The Safety Company

An introduction to

Open-Path-Gas-Detection

WHAT IS AN OPGD?

An Open-Path-Gas-Detector (OPGD) typically includes a Source (sometimes called a Transmitter) and a Receiver. The Source is designed to emit a beam of IR (Infrared) light towards the Receiver. The OPGD is designed to detect and alarm when there is a presence of an IR reactive hydrocarbon gas anywhere along its beam path.

Figure 1: Source and Receiver units of an OPGD

OPGD are widely used today to complement Point Gas Detectors (PGD) as an additional layer of detection within process areas, and as a standalone solution to detect dispersing gas plumes at boundary spaces of process areas and along the perimeter of a facility.

PRINCIPLE OF MEASUREMENT

Hydrocarbon gases are organic compounds made up of carbon and hydrogen atoms. Other organic compound gases such as alcohols will include also oxygen atoms in addition to the carbon and hydrogen atoms. The atoms forming an organic compound molecule are held together by interatomic bonds called covalent bonds. These bonds are not rigid sticks or rods but are like stiff springs that stretch and bend at their own natural frequency.

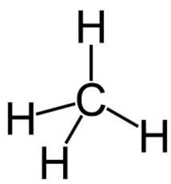

Figure 2: Molecular structure of methane gas

Virtually all organic compounds absorb radiated infrared (IR) energy that resonates with the natural frequency of its stretching and bending of its covalent bonds and the vibration motions of its component atoms. These organic compounds are termed as IR reactive.

Since each hydrocarbon gas has its own unique combination and arrangement of atoms, the IR absorption spectrum associated with it is also unique, like a fingerprint. The IR absorption spectrum can therefore be used to identify the gas with good accuracy. This is the general approach used in IR spectroscopy to identify individual gases in a gas sample.

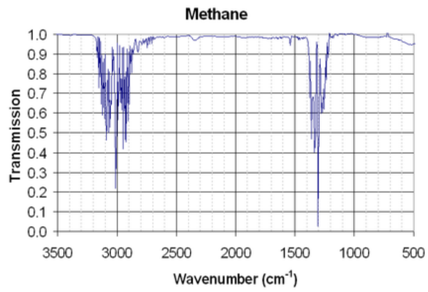

Figure 3: IR absorption spectrum of methane gas

Unlike IR spectroscopy however, the OPGD is not designed to identify individual gases in a sample. But it uses the same IR absorption nature of hydrocarbon/organic gases as the basis of detecting its presence within a space. By measuring the energy transmittance of an IR beam, the OPGD can reliably determine if there is a concentration of hydrocarbon/organic gas between the IR beam Source and the Receiver.

The OPGD is typically calibrated to a specific target gas so that it responds most accurately to the presence of this gas. But its sensing is non-specific. It will also sense other IR reactive hydrocarbon or organic gases, albeit less accurately. Since the OPGD is a safety instrument designed to detect and alarm the presence of any gas that may combust, this non-specificity is not usually a major issue.

The amount of IR energy transmittance from the Source to the Receiver depends on the type of hydrocarbon gas, the gas concentration, and the total length of gas cloud that the IR beam passes through. The relationship between energy transmittance (T) and these three factors can be stated as, $T=T_0 \exp(-acl)$ where T_0 is the transmittance of IR energy when there is no absorbing medium.

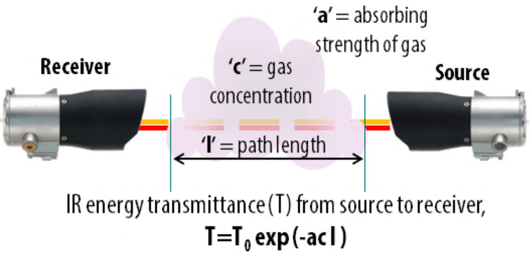

Figure 4: Typical setup of an open path gas detector

The absorbing strength of a gas depends largely on the mass of individual atoms and the types of covalent bonds (eg. C-C, C=C, C-H, C-O, C=O, O-H) that exist in a molecule of the gas. The stronger the absorbing strength of a gas is (i.e. larger 'a') the lower will be the transmittance of IR energy from the Source to the Receiver.

The gas concentration 'c', and path length 'l', determine the number of gas molecules that 'block' the IR beam and absorb energy from it. The higher the concentration is, or the longer the path length is, the greater would be the IR radiation energy that is absorbed.

