Flare Radiation -Not So Friendly Fire

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Abstract

Triple Channel Infrared (IR3) flame detectors are often promoted on the basis of their very high sensitivity to fire.

This feature has resulted in many installations suffering from unwanted alarms and shut-downs as a result of direct or reflected radiation from a process relief flare.

Subsequent ad-hoc remedial action often results in diminished system sensitivity and coverage far below the design intent.

Background

A typical detection 'target' for a modern flame detector is a 10kW Radiant Heat Output (RHO)1 Fire. This is similar to the oft-quoted "1 square foot pan of gasoline".

A typical IR3 detector is promoted as capable of detecting this fire from a range of (typically) 60m. (in practice, a clear view of greater than 10m or so is unusual in offshore process plant but this tends to be overlooked in the battle of the specs).

This very high sensitivity tends to be presented as a justification for reducing the detector count in any given design. However it must be noted that recently the manufacturers of these high sensitive triple channel IR detectors have introduced a number of variants of lower sensitivity, typically 19.8m and 4.6m to a 30 inch (75cm) methane fire.

The Process Relief Flare

Most hydrocarbon and chemical process plants provide a relief flare or vent to assist in handling process upsets. A typical relief flare operating at, say 0.1kg/sec under normal conditions and 10kg/sec under relief conditions will provide flame energies in the order of 2 MW and 100MW respectively. Where a cold vent (rather than a flare) is provided, lightening strikes are surprisingly common and there are many reported instances of an unintentional 'hot' vent.

In addition to the local relief flare, the possibility of a system being activated by an adjacent unit's or site's flare cannot be ignored. This latter case can result in a 'domino' effect that has provoked a number of unscheduled relief (and vent-snuffing!) system tests over the years.

Clearly the fires associated with a flare are several orders of magnitude greater than the target fire size and exhibit precisely the infrared radiation signature required by an IR3 detector.

Reflections

Many materials reflect infrared radiation very efficiently – for example stainless steel, even, weathered after a few years exposure to 'offshore' conditions can still reflect up to 70% of any incident radiation, while the sea surface and any puddles of water on an installation are capable of reflecting up to 30%. These relatively high reflectance efficiencies suggest that single or multiple reflections are more than capable of tripping a detector and in at least one case, stainless steel cladding on an adjacent installation reflected sufficient flare radiation to initiate detection on the host platform's cellar deck.

Unwanted Alarms

Clearly any flame detectors within reach of the infrared radiation associated with a large flare may be expected to produce unwanted alarms although the exact circumstances (wind direction, flare size, local obstructions) may vary thus making the cause of any alarm and shutdown less obvious at first sight.

User Response

Assuming that the flare design is fixed, then the only variable left to adjust is the flame detection system's coverage and sensitivity - both methods are frequently employed in order to reduce unwanted alarms.

Hoods or masks may be used to minimise any view of the flare - this is unlikely to help with reflected radiation which may come from many directions, but it is likely to reduce coverage. Reduction in detector sensitivity is a also a common response and, because this is often done on an ad-hoc basis in the field, it is often not clear to the user that coverage of the flame detection system has been very seriously compromised.

Solution

At present there is simply no way for a simple (single or multiple channel) Infrared unfocused 'radiation' detector to reliably discriminate between a genuine fire and infrared radiation from either a process relief flare or hot work within the field of view of the instrument.

Possible solutions lie in three areas:

1. Visual Image-based Detection

Because of it's spatial dependency, visual image-based detection can provide near total immunity from direct and reflected flare radiation.

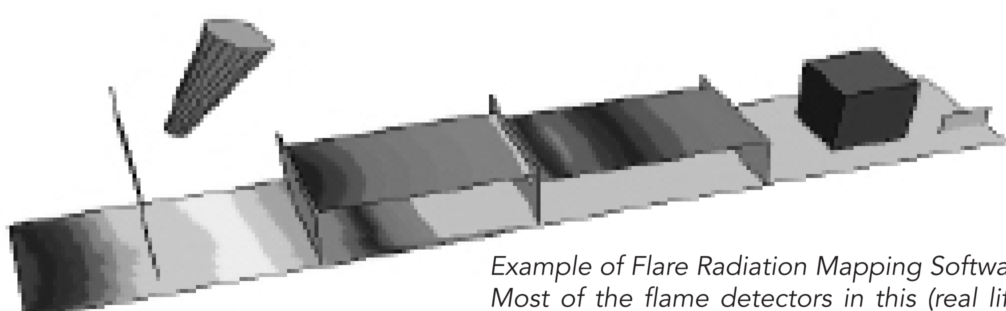
2. Heat Detection (For less sensitive applications)

Fusible plug and fusible tube heat detection is normally immune to flare radiation but cannot approach the sensitivity (by about two to three orders of magnitude) normally associated with optical flame detection.

3. Greatly reducing the sensitivity of a conventional infrared detector

This 'quick fix' may work (although given the huge difference between the flare and the target fire sizes it still may not provide a complete solution). However, with greatly reduced range, the published benefit of the IR3 is largely negated and a large number of detectors will be required to provide coverage. This unsatisfactory outcome – a system which clearly fails to meet the original design intent – is generally ignored because of the high cost of any necessary remedial action.

Notes/References
1. Radiant heat from a fire is about 20% ... 30% of the total energy available from the fuel (see API 521)



Example of Flare Radiation Mapping Software. Most of the flame detectors in this (real life) FPSO study would have been activated by the flare.

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