



Triple Channel IR Flame Detection - Magic or Myth?

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Abstract

When Triple Channel Infrared (IR3) flame detection was first introduced in the mid 1990s, it seemed to cure many of the problems previously encountered with single IR flame detectors.

However, subsequent experience has exposed several serious and fundamental flaws, some of which render the IR3 approach to flame detection completely unsuitable for many petrochemical installations.

Background

Ultraviolet (UV) flame detection was, in the absence of any alternative, used in most petrochemical installations. While it has its attractions (for example, very fast speed of response), this detection technology is prone to blinding by smoke and oil and is not now considered a credible approach for most technically informed oil and gas flame detection applications.

Single channel (and to a lesser extent two channel IR) detection began to replace UV in the mid 1980s. However, while this technology addressed the main shortcomings of UV devices, it was prone to unwanted alarms associated from background infrared radiation from hot plant, exhaust stacks and of course flare radiation.

Triple IR principal of operation

In common with single frequency IR detectors, IR3 detectors respond to the 4.4um emission associated with hydrocarbon flames. However in addition to this 'principal' wavelength, IR3 detectors also view the flame at two other wavelengths, one on either side of the 4.4um emission feature (these are typically located around 4 and 5 um but may vary from one vendor to another).

This approach in principle allows easy discrimination between a true hydrocarbon fire and unwanted 'background' radiation sources.

Performance in the Field

In ideal conditions IR3 flame detection can respond to small fires while ignoring many potential false alarm sources. However, when confronted by the features of a 'real' petrochemical plant environment, many of these benefits are greatly diminished or disappear completely.

'Friendly Fire'

Many petrochemical facilities employ a process relief flare which appears, to a flame detector, exactly the same as a genuine fire. This is a recurring problem on, for example, FPSOs, where directed and/or reflected infrared radiation from the relief flare may be detected throughout the exposed process areas.

Effect of Sunshine & Hot Objects in the Field of View

In the extreme, it is possible for an IR3 detector to be completely blinded by modulated blackbody radiation. While this intensity of modulated radiation is unlikely (but not unknown) in most process areas, the effect of any modulated background blackbody radiation is to reduce the sensitivity of an IR3 detector, generally by an unknown amount. While this may be compensated for by assuming a reduced response to fires, it clearly compromises the high sensitivity that is one of the primary selling points of IR3.

Sunlight is a special - and frequently encountered - case where modulated sunlight reflected from a surface or the sea is likely to reduce the sensitivity of the detector, again by an unknown amount. This unquantifiable response to external infrared radiation effectively constitutes a significant 'unrevealed' failure.

Erratic Response

Because IR3 detectors rely on measuring the ratio of three individual IR Wavelengths they are prone to interference in any one (or all) of these channels by contaminants in the optical path(s). This results in uncertain performance of the detector in the presence of surface

Missed fires, delayed response and unwanted alarms in response to non-fire sources have all been observed during long term tests.

Impaired by Water

While all IR detectors suffer to some degree from absorption of IR radiation by water (as droplets, mist or snow) the IR3 device is at a particular disadvantage. The absorption of IR is significant, varies by a factor of 5 (Reference 1) over the wavelengths of interest and is 'worst' at the precise wavelength of interest – 4.4µm. This absorption, coupled with refraction and internal reflection of droplets on the faceplate, renders the IR3 detector extremely prone to disruption by water.

Unusable / Excessive Sensitivity

One of the much-publicised benefits of IR3 technology is its ability to respond to small fires at great distances – a response to a 1 square foot fire at 60m is typically quoted. This very high sensitivity is typically used as a justification to reduce an installation's detector count. However, extensive survey work over hundreds of offshore platforms has shown that the average useful range of a flame detector in process plant is about 8-10m.

Beyond that local pipework, structure and vessels present an almost impenetrable barrier to infrared radiation from even a relatively large fire. While there are clearly exceptions to this, the limited view available to any flame detector located in an average process area suggests that very high sensitivity is completely unusable.

In practice however, the situation is significantly worse because the IR3's high sensitivity has now produced a large number of unwanted alarms (generally associated with flare radiation) on several FPSOs and platforms around the world.

Summary ... serious limitations of IR3

1. Unwanted response

Unwanted response to direct and reflected flare radiation resulting in shut-downs.

2. Unquantified reduction in sensitivity

Unquantified reduction in sensitivity from modulated sunshine and hot items in the field of view.

3. Erratic response after contamination

Erratic response following contamination of the three optical windows.

4. Poor response with water exposure

Poor response to fires when exposed to water in the optical path.

While some of these issues may be reduced somewhat by the use of intelligent signal processing and /or in-situ testing, the inherent weaknesses of IR3 technology greatly reduce its value in many petrochemical applications.

Reference 1 : G. M. Hale, M. R. Query, "Optical constants of water in the 200 nm to 200 µm wavelength region," *Appl. Opt.*, 12, 555-563 (1973).

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