SELECT THE RIGHT FLAME DETECTOR

Consider a number of factors to determine the most appropriate option | By Edward Naranjo, Emerson Automation Solutions

FIRES AND explosions are common hazards in the chemical and refining industries. Unexpected releases of flammable liquids and gases can ignite, sometimes violently, when mixed with air, leading to injury and property damage. Energy-sensing flame detectors can enhance the safety of processes involving flammable materials by triggering an alarm when a fire erupts, thus providing early warning and helping ensure people's safety.

However, operating staff often debate about which type of device to select and where to place the sensors for best coverage. The confusion stems in part from the wide range of flammable materials that process plants may handle; a single process area may contain several different types. In addition, the development of new technologies like visual flame imaging and pattern recognition, while improving identification effectiveness, has created uncertainty around the choice of flame detectors. Fortunately, the particular application rather than detection technology determines the proper pick. In this article, we'll examine the criteria for selection and review the detector types commonly used to protect against industrial fires.

KEY CONSIDERATIONS

Flame detectors respond to the radiant emissions from a flame — so, the first and perhaps most important consideration when selecting detectors is that they accurately and reliably identify flames. Detection equipment must suit the particular hazard; the devices' spectral responses must match the spectral emissions of the flames to be detected [1]. Few plants fail to choose devices based on the process fluids present in the coverage area but many sites often don't consider other fire hazards. For example, flame detectors at a gas compressor building in Brazil failed to detect a small fire produced by ethylene glycol. The fluid had leaked from a heat exchanger onto a manifold in a compressor and ignited upon contact with the hot surface. Because ethylene glycol flames produce little infrared (IR) light, the IR flame detectors installed to detect natural gas flames didn't offer sufficient coverage to protect against alcohol fires. Luckily, personnel spotted the fire and quickly extinguished it.

Flame detectors vary in capabilities; each type presents advantages and limitations. You should consider several different types of performance variables when selecting the proper flame detector for a particular application:

• *Detector range and response time.* It's important to understand the maximum distance within which the device recognizes flames, based on fuel type, and the amount of time the instrument will take to collect, process and report feedback for the radiated energy detected. The response must be quick — within 30 seconds according to the EN 54-10 fire detection safety standard [2] — and accurate. To achieve best economics, look for wide area coverage per device, coupled with the shortest time to detect a flame. Place flame detectors high up and in the edges or corners of a room.

• *Immunity to unwanted alarms.* A flame detector must mitigate the possibility of false alarms from non-fire sources. A false alarm incident may cause system shutdowns and evacuations, as well as result in investigations by the company or local authority having jurisdiction. Restarting a process may take hours or months, particularly when considering quality, environmental and process safety regulatory requirements. Moreover, false alarms lead to wasted effort by emergency responders and worker downtime as operations sit idle. In addition, they incur costs for replacement of extinguishing agents from fire suppression systems and materials lost within the process. Placing the detectors in more appropriate locations, decreasing their sensitivity setting and increasing their delay setting may mitigate false alarms. You also may tilt the flame detector so it has a better orientation for false alarm rejection.

• *Field of view.* Most flame detectors have a 90° to 120° horizontal field of view. Wide fields of view usually are desirable to protect closed modules where obstructions may limit area coverage over long distances. Place the detectors high off the ground so they have good line of sight to the area of concern; you don't have to take ceiling height specifically into account.

RELATED CONTENT ON CHEMICALPROCESSING.COM

"Effectively Detect Hazardous Gas Leaks," http://bit.ly/2Tq6DvZ

"Instrumentation: New Capabilities Boost Remote Monitoring," http://bit.ly/2TpPbYE

"Emissions: Plants Plug Away at Leaks," http://bit.ly/2TpPbYE

• *Environmental factors.* Flame detectors at process plants must operate over a wide temperature range. You must consider high ambient temperature limits for devices installed inside compressor or turbine enclosures. In addition, flares and flare reflections may affect certain flame detector types like multispectral infrared and ultraviolet/IR (UV/IR) — particularly during blowdown to safely dispose of excess combustible gases or liquids in a flare.

• *Communication capabilities.* The role of flame detectors is to initiate suitable responses such as automatic control actions and alarms. This depends upon effective communication of outputs like 4–20-mA analog signals or relay contacts for remote alarm or fault indication. Bidirectional communication protocols like HART can make information pertaining to parameters, device configuration and device diagnostics available to central control or monitoring systems [3].

