Protection by Detection – Industrial Flame Detectors

Protection of high risk, valuable assets and personnel has never been more vital. Such installations include oil & gas plant (onshore & offshore), petrochemical plant, hazardous material handling and storage, etc. Today's industrial installations are protected by a wide array of detection, monitoring, gauging and preventative devices and systems.

In many situations, such areas are classified as hazardous due to the presence of potentially flammable or combustible materials and require that all potential sources of ignition be protected by suitably designed and approved housings e.g. flameproof Exd, to standards such as IECEx, ATEX, FM, CSA, etc. Many installations also require to be assessed against IEC 61508 for functional safety integrity (SIL).

A key element is the Fire Detection and Protection system. These safety systems include a wide variety of detector types and controls to rapidly identify a fire hazard and prevent or extinguish the fire before it becomes a danger to plant and personnel.

Figure 1: 4040I plus mount

For high risk areas and outdoors, Optical Flame Detectors, like that shown in fig 1, are the favoured solution for this critical role as smoke and heat detectors are not effective outdoors. Unlike smoke and heat detectors, the fire/products of fire (smoke/heat) do not have to reach the optical detector to be recognised as it 'sees' the fire (flames) radiation from a distance of up to 65m over a 100° cone of vision in all directions.

Optical flame detectors provide the fastest detection of a fuel fire in the early ignition stage. Their fast response capability, adjustable field of view and programmability make them extremely well suited for this duty. Flame detection, with high sensitivity and immunity to false alarms, is an essential determining factor when designing systems for this application.

Optical flame detectors operate by sensing one or more wavelengths of electromagnetic radiation emitted by the fuel flames. The precise wavelengths vary depending on the fuel being burned (the chemical reactions that generate energy in the form of electromagnetic radiation), the oxygen supply to the flames and environmental conditions that affect the radiation transmission in the atmosphere.

Many combustible materials include hydrocarbons which typically generate hot carbon dioxide (fig 2). In the presence of an actual fire, the radiation intensity in the carbon dioxide peak band is usually high, while little or no radiation is received in the side bands. Thus, high radiation intensity in the peak band as compared to that in the non-peak side bands is used to determine whether a flame is present.

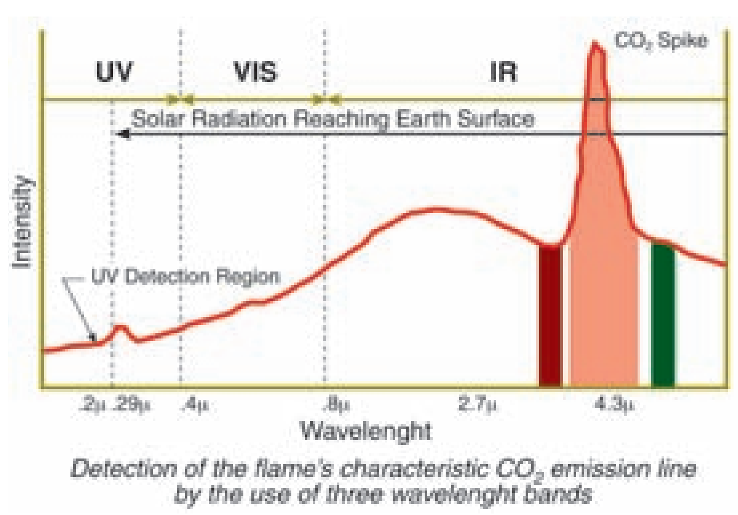

Figure 2: graph

In addition to the two major fire products (CO_2 and H_2O), other intermediate radicals, and ions and by-products created in the fire process (such as CO, CHOH, COOH, CH_3, OH, etc.) emit electromagnetic radiation that can be detected either in the UV solar blind spectrum or in the wide IR bands.

Flame detection has come a long way from the early days when a simple UV sensor was used. Whilst the UV method was a very good and fast fire detector, it was also a very 'good' detector for all sorts of other radiation sources which were not fires e.g. the sun, arc welding etc. These false alarms led to a lowering in confidence in such detectors. They also had a limited detection distance – usually 15m at best.

Over the years, other types and combinations of sensor types were invented, including single infrared (IR), combined double IR, combined UV/IR. All were tried and found deficient in one way or another, mainly due to false alarms and/or low sensitivity (short range detection).