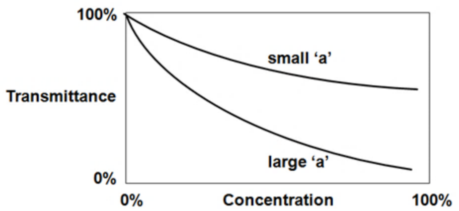

Figure 5: Relationship between transmittance, gas concentration and absorbing strength

For the OPGD, both the gas concentration and the path length 'l' are measurement variables. Therefore, it cannot determine the actual concentration of the gas or the size of the gas cloud. For example, it is possible for a small gas cloud with higher concentration to absorb the same amount of IR energy as a larger but lower concentration gas cloud. It is also possible for a series of small gas clouds of uniform concentration to absorb the same amount of energy as a single large cloud with similar concentration, if the total path length 'l' for both cases is the same. For both scenarios in each of these two possibilities, the OPGD would produce the same gas reading.

Commonly, an OPGD cannot:

- Discriminate the type of hydrocarbon gas it is sensing although it is calibrated to a specific target gas;
- Determine the actual concentration of the detected gas;
- Determine the size of the gas cloud;
- Determine if it is a single gas cloud or a series of gas clouds;
- Determine the location of the detected gas cloud.

IR5500 OPGD

The IR5500 is a very good example of an OPGD which uses the non-dispersive IR (NDIR) absorption principle. It uses a single beam, dual wavelength method of IR absorption detection. An IR reactive hydrocarbon gas will absorb one wavelength (commonly called the active wavelength) but not the other one that acts as a reference wavelength.

The reference wavelength is chosen to compensate for interferences that can occur due to atmospheric variations, such as humidity, rain, dust, snow, fog, steam, and temperature. The IR5500 computes gas readings by comparing the energy measurements of the active and reference wavelengths.

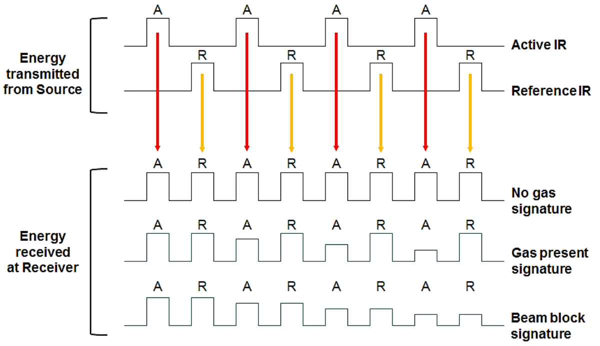

Figure 6: Difference between gas alarm and beam block

Since the OPGD depends on a clear line-of-sight between its Source and Receiver units, it is crucial that it can detect any situation that blocks the transmittance of its beam. The IR5500 does this by continuously checking if both the active and reference wavelengths of its beam are interrupted at the same time, which can happen when the beam is blocked by an object, a person, or dense fog. The IR5500 will interpret such interruptions as a beam block situation and raise a fault notification accordingly.

However, since a beam blockage may be temporary and short duration (e.g. blockage by a passing person or vehicle), a delay (up to 60s) can be set on the IR5500 so that it raises the fault notification only after the delay countdown.

Optimization options:

- Light hydrocarbon gas (CH_4)
- Heavy hydrocarbon gas (C_3H_8)

Measuring ranges:

- 0 - 5000ppm.m/ 0-5LEL.m (CH_4)
- 0 - 2000ppm.m/ 0-1LEL.m (C_3H_8)

Measuring distance:

- 5 - 150 meters

Safety integrity level:

- SIL3 (PFD_{1oo1} = 1.7 x 10^{-4}, SFF>99%)

Body material

- SS 316

EX classification:

- II2GD, Exd IIB+H_2 T4 Gb
- Ex tb IIIC T135°C Db, IP66/67 (T_{amb}= -55°C to +65°C)

Agency approval:

- IECEx, ATEX, FM, CSA, GOST, INMETRO, DNV

Calculating Gas Readings

Most OPGD measure and display readings in LEL.m scale but a high sensitivity OPGD like the IR5500 includes measurements in both ppm.m and LEL.m scales. Table 1 and Table 2 below illustrate how gas readings on the IR5500 are derived.

Size of Gas Cloud	IR5500 Display (LEL•m)
20% LEL x 1 meter	0.2
10% LEL x 2 meters	0.2
100% LEL x 2½ meters	2.5
50% LEL x 5 meters	2.5
100% LEL x 1 meter	1.0
50% LEL x 2 meters	1.0
25% LEL x 4 meters	1.0
10% LEL x 10 meters	1.0

Table 1: Calculating LEL.m readings

Size of Gas Cloud	IR5500 Display (ppm•m)
50 ppm x 2 meters	100
25 ppm x 4 meters	100
10 ppm x 10 meters	100
100 ppm x 5 meters	500
50 ppm x 10 meters	500
500 ppm x 5 meters	2500
100 ppm x 25 meters	2500
5% LEL x 1 meter	2500
1% LEL x 5 meters	2500
.5% LEL x 10 meters	2500

Table 2: Calculating ppm.m readings

Setting Alarming Thresholds

Since the gas risk scenario is likely to vary from area to area, the alarming thresholds at each OPGD position should rightly be individually determined with careful consideration of the following:

- Distance of the OPGD beam path from the potential leak points it is monitoring.
- Terrain and obstructions in the area;
- Process conditions (gas composition, pressure, temperature) in the area.
- Weather conditions (wind speed, humidity, solar radiation, cloud cover etc.) in the area.
- Wind directions probability in the area.

