Technical Note

Flame Detection Selection Part 2 – Design considerations

Introduction

This paper continues our learning about flame detection. Part one of our flame detection guide provided some pointers for the selection of flame detectors based on the sensing technology employed. This paper sets out some design considerations for your flame detection system, broadly speaking these considerations fall into the follow categories: the application, the detector and the design criteria.

Understanding the application

Before selecting a detector type it is important the designer understands the application. Things to consider include:

Fire Risk

What is going to burn? What size fire needs to be detected, and how quickly?

Presence of false alarm sources

Is there anything that may cause the detector to alarm without a genuine fire being present? The most obvious source of an unwanted alarm is a flare, but engines or turbine exhausts should be considered too.

Operating conditions

What environmental issues may exist? Rain, snow, salt spray, sand and dust storms, the list can go on.

Maintenance and function testing

Flame detectors require routine testing and may need periodic maintenance in atmospheres containing high levels of contamination. If possible, access should be available without the need for scaffolding, although this is not always possible.

Area classification

Are the units to be installed in a hazardous area? If so, ensure the products are certified accordingly.

Diagnostics capabilities

Increasingly, flame detectors are being specified with additional communication capabilities such has HART®. If the control system supports HART® check to see if the flame detectors you wish to specify provide information for planned (preventative) maintenance, not just indications of faults that have occurred.

Understanding detector response

In this section we will cover field of view, detection distance and the detection of different fuels.

What is the field of view of an optical flame detector?

As the name implies the field of view (FOV, sometimes called cone of vision) of an optical flame detector defines the unobstructed area of coverage a flame detector has for a given fuel.

The greatest sensitivity to a fire is seen directly through the centre line to the detector face, this is sometimes called on-axis sensitivity. The detection distance then rolls off the further you move away from the centre line with the shape formed by the field of view generally looking like a teardrop.

FM3260 defines the field of view by stating "the detector response shall be at least 50% of the on-axis sensitivity (measured in units of distance) in at least four directions (left, right, up, and down)".

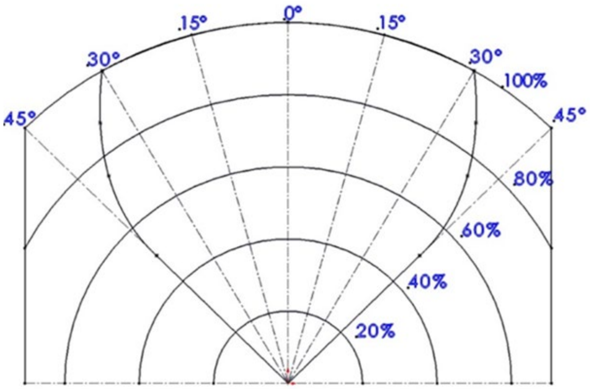

Figure 1 Typical horizontal field of view

The horizontal field of view of a detector is typically 90° but can vary due to the optomechanical construction of the detector and / or the fuel being burnt. The vertical field of view tends to be smaller than the horizontal one due to obstructions from the reflector plates used by through-the-lens optical tests.

Some flame detectors have FOV's that are greater than 90° whilst on paper this may seem to offer an advantage in terms of coverage, there can be some unforeseen consequences for multi-spectrum flame detectors. Practical installations tend to favour placing detectors into the corners of rooms or process modules meaning there is little benefit to be gained with detectors having a wider FOV. Another point for consideration is fire zoning, limiting the FOV to 90° makes zoning easier and helps ensure flame detectors from one area are not activated by a fire in an adjacent zone.

Many people ask, how far can your detector detect?

This is a reasonable and straightforward question, unfortunately numerous factors affect the detection distance of a flame detector and so, a reproducible means of testing detectors had to be established to ensure consistency from product to product and in product comparisons.

Today FM 3260 and EN-54 part 10 are international standards for the performance of optical flame detectors. According to these standards triple IR flame detectors generally tend to be more sensitive (80 metres) than UV-IR flame detectors (30 metres), to a one-foot square n-heptane fire when used on the highest sensitivity setting the detector can employ.

Having said this, the distance at which a flame detector can detector a fire is linked to many factors, including:

- Detection technology

- Detector sensitivity
- Fuel burning
- Fire size

Most flame detectors have an adjustable sensitivity setting to cater for the needs of the environment in which the detector is located. The fire protection engineer should understand this and note that the default sensitivity of most IR3 detectors is 30 metres and that typically this is called "medium" sensitivity.

Once we have defined the detector sensitivity it is important to understand that the detection range is dynamic as it relates to fire size. A small fire close to the detector can trigger an alarm just as easily as a large fire further away.

The detection distance is governed by the inverse square law, which in basic terms means if a detector responds to a 1 square foot n-heptane fire at 30 metres, it will also respond to a fire that is four times larger at double the distance (60 metres). Unfortunately, this calculation cannot be applied indefinitely as external influences, like, water vapour, cold CO_2 and flame flicker also affect "detection."

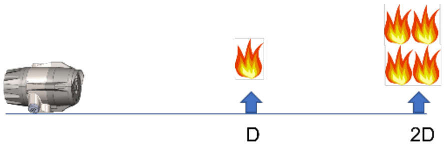

Figure 2 Inverse Square Law

Finally, it is important to know that there are significant differences in the detection distances between different fuels. The designer must ask the detector manufacturer about their expected detection distances based on the fuels in the application under consideration. It would of course be preferable if this response data could be validated by an independent laboratory, such as Factory Mutual.

