Technical Note

Flame Detector Selection Part 1 – Detection Technologies

Introduction

For decades, radiant energy-sensing flame detectors have been applied as optical fire detectors for industrial and commercial facility fire protection.

Fires are known to emit electromagnetic radiation in the infrared (IR), visible light (VIS), and ultraviolet (UV) wavelengths depending on the fuel source. Flame detectors utilising sensors matched to the respective spectral bands measure the emitted radiant energy to determine if a flame is real.

Flame detector designers have long understood that the "perfect" detector must achieve a precise balance between positive flame detection and absolute false alarm rejection. Today, it is generally accepted that there is no such thing as a perfect flame detector, all have strengths and limitations, and a variety of flame sensing technologies is needed to match flame type with the environment / application the detector will work in.

Optical detectors can 'see' a fire from a long distance without the smoke or heat needing to reach the detector first. The detectors can respond to a fire event extremely quickly, and at long distances, for example, a flaming 1 square foot ($0.1m^2$) of n-heptane fire can be detected up to 80 m away in only 7.1 seconds[1]. This capability makes optical flame detection highly effective in outdoor locations and in large volume buildings where conventional fire detection techniques would not work.

This document provides pointers for flame detector selection, based on the detection technologies used.

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What are the most common types of optical flame detectors available?

The most common optical flame detectors used today are:

- UV-IR — A combination of UV and IR sensing technologies.
- IR3 — Triple IR – the use of three IR bands for fire detection and false alarm rejection.

What is UV Flame Detection?

UV flame detection has been used since the early 1970's. Most UV detectors use a sensor tube that detects radiation emitted in the range of 180 to 250 nanometres (nm).

UV flame detectors can respond very quickly to fires as their detection mechanism is simply related to the number of photons (light energy) being received by the detector each second. Once the pre-set threshold has been exceeded the detector alarms.

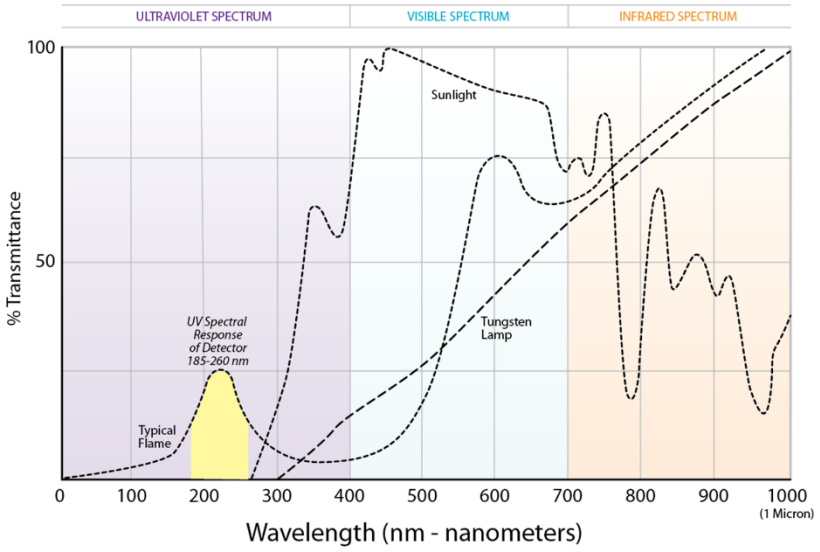

Figure 1 UV flame detection

Virtually all fires emit radiation in this band, while the sun's radiation is absorbed by the earth's atmosphere. The result is a detector that is solar blind.

UV detectors are sensitive to most fires, including hydrocarbon (liquids, gases, and solids), metals (magnesium), sulphur, hydrogen, hydrazine, and ammonia.

Today UV flame detectors are mainly used within the acoustic enclosure of gas turbines. This is because UV detectors are insensitive to the heat generated by the turbine.

Whilst UV detectors are good general-purpose devices, they do have false alarm issues with arc welding, lightning, X-rays, sparks, arcs, and corona.

It should also be noted that some gases and vapours inhibit detection, e.g., toluene and that optical contamination, oil mist, dust, dirt, sand can blind the detector.

What is Single Frequency IR Flame Detection?

Single frequency IR (SFIR) flame detectors essentially monitor a narrow band of radiation around 4.5 microns, which is a predominant emission band for hydrocarbon fires. This band is particularly useful as the sun's radiation is absorbed by the earth's atmosphere, making single frequency IR flame detectors solar blind.

SFIR detectors use a pyroelectric sensor and a low frequency band pass filter, which limits their response to those frequencies that are characteristic of a flickering fire.

Single frequency IR detectors are highly immune to optical contaminants and are insensitive to solar, welding, lightning, X-rays, sparks, arcs, and corona. They are however not suitable for non-carbon fires and may false alarm to modulated infra-red sources. Rain and ice on the detector lens inhibit detection.