Unrealistically high alarming thresholds could result in low and unsatisfactory probability of alarming, as well as longer response times.

The effect of alarm thresholds on alarming likelihood can be observed by assessing the scenario detection coverage of a given OPGD layout with the OPGD set at different alarm thresholds. An example assessment is shown below. High scenario detection coverage factors imply high alarming likelihoods and vice versa.

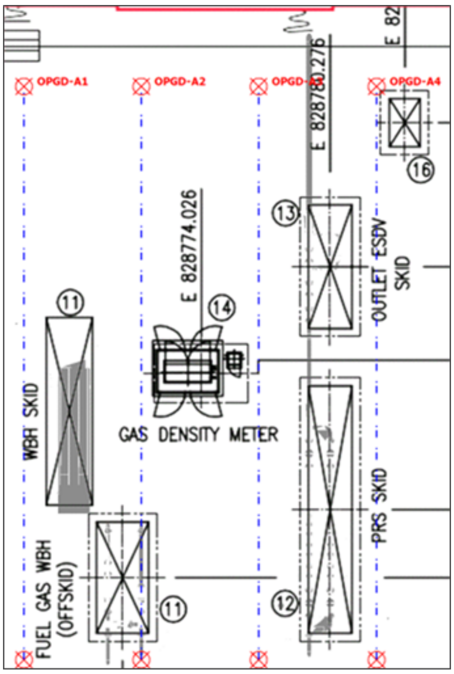

Figure 7: Detector layout used in scenario detection coverage assessment.

Detector	Threshold	Leak size	Plume	Scenario coverage	
				1ooN	2ooN
OPGD-A1 OPGD-A2 OPGD-A3 OPGD-A4	0.2LFL.m	5mm	10%LEL	99%	44%
	1.0LFL.m			17%	4%
	2.0LFL.m			1%	0%

Table 3: Scenario detection coverage factors for different alarm threshold settings.

Adjusting Pan-Tilt

Most OPGD instruments today come with mounting arms or mounting base assemblies that permit pan-tilt adjustments. Pan-tilt adjustments are needed so that the Receiver and the Source units can be aligned with relative ease.

But the design and sturdiness of the pan-tilt mechanics on the assembly are crucial. The design must allow *fine* pan-tilt adjustments so that it is easier to achieve accurate alignment, especially when the separation distance between the Source and Receiver is long. Over a long distance, a small step change in pan or tilt angle of the Source, would translate into a corresponding large lateral or vertical movement of the IR beam at the Receiver end. Therefore, it is very helpful if final adjustments can be done in very fine small steps. Otherwise the process of alignment would be difficult and arduous. Fine pan-tilt adjustment is standard on both the arm and base type assemblies of the IR5500.

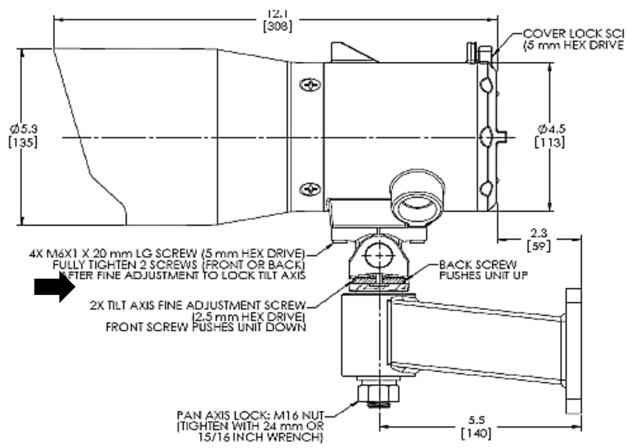

Figure 8: Pan-tilt arm assembly with fine adjustments

Additionally, the pan-tilt mechanics on the mounting arm or base must be sturdy enough so that the perfect alignment that was fixed during instrument setup is maintained even though the instrument experiences vibrations during operation. Otherwise, because of vibrations the IR beam may gradually shift from perfect alignment during operation and this would eventually lead to an OPGD optical fault. Both the arm and base assemblies of the IR5500 are certified to FM6325 performance standard.

