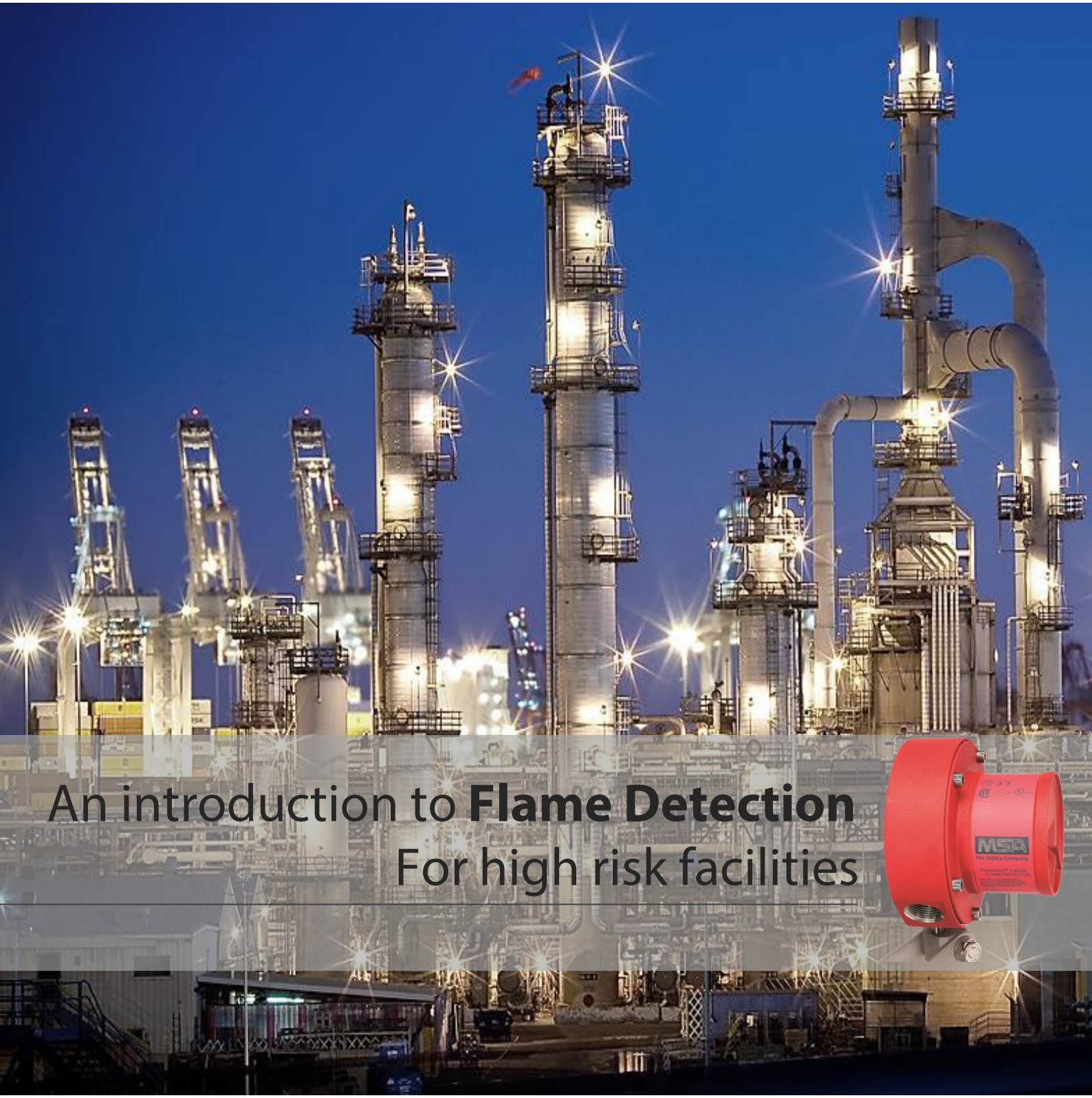
Fire and Gas **System Solutions**

Application Note

MSA The Safety Company



An introduction to **Flame Detection**

For high risk facilities

*Because every life has a **purpose…***

Principles Of Flame Detection

Flaming fires in many high risk facilities (eg. offshore platforms, FPSO, refineries, gas plants, petrochemical plants and power stations) are generally fuelled by hydrocarbons, which when supplied with oxygen and an ignition source, produce heat, carbon dioxide, and other products of combustion. The intense reaction is characterized by the emission of visible, UV, and IR radiation.