Besides considering performance variables, check that the flame detectors are listed or approved for use in hazardous or classified areas and for the specific environments in which they will operate. Certification under regulatory performance standards such as FM 3260 [4], EN 54-10 [2] and ULC/ORD-C386 [5] also attests to product fitness because these norms subject detection systems to a set of reproducible tests to certify their performance on deployment.

DETECTION TECHNOLOGIES

Let's now look at the different types of instruments available, their applicability and limitations, as well as factors to consider in making a choice.

• *IR flame detectors.* These devices find broad use in process plants. They are popular because the fixed emission wavelengths of flame in the IR spectrum can be separated from most non-flame sources and analyzed in various domains [6,7].

IR flame detectors can detect hydrocarbon or hydrogen flames. Hydrocarbon configurations suit facilities that process hydrocarbon gas or liquids — but are wholly unsuitable for detecting hydrogen flames or flames from other inorganic materials. Modulated radiation from hot surfaces, hot exhaust gases, sunlight, light from flares, and solar and flare reflections can affect certain IR flame detectors. The presence of these sources reduces flame response sensitivity and may cause false alarms. Don't use IR flame detectors if flare radiation can be seen, either directly or reflected.

Multispectral IR flame detectors are recommended for many uses, including crude oil tanks, diesel storage facilities and enclosed gas compressor buildings. They are the most versatile of the detector types available and have the longest detection range as well as strong false alarm immunity. These detectors can characterize flames more fully due to their large number of sensors. Instead of relying on a single spectral span, they use several to establish the presence of a flame. As a result, the instruments don't produce a false alarm when only one spectral span indicates a flame. Moreover, some sensors — called immunity sensors — monitor for the presence of false alarm sources.

• *UV flame detectors.* These devices suit facilities in which the only fuel sources are hydrogen and hydrocarbon gas. Because smoke scatters UV light to a far greater extent than it does IR, it's best to locate UV detectors well below roof level as smoke produced by paint, cables or oils may accumulate in ceilings or roofs. To prevent false alarms, inhibit UV detectors during welding, radiography and exposed flame hot work. Just as for IR devices, don't use UV detectors in areas where you can see direct or reflected flare radiation.

UV detectors are unsuitable for detecting hydrocarbon liquid fires or fires in highly congested spaces. Liquid fires produce little UV light and the dense smoke from these fires greatly reduces detection coverage. In addition, because UV light is most prevalent at the base of an open flame, the devices may not readily detect fires in congested spaces that block the line of sight to the base of the fire. Another consideration for UV detectors is the presence of oil or dust. Deposits of

UV/IR DETECTOR

Figure 1. This instrument must detect flames on both bands to trigger an alarm.

oil film or dust on detector windows can severely reduce flame response sensitivity; therefore don't use these devices to monitor environments that contain airborne oil droplets or are dusty. UV detectors do best when detecting clean flames (i.e., those from natural gas, pure ethane or butane).

• *UV/IR flame detectors.* These devices, such as the one shown in Figure 1, combine the characteristics of UV and IR to provide a detector for general hydrocarbon or hydrogen fuel applications. They generate an alarm signal only if a flame is detected on both bands. UV/IR detectors best suit clean flames because few light sources emit as strongly in both spectral regions as clean flames. Such flames afford a shorter detection range than that of a fire from a liquid fuel (ethanol, for example).

• *Closed-circuit-television (CCTV) flame detectors.* These devices process video images and resolve flame characteristics. They best suit highly hazardous areas and normally unattended ones, where manual intervention could take a long time, making loss prevention more difficult. Because CCTV detectors transmit a video signal to the control room, they can allow quick assessment of the overall situation in the event of a fire alarm and confirm the presence and magnitude of the fire. Certain CCTV flame detectors can mask parts of their field of view, a feature useful for monitoring areas exposed to direct light from flares or flare reflections, such as top deck process areas on offshore platforms.

Don't use CCTV detectors when you're concerned about invisible or nearly invisible flames like those produced by hydrogen and alcohol fires.

Table 1 provides an overview of the principal characteristics of these flame detector types.

Keep in mind that flame detection isn't always the best choice for identifying a fire. For instance, flame detectors may not be wholly effective in protecting zones due to high levels of congestion, interference from flare activities or environmental conditions. In such cases, other methods like heat and smoke detectors and pneumatic detection systems may do a better job.