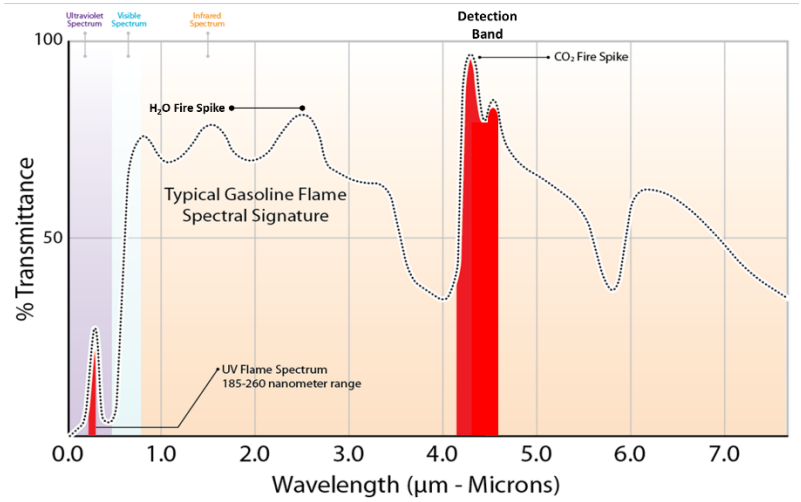

Figure 2 Single Frequency IR Flame Detection

Like UV detectors, it is quite rare to see SFIR detectors used today, this is mainly due to advances in UV-IR and triple IR (IR3) flame detection.

What is UV-IR Flame Detection?

As it sounds UV-IR flame detection is the combination of both UV and IR flame detection technologies. UV-IR flame detectors employ a solar blind UV sensor with an IR sensor and filter matched to the desired fire / fuel type.

The response characteristics of the detector is determined by the IR wavelength selected. Typically, this will be 2.7 microns for non-hydrocarbon fires and 4.5 microns for hydrocarbon-based fires.

UV-IR flame detectors are very resilient to false alarms as the UV and IR detection technologies share few false alarm sources. Care should however be taken when using these devices as there are numerous factors that can inhibit the detector response, for example, optical contamination, airborne solvents, as well as water and ice on the detector optics.

What is triple IR Flame Detection - IR3?

In the late 1990's advances in microprocessor speeds allowed more complex analysis of spectral bands to be calculated quickly.

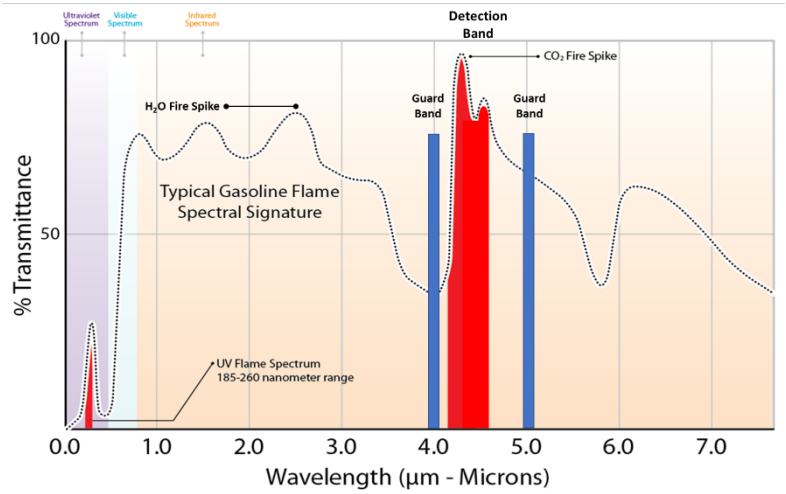

Figure 3 Triple IR flame detection (HC fire) with adjacent guard bands

A triple IR detector has three sensors, each sensitive to a different IR wavelength. The IR radiation emitted by a typical hydrocarbon fire is more intense at the wavelength accepted by one sensor, typically 4.5 microns, than the other two which monitor adjacent spectral bands (guard bands) for false alarms. "With other sources of radiation (e.g., heaters, lamps, sunlight) this is not the case, as. the intensity at 4.5 micron is no greater than the intensity of at least one of the guard bands. Electronic circuitry in the detector translates the information received into data that can be analysed for:

- Flame flicker analysis.
- Threshold energy signal comparison.
- Mathematical ratios and correlations between various signals.

Triple IR detectors are virtually immune to false alarms and can have extremely long detection distances to some fire types. There are however wide performance variations from brand to brand, with regards to detection distances and response times. No two triple IR detectors are the same. The fire and gas design engineer must carefully review detector performance for their application, specifically for detection distance to the fire type of interest and speed of response.

When triple IR flame detection first entered the market, it was only capable of detecting hydrocarbon flames due to the waveband selected for the main fire detection channel. In recent years advances have been made in filter selection and units capable of detecting hydrogen are now available. These units utilize 2.7 microns for the non-hydrocarbon fire detection channel and two adjacent wavelengths for false alarm rejection.

When compared to UV-IR detectors, the IR3 detector, although slightly higher in cost, provides greater area coverage meaning that few detectors are needed to cover the same risk and so the overall installation cost is lower.

Conclusion

This document has provided some pointers for the selection of flame detectors based on the technologies employed. Today most flame detectors sold are either UV-IR or IR3 based. Devices using these technologies can detect a wide range of fire types, with the performance mainly being determined by the IR wavelength selected. The detectors are extremely immune to false alarm but significant differences in performance exists from vendor-to-vendor, particularly for IR3 based detectors. In the next part we will discuss design considerations for your flame detection system.

References

1 FM approved performance data taken from FlameSpec-IR3 product datasheet F120V0010.06 dated, October 2020.

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