377-9130
contactcsa@draeger.com

Locate your Regional Sales Representative at: www.draeger.com/conta