		Manufacturer 1		Manufacturer 2	
Fuel	Size	Distance ft (m)	Response	Distance ft (m)	Response
n-Heptane	1 x 1 foot	98 (30)	2.2 s	100 (30.5)	7 s
Diesel	1 x 1 foot	79 (24)	3.9 s	70 (21.3)	4 s
Methanol	1 x 1 foot	75 (23)	1.2 s	70 (21.3)	6 s
Ethanol	1 x 1 foot	75 (23)	1.6 s	85 (25.9)	7 s

Figure 3 Response data from different IR3 manufacturers

Understanding false alarm sources

It is rare to have a flame detector installation that doesn't have potential false alarm stimuli present. Typical sources include flare stacks, direct and reflected sunlight, hot process, and engine exhausts, to name but a few. During maintenance work, detectors typically need to be isolated as additional sources of false alarm can be introduced, these include, X-raying, cutting, grinding and arc welding.

The fundamental question remains; how many detectors are needed to cover an installation?

The facility design criteria will have a major impact on the number of detectors needed for any installation. In industry, many End Users (for example, Shell or bp)[1,2] define the actions that will be taken in the event of an alarm, and this largely depends on the criticality and escalation potential of an installation. The initiated action is normally automatic, except where human action has been assessed for the facility and hazard type and can be demonstrated as being an effective part of the mitigation process. The actions typically range from alarm only, where human action is needed – perhaps by using a CCTV video feed for confirmation, to plant shutdown and suppression system / deluge discharge, where a voted detector configuration is needed. Detector voting uses a logic function, for example "2 out of N" (2ooN) to trigger, where "N" represents the number of detectors in fire zone. An alarm only configuration would typically use a single detector, without voting, to initiate an action.

We also know that flame detectors respond to flickering fires located within their field of view; we should also note they do not respond to embers or smouldering fire. And, as we have seen there are several important factors to consider, such as:

- What is going to burn?
- What size fire do I need to detect?
- What false alarm sources are present?
- What are the conditions at site? Hot, cold, dusty, salt spray, snow, etc.
- Is the flame detection technology suitable for all the above?

When proposing a design, it is a good idea to conduct a site survey, for existing plant, or to walk through a 3D model of a new facility, if such a design exists. When doing this, look for solid structures to mount the detectors, that covers the objects/area that need protection. Try to experience what the detector 'sees' taking into consideration the field of view of the detector. The detectors should be mounted looking down at an angle to prevent dirt, dust, and moisture from collecting on the windows and avoid potential false alarm sources in the cone of vision - such as flares, engine, or turbine exhausts. Finally, particular care should be taken to eliminate blind spots (shadows) cast by obstructions in the field of view, see figure 4. This may be achieved by either locating the device in a more optimal location or by adding additional devices, see Figure 5.

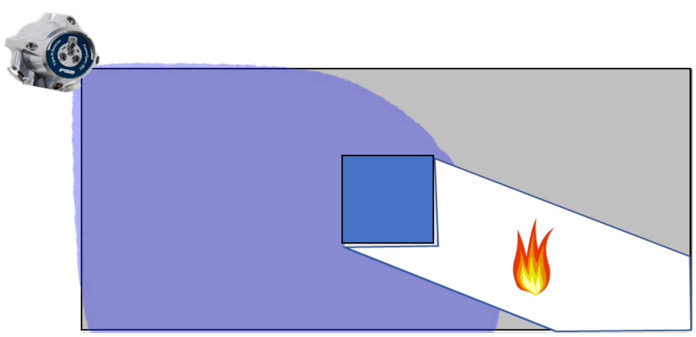

Figure 4Flame detector coverage with obstruction hiding the location of a flame

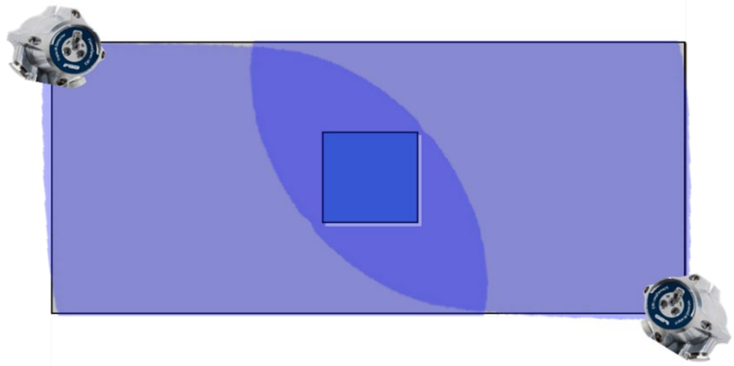

Figure 5 Using another detector to cover the area of risk

These elements are important, but we also need to address another practical aspect of the installation - accessibility for maintenance purposes. This aspect should not be overlooked as flame detectors are usually mounted in elevated locations and the long-term operational aspects of the installation should be considered. This does however present a challenge for the designer as they are usually tasked with producing an optimised design, that essentially minimises the number of detectors used without consideration to access. It is quite probable that a less optimised detector layout, that uses existing structure with good access, would benefit the facility owner / operator from a maintenance perspective and that this may potentially improve facility uptime if it negated the need to construct scaffolding towers, for example.

Conclusion

This paper has continued our learning about flame detection. We have broadly discussed, the application, the detector, the design criteria, to answer to the question, how many detectors do I need to cover an installation?

References

1 FIRE, GAS AND SMOKE DETECTION SYSTEMS Shell DEP 32.30.20.11-Gen.

2 Engineering Technical Practice (ETP) Group Practice (GP) GP 30 85