Flame detectors are designed to detect the emission of light at specific wavelengths, allowing them to discriminate between flames and false alarm sources. Almost all materials emit ultraviolet radiation to some degree during flaming combustion, whereas only carbon-containing fuels emit significant radiation at the 4.35µm (CO_2) wavelength used by many detector types to detect a flame (See Figure 1 below).

[From NFPA72-2002 Fig A.5.8.2.1]

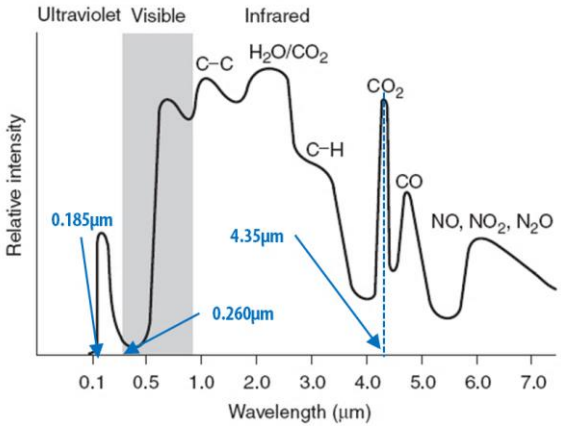


Figure 1: Spectrum of a typical hydrocarbon flame

Different hydrocarbon fuels produce different radiation spectrum. Knowing the kind of hydrocarbon fuel and understanding the kind of fire that it is likely to produce is an important step in flame detector selection for an application.

Thick sooty smoke typically produced by heavy hydrocarbon fuel such as crude oil, tend to scatter and attenuate UV radiation. This may reduce the effectiveness of UV and UVIR type flame detectors. In such situations, MSIR flame detectors are usually more suitable.

Non-carbon-containing fuels such as hydrogen sulphide gas produce very little IR radiation. In this case, MSIR flame detector would not be a suitable choice of flame detector.

Flame Detection For Common Fuels

Fuel	Radiation emission	Detector type
C_1 to C_{10} gas	UV, IR	UV[1], UVIR, MSIR
LNG / LPG	UV, IR	UV[1], UVIR, MSIR
H_2 gas	UV, IR	UV[1], UVIR-H_2, MSIR[2]
H_2S gas	UV	UV[1]
Alcohols	UV, IR	UV[1], UVIR, MSIR
Solvents	UV, IR	UV[1], UVIR, MSIR
Gasoline	UV, IR	UV[1], UVIR, MSIR
Jet fuel	UV, IR	UV[1], UVIR, MSIR
Crude oil	UV, IR	MSIR
Paper / wood	UV, IR	UV[1], UVIR, MSIR
Textile	UV, IR	UV[1], UVIR, MSIR

[1]UV detectors are usually not suitable for outdoor installations

[2]MSA's MSIR is not designed for H_2 detection at this time.

Suitable Areas Of Application

Types of applications where flame detectors are suitable:

a) High-ceiling, open-spaced buildings such as warehouses and aircraft hangars;
b) Outdoor or semi-outdoor areas where winds or drafts can prevent smoke from reaching a heat or smoke detector;
c) Areas where rapidly developing flaming fires can occur, such as aircraft hangars, petrochemical production areas, storage and transfer areas, natural gas installations, paint shops, or solvent areas ;
d) Areas needing high fire risk machinery (eg. gas turbines) or installations, often coupled with an automatic gas extinguishing system;
e) Environments that are unsuitable for other types of detectors.

[From NFPA 72-2002 A.5.8.3.2.1]

Flame Detectors For Outdoor Areas

Because UV type detectors are susceptible to arc welding, halogen lamps, and electrical discharges like lightning, they tend to be installed indoors and rarely used outdoors.

There are two primary optical flame-sensing technologies that are widely used today for flame detection in outdoor process areas common within OGP facilities. These are ultraviolet/infrared (UVIR) and multi-spectrum infrared (MSIR). Both are based on line-of-sight detection of radiation emitted in the UV, visible, and IR spectral bands by flames. Selecting which technology to use will depend on the application, fuel type, detection range, FOV, response time, and particular immunity against certain false alarm sources.