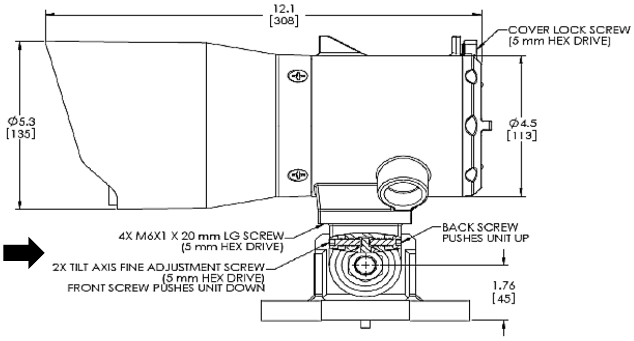

Figure 9: Pan-tilt base assembly with fine adjustments

FM 6325 performs vibration tests at a frequency range of 10 Hz to 30 Hz at a total excursion of 1mm and 31Hz to 150 Hz at a 2 g acceleration peak for a period of 1 hour in each of three mutually perpendicular directions. The rate of change of frequency does not exceed 10 Hz/min.

The gas reading of the IR5500 remains accurate up to a misalignment angle of ±0.5 degrees. The IR5500 passes the alignment test criteria of IEC 60079-29-4 which requires that at the stated misalignment angle, the equipment shall not generate any false alarms and the measured values of the integral concentration for each gas shall not differ from the nominal values by more than ±10% of the measuring range or ±20% of the measured value, whichever is greater.

Aligning Source And Receiver Units

The goal of this process is to align as accurately as possible the optical centreline of the Source and Receiver units. This is to ensure that the signal that is received by the Receiver is as strong as possible and above the minimum requirement for a given monitoring distance.

The IR5500 receiver unit has an accurate method of determining if the signal received is adequate. During the alignment procedure, the receiver indicates the actual signal strength received as an AJ value on the local indicator.

Figure 10: Receiver unit with built-in alignment indicator

Std Config Range (20-100 m)	20 m	30 m	40 m	50 m	60 m	70 m	80 m	90 m	100 m
Extended Path Range (80-150 m)	n/a	80 m	90 m	100 m	110 m	120 m	130 m	140 m	150 m
AJ value	72 to 67	65 to 60	59 to 54	53 to 48	49 to 43	45 to 38	43 to 35	39 to 32	35 to 30

Table 4: Optimal AJ value band for a given monitoring distance

The wide misalignment angle of the IR5500 at ±0.5 degrees also means that this instrument is easier to align than other OPGD with narrower misalignment angles.

Positioning Source and Receiver Units

When two or more units of OPGD are positioned to monitor adjacent spaces, care must be taken to avoid measurement errors caused by IR interference from one unit to the other. There are two scenarios where this could easily happen.

First, when two OPGD units are positioned side by side and because of cabling or other reasons both Receiver units are located at the same end. This is illustrated in the diagram below. In this scenario, the nearer OPGD may pick up additional IR energy from the adjacent IR Source thereby producing a reading error.

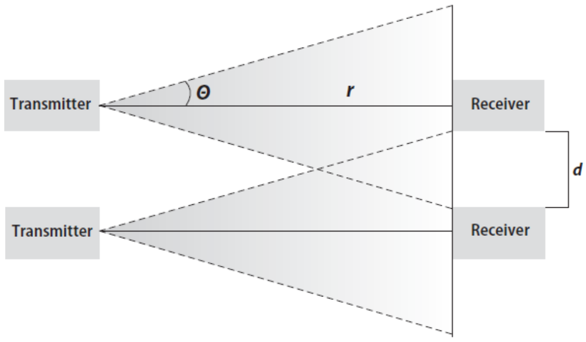

Figure 11: IR interference when two adjacent OPGD units have Receivers at the same end

One way to eliminate this problem is by separating the two sets by a minimum distance *d*. Assuming the Source is oriented so that the Receiver is barely aligned, the minimum separation is given by $d = 2r\tan\theta\cos\theta$ where *r* is the open path length and θ is the misalignment tolerance angle.