Today, the most respected and widely used method is Triple Infrared (IR3) technology using three different IR wavelengths. This type of spectral analysis ensures no false alarm to any continuous, modulated or pulsating radiation sources other than fire (including sources like black or gray body radiation). The high sensitivity of the Triple IR technology coupled with its inherent immunity to false alarms enables substantially longer detection ranges than previously obtained with standard detectors.

This detection approach offers

- Fast response (<5 secs)
- Long-range detection (up to 65m from fire)
- High sensitivity to small fires
- Highest immunity to false alarms
- High reliability and availability (IEC 61508-SIL2 TUV approved)

These benefits are combined in the Spectrex 40/40I IR3 Flame Detector with additional features to ensure unattended, reliable operation such as automatic integral self-test (every 15 mins); heated optics to ensure continued operation in weather extremes; a wide variety of interfaces (relays, milliamp, ModBus, HART); and a long warranty period (5 years) along with independent 3rd party performance approvals (EN54-10, FM 3260 etc).

These types of detector are used to detect fire from hydrocarbon fuels, gases and materials mainly focusing on the resultant carbon dioxide (CO_2) produced from such fires - along with a lot of other clever stuff! However, until now, 'invisible' hydrogen fires were detected by UV type detectors as the products of the hydrogen fire were different (no CO_2 product from the fire) thus detection distance was very limited. Now, the Spectrex 40/40M Multi IR flame detector, incorporating four IR sensors, allows simultaneous detection of hydrogen flames at distances of 30m as well as detecting hydrocarbon fires up to 65m distant.

The Triple / Multi IR detection technology overcomes the long time problem of false alarms. One of the problems in detecting small fires in the high-risk oil & gas industries, particularly at long ranges, was the potential for a high false alarm rate. False alarms could be generated by other electromagnetic radiation sources which are either termed as "friendly fires"(like flares in the petrochemical industry) or by spurious radiation sources, such as direct and reflected sunlight, artificial light, welding, electrical heaters, ovens, and other sources of 'noise'. A false alarm could result in a costly discharge of the fire extinguishant; and if the fire extinguishant is of the type requiring replacement before reuse, the false alarm may disable the fire extinguishant system until it has been replaced or recharged and cause facility "shut-down".

Several generations of optical flame detectors have been developed to address the various fire and explosion hazards, particularly in the modern oil & gas exploration, processing storage, loading and

Figure 3: 4040 Multi IR

shipping facilities. The Spectrex 40/40 Series is the most durable and weather resistant range of flame detectors currently on the market. Its features include a heated window, to eliminate condensation and icing; HART capabilities for digital communications; lower power requirements; and a compact, lightweight design.

These detectors are fully tested to withstand harsh environmental conditions, including strong vibration, elevated temperatures (+85°C) as well as deep freezing conditions (-55°C), high density fog, rain, snow and other extreme environmental conditions - making them ideal for installation in isolated (difficult to reach) industrial facilities located in Alaska, Siberia or on offshore oil rigs and FPSOs.

Due to the detectors' increased reliability and durability, the SharpEye 40/40 Series warranty period has been extended to 5 years and approved by TUV to SIL2. Performance approvals (EN54-10, FM3260, DNV) and Ex approvals (ATEX, IECEx, FM, CSA, GOST) are also essential requirements to prove, via 3rd party testing, that manufacturers' claims are justified.

Better discussed in greater detail elsewhere, it is also important to mention the testing of flame detectors. The internal self-test will check the sensors etc but, necessarily, will not check the outputs (it happens every 15 minutes!). Therefore, the Spectrex range of Flame Simulators provide an in-situ means to fully 'end-to-end' loop test flame detectors, including the wiring connections, control system reaction etc. The main advantages are that the simulators can be used in Ex hazardous areas and can test the detector from up to 9m away. This avoids the high cost of scaffolding and other access equipment and encourages testing when it may otherwise have been deemed too difficult.

Figure 4: Fire Simulator

Summary

Flame detection technologies have come a long way since the first phototube (UV) detected the photons emitted by flames, primarily driven by the ever-growing requirements of today's industries that require high reliability and availability combined with cost effectiveness in their detection equipment for their expensive, high-risk facilities and processes. Smaller in size, larger in brains (with their miniature micro-processors), modern optical flame detectors provide industry with enhanced flame detection capability and reliabilty with much longer detection ranges and minimal (or no) false alarms.

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