MSIR Flame Detector *(Flamegard 5MSIR / FL4000H)*

Multi-Spectrum IR flame detectors use multiple infrared spectral regions to further improve differentiation of flame sources from non-flame background radiation. These flame detectors are well suited to locations where combustion sources produce smoky fires. They operate at moderate speed with a range of up to 70 meters from the flame source — both indoors and outdoors. These instruments exhibit relatively high immunity to infrared radiation produced by arc welding, lightning, sunlight, and other hot objects that might be encountered in industrial backgrounds.

- Sensitivity in detecting fires: 70m (0.092m^2 heptane fire)
- Speed of response: ≤10s
- PFD (1oo1): 2.4 x 10^{-5} (SIL3, SFF>99%)
- Body material: SS 316
- EX classification: II 2 G D , Ex d IIC T5 Gb
  Ex tb IIIC T100°C Db
  (Ta =-40°C to +80°C)
- Agency approval: IECEx, ATEX, FM, CSA, ULC, INMETRO, VNIIPO, BV, MED, DNV (only for FL4000H)

UVIR Flame Detector *(Flamegard 5 UVIR / FL3100H)*

When a UV optical sensor is integrated with an IR sensor, a dual band detector is created that is sensitive to the UV and IR radiation emitted by a flame. The combined UVIR flame detector offers increased immunity over the UV detector, operates at moderate speeds of response, and is suited for both indoor and outdoor use. As with UV detectors, however, the detection range of UVIR flame detectors may be reduced by heavy smoke.

- Sensitivity in detecting fires: 15.2m (0.092m^2 heptane fire)
- Speed of response: <3s @ 15.2 m (50 ft)
- PFD (1oo1): 3.9 x 10^{-5} (SIL3, SFF>99%)
- Body material: Anodised aluminium or SS 316
- EX classification: II 2 G D, Ex d IIC T5 Gb
  Ext IIIC T100°C Db IP66/67
  (Ta =-40°C to +85°C)
- Agency approvals: IECEx, ATEX, FM, CSA, GOST, INMETRO

UVIR-H_2 Flame Detector *(Flamegard 5 UVIR-H_2 / FL3100H-H_2)*

The UVIR-H_2 flame detector is optimized to detect hydrogen flames. It detects the 2.95µm IR wavelength (H_2O) instead of the 4.35µm IR wavelength of standard UVIR flame detectors.

- Sensitivity in detecting fires: 4.6m (6"-8" height H_2 flame)
- Speed of response: <3s @ 4.5 m (15 ft)
- Body material: Anodised aluminium or SS 316
- EX classification: II 2 G D, Ex d IIC T5 Gb
  Ext IIIC T100°C Db IP66/67
  (Ta =-40°C to +85°C)
- Agency approvals: IECEx, ATEX, CSA,GOST,INMETRO

Flame Detector For High Temperature Enclosures

UV Flame Detector *(FL3111HT)*

This UV flame detector detects only the ultraviolet (UV) spectral range of the flame for high speed of response and has a maximum operating temperature of 125°C. It is designed specifically for flame detection and automatic fire suppression in enclosures such as those used for gas turbines within which the operating ambient temperatures can be very high. The high operating temperature rating was achieved by the use of a specially selected detector and electronic components, with very low power consumption to reduce self-heating.

- Sensitivity in detecting fires: 15.2m (0.092m^2 heptane fire)
- Speed of response: <1s @ 15.2 m (50 ft)
- PFD (1oo1): 2.6 x 10^{-4} (SIL2, SFF<99%)
- Body material: SS 316
- EX classification: Ex de IIC T3 T140°C
  (Ta = -40°C to 130°C)
- Agency approval: ATEX

Flame Detector Field of View (FoV)

Detection range and FoV define area coverage per device. Like a camera with a wide angle lens, a flame detector with a large FoV can take in a broader scene, which may help reduce the number of flame detectors required for certain installations. A wide FoV is particularly useful when the detectors are mounted in close proximity to the monitored area. The horizontal and vertical FoV of a flame detector are determined by the design of the detector optics.