LINE OF SIGHT DISTANCE M (FT)	MINIMUM SEPARATION, M (FT)	LINE OF SIGHT DISTANCE M (FT)	MINIMUM SEPARATION, M (FT)
10 (33)	0.5 (2)	110 (361)	5.8 (19)
20 (66)	1.0 (3)	120 (394)	6.3 (21)
30 (98)	1.6 (5)	130 (427)	6.8 (22)
40 (131)	2.1 (7)	140 (459)	7.3 (24)
50 (164)	2.6 (9)	150 (492)	7.9 (26)
60 (197)	3.1 (10)	160 (525)	8.4 (27)
70 (230)	3.7 (12)	170 (558)	8.9 (29)
80 (262)	4.2 (14)	180 (591)	9.4 (31)
90 (295)	4.7 (15)	190 (623)	9.9 (33)
100 (328)	5.2 (17)	200 (656)	10.5 (34)

Table 5: The minimum separation distance *d* of two adjacent IR5500 units when both Receivers are at the same end

If there is no cabling or any other constraint, a better solution would be to mount both Receivers at opposite ends, as illustrated in the diagram below. This will completely avoid cross interference between two adjacent OPGD units.

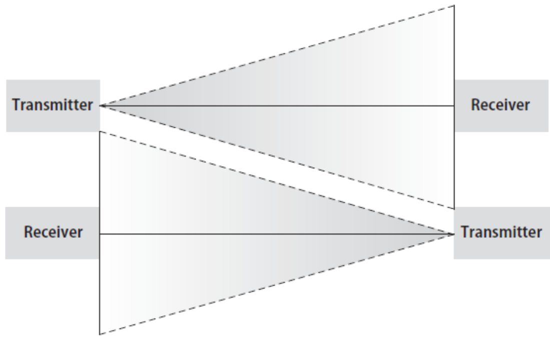

Figure 12: No IR interference when two adjacent OPGD units have Receivers at opposite ends

The second scenario where interference can happen is when two OPGD units are in a straight line, such as when two sets of OPGD are used to monitor a very long boundary line. When both Source units are facing the same direction, like in the top diagram of Figure 13, one Receiver unit may see IR radiation from both Sources. To prevent this from happening, the Source units of adjacent OPGD units should be positioned to face opposite directions, like in the lower two diagrams.

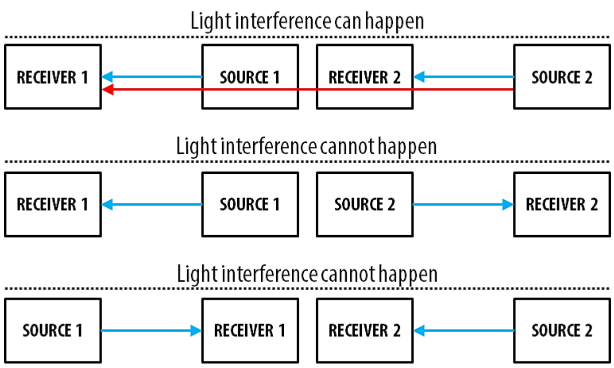

Figure 13: Avoiding IR interference when two OPGD units are positioned in a line

Applying OPGD

There are 3 common ways of applying OPGD:

1) Leak points monitoring

The OPGD beam is positioned above or near a cluster of potential leaks points, such as a row of compressors, pumps, valves, pipe joints, flanges or transfer hose nozzles.

Shown below is an example of OPGD monitoring (white dashed line) over a line of LPG offloading transfer nozzles on a FPSO. The OPGD is positioned to detect formations of propane gas cloud due to LPG spillage during offloading.

Figure 14: Leak point monitoring of offloading nozzles at a FPSO LPG offloading area

The second example below illustrates the use of OPGD to monitor a long line of valves at an LPG storage area.

Figure 15: Leak point monitoring of a row of valves

2) Boundary line monitoring

The OPGD beam is positioned to form a boundary on one side of an area where gas release could occur. Shown below is an example of boundary monitoring at an LPG storage area. The OPGD beam forms an imaginary boundary between the storage area and the vehicle access road.

Figure 16: OPGD monitoring at boundary of LPG storage tank farm

It is important to note that in boundary line monitoring, the OPGD beam is likely to be at some distance away from the point where gas release happens. Due to diffusion and wind dilution, the concentration of gas plumes at the OPGD beam path is likely to be low, not uniform and therefore difficult to detect.

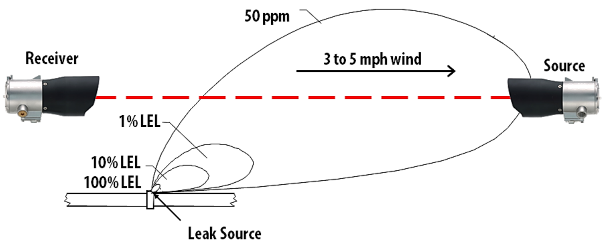

Figure 17: Decreasing gas cloud concentration under light breeze condition

It should be realized that a low concentration at the outer fringes of the plume does not mean that the gas release is any less dangerous. Closer to the point of release, the size of a higher gas concentration plume can be significant and can therefore pose a significant explosion risk.

If the gas release continues unmitigated over some time, this high gas concentration core could grow larger in size and pose a substantially greater threat.