Also, always remember that flame detectors don't negate the need to consider ways to prevent fires in the first place. Identify adequate safeguards using engineering standards and process hazards evaluation methods like event tree and layer of protection analysis [8].

MAKE THE RIGHT CHOICE

Successful performance of fire detection systems depends on the early and reliable identification of fire. Key to this is the careful choice of flame detectors in the process area. Base your device selection on an analysis of the characteristics of potential fires, their causes and the environment. UV detectors offer fast

FLAME DETECTOR OPTIONS

Detector	Advantages	Limitations	Typically Used for Monitoring
IR	• Strong false alarm rejection • Long detection range • Able to detect fire through dense smoke	• Susceptible to producing false alarms under certain combinations of heat, motion and gas emissions • Can't be used if flare radiation can be seen • Effective detection coverage reduced in presence of false alarm sources	Hydrocarbon gas or liquids (enclosed buildings and outdoor locations)
UV	• Fast response speed	• Unsuited for environments that are dusty or contain airborne oil droplets • Susceptible to interference from welding activities, x-rays used in non-destructive testing, lightning and direct and reflected sunlight	Clean burning fuels (e.g., natural gas) in closed or semi-enclosed modules
UV/IR	• Fast response to fires • UV/IR technology reduces possibility of false alarms • Wide field of view	• Unable to detect dense smoky fires • Affected by strong sources of UV radiation (e.g., arc welding) or certain combinations of UV and IR radiation	Clean burning fuels (e.g., natural gas) in closed or semi-enclosed modules
CCTV	• Enables operators to confirm presence of fire, assess hazard severity • Certain models may mask flare light, making them suitable for applications where other devices don't perform satisfactorily	• Not suitable for detecting invisible flames (i.e., hydrogen or alcohol flames)	Hydrocarbon gas or liquids in normally unattended installations

Table 1. Proper selection requires considering the nature of the flame as well as the operating environment.

response and good sensitivity while UV/IR and multispectral IR models provide increased false alarm immunity over UV models and operate at moderate response speeds. Multispectral IR detectors offer the largest area coverage per device of any detector type and boast versatility and strong false alarm rejection; so, plants prefer them for a whole host of uses. CCTV detectors, which can provide images of the area under scrutiny, may serve for event management in case of a fire. In practice, their singular advantage is discrimination of flames produced by process flares.

No flame detector technology is best in all situations; usually a combination of thermal, flame and smoke detectors or several flame detector types is necessary. Bear in mind that some operations such as raw material receiving, sorting and storing as well as reaction and product generation may involve a variety of fuels. In addition, regulatory bodies in certain jurisdictions (e.g., the Bureau of Safety and Environmental Enforcement in the Gulf of Mexico) mandate the installation of pneumatic fusible-loop heat detection systems as an additional and complementary layer of protection. ●

EDWARD NARANJO is director of Rosemount fire & gas systems, Emerson Automation Solutions, Shakopee, Minn. Email him at Edward.Naranjo@emerson.com.

REFERENCES

1. "NFPA 72: National Fire Alarm and Signaling Code," National Fire Protection Assn., Quincy, Mass. (2016).
2. "EN 54-10: Fire Detection and Fire Alarm Systems," Part 10, European Committee for Standardization, Brussels (2002).
3. Helson, R.B., "The HART Protocol – A Solution Enabling Technology," HART Communication Foundation, Austin, Texas (1996).
4. "FM 3260: Radiant Energy-Sensing Fire Detectors for Automatic Fire Signaling," Factory Mutual Global, Johnston, R.I. (2000).
5. "ULC/ORD-C386: Flame Detectors," 2nd ed., Underwriters Laboratories of Canada, Toronto (2015).
6. Huseynov, J., Boger, Z., Shubinsky, G. and Baliga, S., "Optical Flame Detection Using Large-Scale Artificial Neural Networks," pp. 1,951–1,964, *Proceedings*, Intl. Joint Conf. on Neural Networks, Montréal (2005).
7. Jacobson, E. and Spector, O., "Optical Flame Detectors: Immunity to False Alarms," pp. 46–49, *FS-World*, Spring 2011 (2011).
8. Marszal, E.M. and Scharpf, E.W., "Safety Integrity Level Selection: Systematic Methods Including Layer of Protection Analysis," ISA, Research Triangle Park, N.C. (2002).