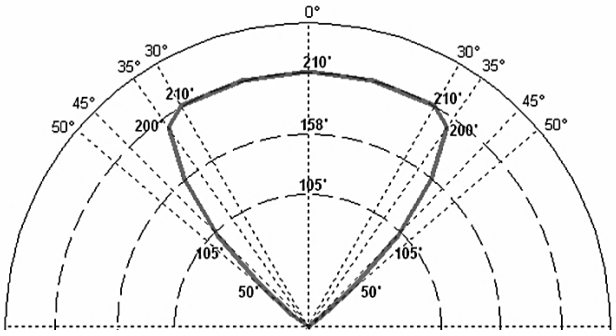


Figure 2 FlameGard 5 MSIR/FL400H horizontal FoV at high sensitivity with 0.092m^2 n-Heptane test flame

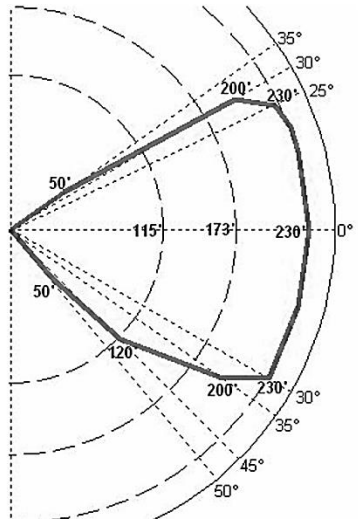


Figure 3 FlameGard 5 MSIR/FL4000H vertical FoV at high sensitivity with 0.092m^2 n-heptane test flame

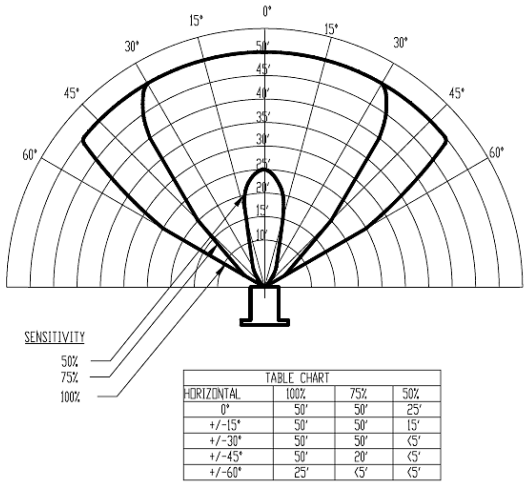


Figure 4 FlameGard 5 UVIR/FL3100H horizontal FoV with 0.092m^2 n-Heptane test flame

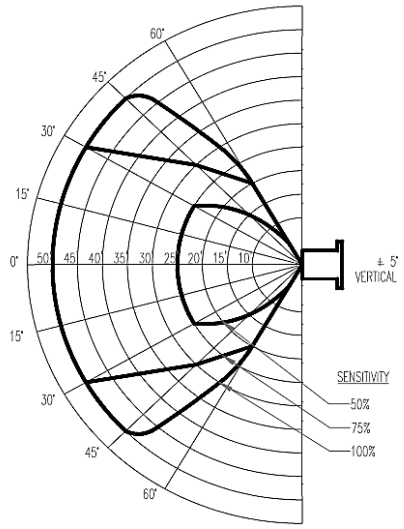


Figure 5 FlameGard 5 UVIR/FL3100H vertical FoV with 0.092m^2 n-Heptane test flame

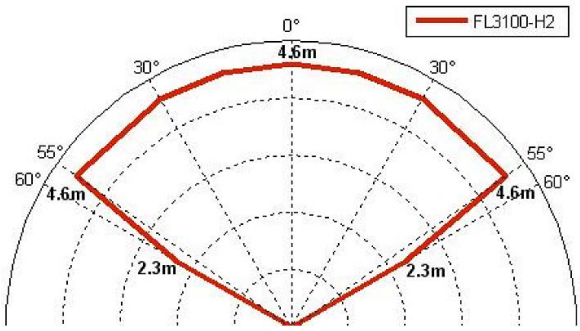


Figure 6 FlameGard 5 UVIR-H_2/FL3100H-H_2 horizontal FoV with a 15 cm (6 in) diameter and 15 – 20 cm (6 – 8 in) high H_2 gas flame