It is therefore advantageous for gas alarming, if the OPGD that is applied for boundary line monitoring is also capable of measuring and alarming gas at lower concentrations (ppm.m) in addition to the more common LEL.m measurements.

3) Volumetric monitoring

The aim of volumetric monitoring is to ensure that gas clouds that are produced by gas leaks, do not grow to a size that can produce more destructive explosions.

Experiments have shown that for methane or propane gas clouds within an unconfined or partially confined space, a smaller than 6 meters long cloud is unlikely to produce a very destructive explosion should it be ignited. In spaces with greater obstructions and confinement, and for gases with greater reactivity, this distance can be considerably shorter than 6 meters. Radial distances of between 3 meters (high degree of obstruction, high degree of confinement, high gas reactivity) and 6 meters (low degree of obstruction, low degree of confinement, natural gas reactivity) are commonly used.

Both Point Gas Detectors (PGD) and OPGD can be applied for volumetric monitoring, but the OPGD offers the advantage of larger volumetric coverage with a single unit. This makes the OPGD a more cost-effective solution when applying volumetric monitoring for a large space.

Shown below is an example where several units of OPGD are positioned to provide volumetric monitoring of a wellhead deck. The OPGD beams are spaced 5 meters apart and positioned to ensure that no gas cloud formations can grow larger than 4~5 meters without triggering a gas alarm.

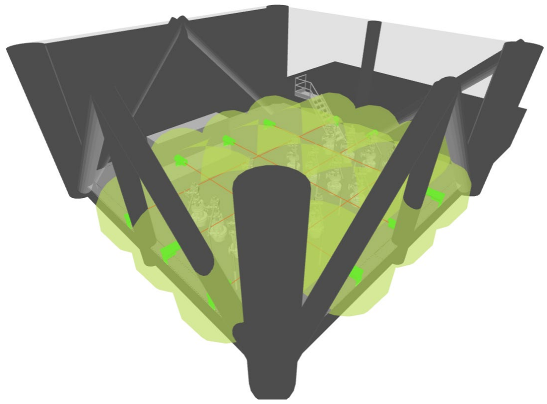

Figure 18: Volumetric monitoring on a Wellhead deck

Improving Detection Likelihood with OPGD

A scenario gas detection coverage mapping study is one good way to determine the optimal quantity and positions of detectors that would give the highest likelihood of detecting gas hazards. This method of mapping study considers:

- Layout and failure rates of equipment
- Gas composition
- Process conditions
- Weather conditions
- Wind direction probabilities
- Alarming threshold

Such studies are typically performed with software tools like DNV's PHAST consequence analysis software and KENEXIS's EFFIGY Flame & Gas mapping software.

Figures 19 to 21 illustrate how such a study is used to progressively improve the likelihood of detecting gas hazards in an area. The various colours represent the likelihood of gas hazards in an area. On the scale shown, grey areas are where undetected gas hazards is most unlikely with a likelihood of almost 10^{-7} per year. This can mean either gas hazards arising within the area is most unlikely or the likelihood of gas detectors detecting the gas hazards before it reaches the area is near perfect (i.e. >99.99%).

Figure 19 is the initial gas risk map before mitigation. It shows that the likelihood of undetected gas hazards over large portions of the area is between 10^{-6} to 10^{-4} per year.

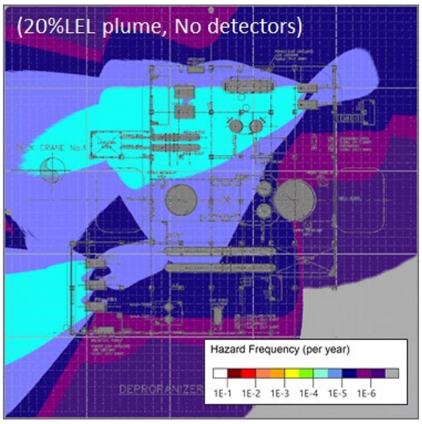

Figure 19: Gas risk map without gas detectors

Figure 20 is the gas risk map of the same area when twelve units of PGD were applied. The likelihood of undetected gas hazard remains between 10^{-6} to 10^{-4} per year over significant portions of the area, although there is slight improvement over a small section in the centre. There are a few ways to improve the likelihood of detection, including using OPGD.