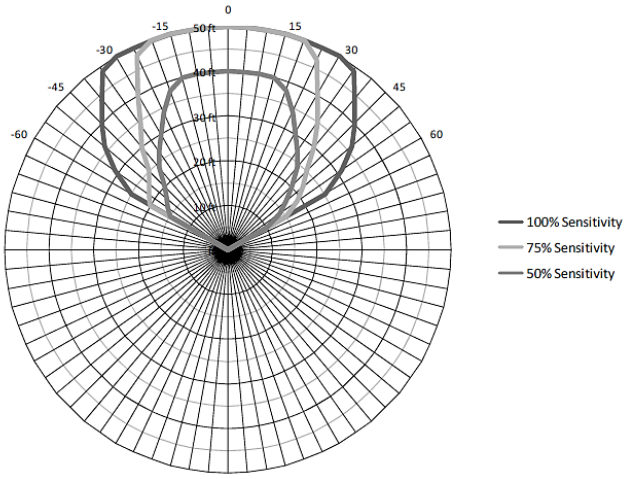


Figure 7 FL3111HT horizontal FoV with 0.092m^2 n-heptane test flame

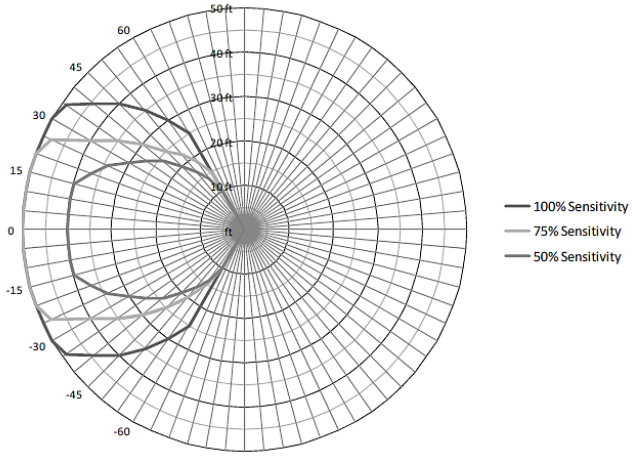


Figure 8 FL3111HT vertical FoV with 0.092m^2 n-heptane test flame

It should be noted that the horizontal FoV shown in Figures 2, 4 and 7 were derived in tests where the detector optical centre-line is parallel to the earth plane and the test flames were on the same height as the detector. This is the standard way of representing horizontal FoV in most flame detector manuals. But this representation may not accurately reflect flame detection coverage when the height of the detector relative to the flame is significantly different.

Mounting Affects Flame Detection Coverage

Figures 9-11 illustrate how the mounting height of the detector and its tilt-angle can affect the effective FoV of the flame detector. The effective FoV in turn directly impacts the detection coverage provided by the flame detector so careful attention should be given to it during installation.