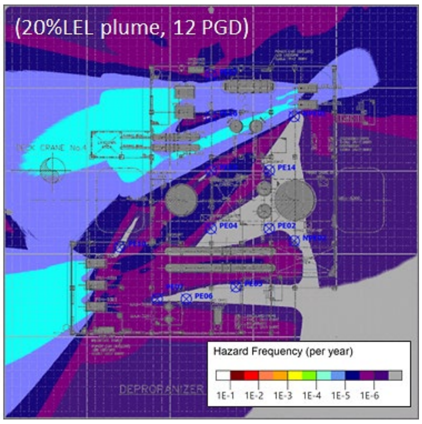

Figure 20: Gas risk map with 12 PGD

Figures 21a, 21b and 21c are gas risk maps of the same area when six OPGD were added to supplement the twelve PGD. Clearly, the OPGD with its greater coverage can easily improve the likelihood of detection, but the degree of improvement is highly dependent on its alarm threshold setting.

When the OPGD alarm threshold is set at 1000ppm.m (Figure 21c), the likelihood of undetected gas hazard over almost the entire area is lower than 10^{-5} per year, with large portions of the area lower than 10^{-6} per year. This is a significant improvement over the initial likelihood.

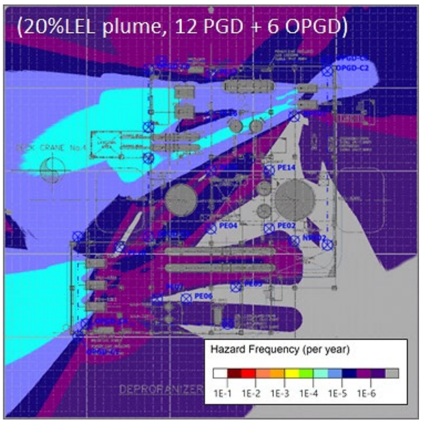

Figure 21a: Gas risk map with 12 PGD (20%LEL alarm threshold) + 6 OPGD (1.0 LEL.m alarm threshold)

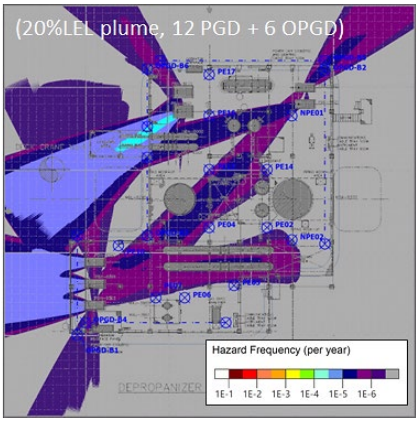

Figure 21b: Gas risk map with 12 PGD (20%LEL alarm threshold) + 6 OPGD (0.2 LEL.m alarm threshold)

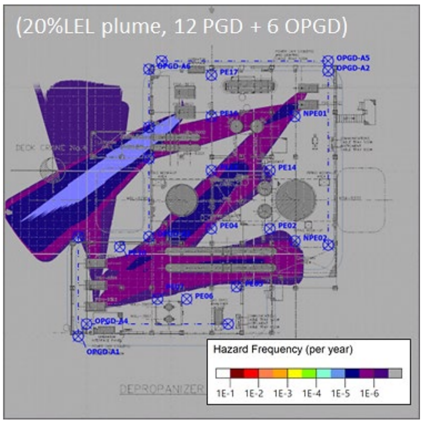

Figure 21c: Gas risk map with 12 PGD (20%LEL alarm threshold) + 6 OPGD (1000 ppm.m alarm threshold)

Calibrating & Testing

The IR5500 does not require periodical field calibration. The filters that are used for active and reference IR wavelength selection do not degrade with time so the detector will remain accurate throughout its operational lifespan. To change the detector calibration from methane to propane or vice-versa would require the unit to be returned to the factory.

The IR5500 uses a single beam, dual wavelength, single IR detector method of IR absorption detection. This minimizes zero drift compared with designs that use more than one IR detector in the Receiver. Zeroing adjustments are performed automatically by the detector electronics when the alignment process in completed and the AJ reading is accepted. No special tools are needed.

To test the response of the detector, test filter kits P/N329083-1 (methane) and P/N 329084-1 (propane) are used. Each part number contains one ppm.m filter and one LEL.m filter.

About the Author

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The author has a bachelor's degree in electrical & electronics engineering from the National University of Singapore and is a Certified Functional Safety Professional. He has 28 years of professional experience in Fire & Gas System solutions and is now providing technical consulting support for MSA's global FGFD organization.

Acknowledgements

My appreciation and thanks to Ian Cameron for reviewing this application note and giving me valuable feedback.