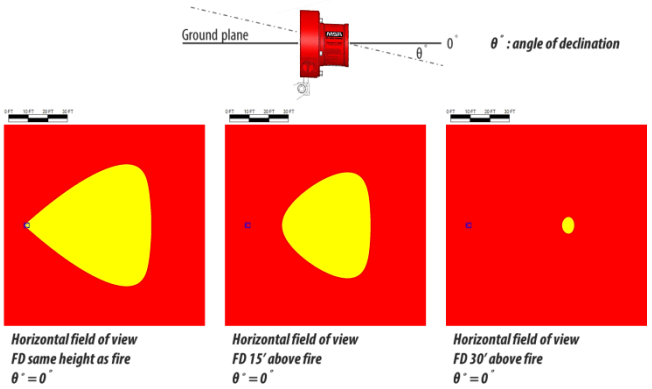


Figure 9

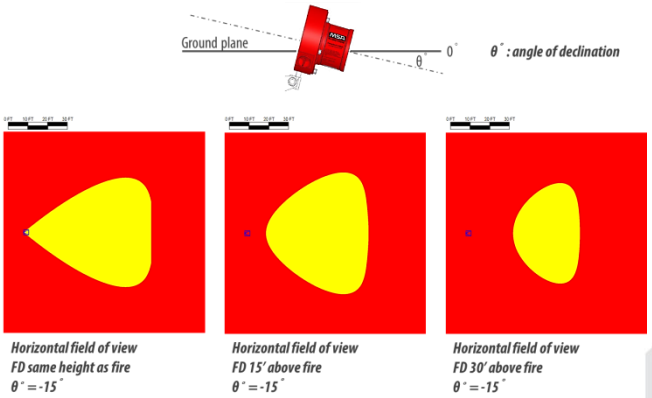


Figure 10

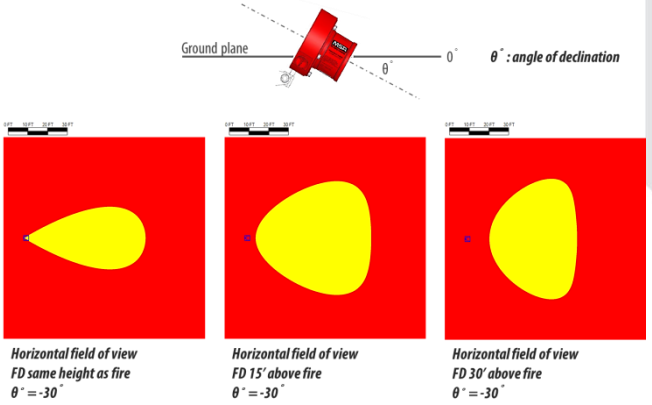


Figure 11

Blockage Affects Flame Detection Coverage

Flame detectors depend on optical line of sight. For a flame detector to be effective it is important that its viewing area is not obstructed by structures, machinery or other objects at all times.

At the design stage, engineers typically perform an assessment of flame detection coverage starting with an initial quantity of flame detectors that is deemed sufficient to provide the needed coverage. Using software tools that are widely available today, the initial assessment is then performed with consideration of detector quantity, mounting location, mounting height, optical sweep angle, tilt angle, sensitivity, and sensing range.

An example of an initial assessment is shown in Figure 12 below. In this example flame detectors (blue arrows) were positioned at two opposing corners of the protected process area.

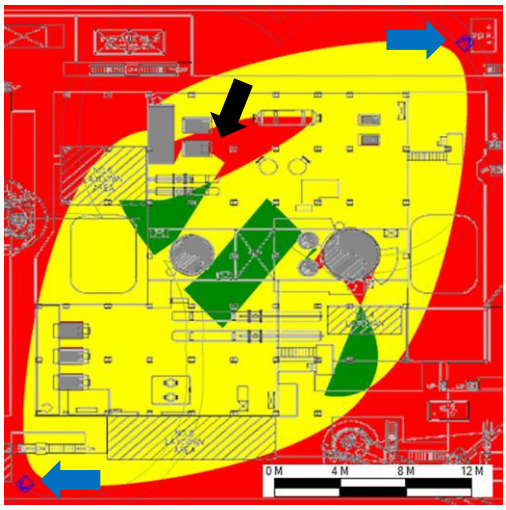


Figure 12: Initial coverage assessment

The red shaded areas are areas where a fire will not be noticed by both flame detectors. The yellow shaded areas are areas where a fire can be seen by at least one flame detector. The green shaded areas are areas where a fire can be seen by both flame detectors.

This initial coverage assessment reveals that a critical section (black arrow) within the protected zone is hidden from the view of both flame detectors. Incipient fires in this section will not be detected until it becomes larger and significantly more dangerous. This is a source of risk that must be eliminated.

To eliminate the blind spot, the design engineer can either re-position one or both of the initial two flame detectors, or add more detectors to improve detection coverage.

Shown in Figure 13 below is the result of a second assessment after a third flame detector was added. The result shows that the previously hidden section (black arrow) is now covered by at least one flame detector thereby significantly increasing the likelihood of flame detection.

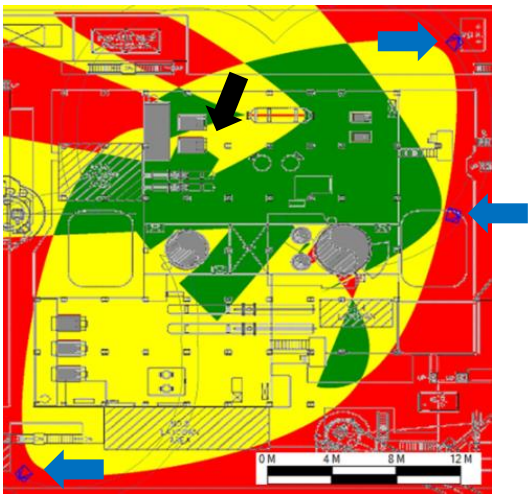


Figure 13: Second coverage assessment

Flame Detector Self Diagnostic

All flame detectors that are certified compliant with NFPA72 must have built-in provisions to ensure that its optical window is not coated with airborne particulates or aerosols to the point that it affects the detecting function or responsiveness.

On the featured flame detectors, this automatic self-diagnostic procedure is called Continuous-Optical-Path-Monitoring (COPM). It is built into the detector circuitry and triggers automatically about once every minute. When it activates it tests the optical window, sensors, and all electronic circuitry to confirm that the flame detector is fully functioning and is able to respond to fires.

Manual Testing

The TL105 test lamp is an explosion-proof battery operated rechargeable test lamp specifically designed to test MSA's UV, UVIR, DFIR, and MSIR flame detectors.

The hand-held tester is effective up to 10 meters away from the detector. When activated, it provides a high-energy, broadband radiation source that emits sufficient energy in both the UV and IR spectra to activate UV and/or IR detectors. To simulate the flickering of a fire, the test lamp automatically flashes at various selectable rates.

Figure 14 TL105 test lamp

For More Information

Please visit our website at: *http://www.msasafety.com/detection*

Configuring & Selecting Options

FLAMEGARD 5 MSIR / FL4000H

	A	B	C	D	E	F	G
5MSIR -	☐	☐	☐	☐	☐	☐	☐
FL4000H -	☐	☐	☐	☐	☐	☐	☐

A. ALARM-OUTPUT

1-□ (Std)	DUAL MODBUS/0-20mA NO RELAYS
2-□	DUAL MODBUS - 0-20mA RELAYS
3-□	SINGLE MODBUS - 3.5-20mA RELAYS HART
4-□	SINGLE MODBUS - 1.25mA RELAYS HART
5-□	SINGLE MODBUS 1.25mA HART NO RELAYS
6-□	SINGLE MODBUS 3.5mA HART NO RELAYS

B. RELAY-STATE-NC:

0-□ (Std)	NO RELAYS
1-□	LATCH ALARM/NON-LATCH WARN DE-ENERGIZED
2-□	LATCH ALARM/NON-LATCH WARN ENERGIZED
3-□	LATCH ALARM/LATCH WARN DE-ENERGIZED
4-□	LATCH ALARM/LATCH WARN ENERGIZED
5-□	NON-LATCH ALARM/NON-LATCH WARN DE-ENERGIZED
6-□	NON-LATCH ALARM/NON-LATCH WARN ENERGIZED
7-□	NON-LATCH ALARM/LATCH WARN DE-ENERGIZED
8-□	NON-LATCH ALARM/LATCH WARN ENERGIZED

C. SENSITIVITY:

1-□ (Std)	HIGH
2-□	MEDIUM
3-□	LOW

D. TIME-DELAY:

1-□	0 SECOND DELAY
2-□	8 SECOND DELAY
3-□ (Std)	10 SECOND DELAY
4-□	14 SECOND DELAY

E. APPROVALS/LANGUAGE:

1-□ (Std)	CSA/FM/ATEX/IECEx (GMI)
2-□	CSA/FM/ATEX/IECEx (GMIL)
3-□	CCCF -LED indication for China (GMI)
4-□	CCCF -LED indication for China (GMIL)