Configuring & Selecting Options

MODEL IR5500 OPEN PATH COMBUSTIBLE GAS DETECTOR

	A		B		C		D		E		F		G		H		I		J
	□		□		□		□		□		□		□		□		□		□
IR5500 -	1	-	1	-	1	-	1	-	2	-	2	-	1	-	1	-	1	-	1

IR OPEN PATH COMBUSTIBLE GAS DETECTOR

(Std) IR5500 IR OPEN PATH COMBUSTIBLE GAS DETECTOR

A. ALARM-RELAYS:

0- □	RELAYS INHIBITED
1- □(Std)	W/ALARM RELAYS ALL DE-ENERGIZED
2- □	W/ALARM RELAYS ALL ENERGIZED

B. ALARM-RELAY-STATES:

1- □(Std)	LATCH HIGH, NON-LATCH LOW, NON-LATCH ppm HIGH
2- □	LATCH HIGH, NON-LATCH LOW, LATCH ppm HIGH
3- □	LATCH HIGH, LATCH LOW, NON-LATCH ppm HIGH
4- □	LATCH HIGH, LATCH LOW, LATCH ppm HIGH
5- □	NON-LATCH HIGH, NON-LATCH LOW, NON-LATCH ppm HIGH
6- □	NON-LATCH HIGH, NON-LATCH LOW, LATCH ppm HIGH
7- □	NON-LATCH HIGH, LATCH LOW, NON-LATCH ppm HIGH
8- □	NON-LATCH HIGH, LATCH LOW, LATCH ppm HIGH

C. ID NUMBER OPTION:

1- □(Std)	ID=1
2- □	CUSTOMER TO SPECIFY ID#

D. MOUNTING ASSEMBLY:

0- □	NO MOUNTING ASSEMBLY
1- □(Std)	PAN-TILT ARM ASSEMBLY, 2 ea

E. OUTPUT:

2- □(Std)	0-20mA/1.25mA HART/MODBUS
3- □	0-20mA/3.5mA HART/MODBUS
5- □	SPLIT RANGE 0-20mA/1.25mA HART/MODBUS
6- □	SPLIT RANGE 0-20mA/3.5mA HART/MODBUS
9- □	Dual analog/HART off/MODBUS

F. RANGE:

1- □	5-30 METERS (SHORT RANGE)
2- □(Std)	20-100 METERS (STD RANGE)
3-	80-150 METERS (LONG RANGE)

G. IR-SOURCE/THREAD TYPE:

0- □	NO SOURCE
1- □ (Std)	3/4in NPT
2- □	25mm
3- □	3/4in NPT w/VISIBLE LIGHT FILTER
4- □	25mm w/VISIBLE LIGHT FILTER

H. IR-RECEIVER/GAS TYPE/THREAD TYPE:

0- □	NO RECEIVER
1- □ (Std)	METHANE 3/4in NPT
2- □	METHANE 25mm
4- □	PROPANE 3/4in NPT
5- □	PROPANE 25mm

I. CONNECTOR TYPE

1- □ (Std)	PUSH TERMINAL
2- □	SCREW TERMINAL
3- □	SCREW TERMINAL M20, GREY
4- □	SCREW TERMINAL 3/4 NPT, GREY

J. APPROVALS:

1- □ (Std)	FM/CSA/ATEX/IECEx
2- □	INMETRO/Japan
3- □	GOST

IR5500 OPEN PATH DETECTOR:

329001-1	IR5500 SOURCE ASSY, 3/4" NPT, SCREW, STD RANGE
329001-2	IR5500 SOURCE ASSY, 3/4" NPT, PUSH, STD RANGE
329001-9	IR5500 SOURCE ASSY, 3/4" NPT, SCREW, STD RANGE, VISIBLE LIGHT FILTER
329001-10	IR5500 SOURCE ASSY, 3/4" NPT, PUSH, STD RANGE, VISIBLE LIGHT FILTER
329001-25	IR5500 SOURCE ASSY, 3/4" NPT, SCREW, SHORT RANGE
329001-26	IR5500 SOURCE ASSY, 3/4" NPT, PUSH, SHORT RANGE
329001-31	IR5500 SOURCE ASSY, 3/4" NPT, SCREW, SHORT RANGE, VISIBLE LIGHT FILTER
329001-32	IR5500 SOURCE ASSY, 3/4" NPT, PUSH, SHORT RANGE, VISIBLE LIGHT FILTER
329073-1	PAN-TILT ARM ASSEMBLY IR5500 (STD)
329082-1	LONG RANGE ALIGNMENT KIT IR5500
329083-1	FILTER KIT IR5500, METHANE
329084-1	FILTER KIT IR5500, PROPANE
329136-1	PAN ADJUSTMENT TOOL (WRENCH)
329314-1	SOURCE STACK KIT, SCREW TERMINALS*
329314-2	SOURCE STACK KIT, PUSH TERMINALS*
954-021	ALLEN WRENCH T-HANDLE 5mm X 9in BALL END
31037-1	DOUBLE CALIBRATION MAGNET (FOR OPEN PATH)

The Safety Company