F. WIRING-ARRANGEMENT:

1-□ (Std)	3/4" NPT CONDUIT ENTRY
2-□	1x25mm

G. MOUNTING BRACKET

0-□	W/O MOUNTING BRACKET
1-□ (Std)	W/MOUNTING BRACKET

FL3111HT

	A	B	C
FL3111HT-	☐	☐	☐

A. SENSITIVITY:

1-□ (Std)	100% SENSITIVITY
2-□	75% SENSITIVITY
3-□	50% SENSITIVITY

B. TIME-DELAY:

1-□	2 SECOND DELAY
2-□	4 SECOND DELAY
3-□ (Std)	8 SECOND DELAY
4-□	10 SECOND DELAY

C. APPROVALS/LANGUAGE:

1-□ (Std)	ATEX/ENGLISH
2-□	RUSSIAN W/RUSSIAN NAMEPLATE

CONFIGURING & SELECTING OPTIONS

FLAMEGARD 5 UVIR / FL3100H

	A	B	C	D	E	F	G
5UVIR -	☐	☐	☐	☐	☐	☐	☐
FL3100H -	☐	☐	☐	☐	☐	☐	☐

A. ALARM-OUTPUT:

1-□ (Std)	SINGLE MODBUS (CUSTOMER TO CONFIGURE) 4-20mA & RELAYS
2-□	DUAL MODBUS (CUSTOMER TO CONFIGURE) RELAYS, NO 4-20mA
3-□	SINGLE MODBUS (GMI TO CONFIGURE) 4-20mA & RELAYS
4-□	DUAL MODBUS (GMI TO CONFIGURE) RELAYS, NO 4-20mA
5-□	SINGLE MODBUS (CUST CONFIG) 4-20mA & RELAYS HART 3.5mA
6-□	SINGLE MODBUS (CUST CONFIG) 4-20mA & RELAYS HART 1.25mA

B. RELAY-STATE-NC:

1-□	LATCH ALARM/NON-LATCH WARN DE-ENERGIZED
2-□	LATCH ALARM/NON-LATCH WARN ENERGIZED
3-□	LATCH ALARM/LATCH WARN DE-ENERGIZED
4-□	LATCH ALARM/LATCH WARN ENERGIZED
5-□ (Std)	NON-LATCH ALARM/NON-LATCH WARN DE-ENERGIZED
6-□	NON-LATCH ALARM/NON-LATCH WARN ENERGIZED
7-□	NON-LATCH ALARM/LATCH WARN DE-ENERGIZED
8-□	NON-LATCH ALARM/LATCH WARN ENERGIZED

C. SENSITIVITY:

1-□ (Std)	100% SENSITIVITY
2-□	75% SENSITIVITY
3-□	50% SENSITIVITY

D. TIME-DELAY:

2-□	2 SECOND DELAY
3-□ (Std)	4 SECOND DELAY
4-□	8 SECOND DELAY
5-□	10 SECOND DELAY

E. HOUSING/FIRE-TYPE:

1-□ (Std)	ALUMINUM
2-□	STAINLESS STEEL
3-□	ALUMINUM / HYDROGEN
4-□	STAINLESS STEEL/ HYDROGEN

F. APPROVALS/LANGUAGE:

1-□ (Std)	FM/CSA
3-□	ENGLISH/ATEX/IEC Ex

G. CABLE ENTRY:

1-□ (Std)	2x3/4" NPT
2-□	2X25mm

FLAMEGARD 5 TL105

	A	B
TL105 - 1 - 2	☐	☐

A. LAMP-SETTINGS:

0-□ (Std)	FL4000, FL4000H SENSITIVITY
1-□	FL3100, FL3110, FL3000 SENSITIVITY
2-□	FL3101, FL3101H, FL3111, FL3001 SENSITIVITY
3-□	FL3102, FL3112, FL3002 SENSITIVITY
4-□	TYPE V, VI SENSITIVITY

B. BATTERY-CHARGER:

1-□	NO CHARGER
2-□ (Std)	71676-1 CHARGER ASSEMBLY - TL105

DETECTOR MOUNTING HARDWARE:

71172-2	BRACKET ASSEMBLY, STAINLESS STEEL, (FL310X SERIES)
71370-1	BRACKET ASSEMBLY, STAINLESS STEEL, (FL4000)

BATTERY CHARGER:

940-406	BATTERY CHARGER (12.7v)
70338-1	BATTERY PACK (TL101, TL102, TL103 & TL104)
71650-1	BATTERY PACK, 12V, TL105 NiMH
71676-1	CHARGER ASSEMBLY - TL105

MISCELLANEOUS:

10272-1	WINDOW CLEANING SOLUTION
954-007	WRENCH 6in LONG REACH T HANDLE 3/16 ALLEN WRENCH
71552-1	FLAME SHIELD ASSEMBLY
71271-1	FILM REPLACEMENT KIT FL4000

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An introduction to flame detection
E.CHOO / S.BALIGA
REVISION.A, 04 September, 2015

For sales enquiry, contact us here.