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WHITE PAPER

Best practices for fire protection in hazardous locations:

Procedures for detecting combustible gas, smoke and flames



Recent research results from the National Fire Protection Association (NFPA) indicated that almost two-thirds (65%) of the combined industrial and manufacturing facility structure fires occurred specifically in manufacturing properties.[1]

The danger of fire in processing and manufacturing facilities often stems from the very production processes taking place, which frequently involve volatile and potentially flammable materials. To protect workers, industrial facilities staff need to understand and follow best practices for life safety fire systems.

Best practices are defined as professional procedures shown by research and experience to produce optimal results. While a number of organizations such as the National Fire Protection Agency (NFPA) stipulate specific procedures related to fire and gas detection in their standards, some best practices can be developed through years of practical experience. This paper documents ten practices for developing and maintaining effective fire and gas detection in hazardous locations.



It is important to conduct a fire hazard analysis to determine the hazards present in a facility and their potential consequences.

Best practice #1: Identify fire hazards

Before designing and installing a fire-protection system, it is important to identify the fire hazards within the specific facility. This is done by conducting a fire hazard analysis (FHA) to determine the expected outcome triggered by a specific set of conditions called a fire scenario.

Methods used to estimate the potential impact of fire can be divided into two categories: risk-based and hazard-based. Both approaches estimate the potential consequences of possible events. Risk-based methods analyze the likelihood of scenarios occurring, whereas hazard-based methods do not.

An FHA conducted in an industrial plant is often done with the help of a consulting fire protection engineer (FPE). An FHA fire scenario takes into account building considerations such as room dimensions, contents, construction materials and potential sources of combustion.

Best practice #2: Be aware of standards and certifications

Another important preliminary step is the review of applicable standards, such as the fire standards from the NFPA. In particular, plant operators should review NFPA 70® (also known as the NFPA 70® National Electrical Code®, or NEC) and NFPA 72®: National Fire Alarm and Signaling Code®.

Chapter 5 of the NEC addresses "special occupancies." Within that chapter, Article 500 stipulates that hazardous locations be classified based on flammables that may be present, as well as their concentration or quantity. Class I areas are those in which flammable gases, flammable liquid-produced vapors or combustible liquid-produced vapors may be present in the air in quantities sufficient to produce explosive or ignitable mixtures.

Some detector manufacturers self-certify product performance; meaning they rely solely on their own internal tests and evaluation to verify their products meet applicable standards. Another method is to have products certified by an accredited, third-party testing agency, which provides an independent and unbiased product evaluation.



Figure 1: The Det-Tronics PointWatch Eclipse® is a point-type infrared gas detector that provides continuous monitoring of combustible hydrocarbon gas concentrations in the range of 0 to 100% LFL.

Many NFPA codes and standards for specific processes reference NFPA 72, the National Fire Alarm and Signaling Code. Chapter 17 of NFPA 72 provides requirements for various types of devices that can be used to detect indications of fire. The surest way to know that detectors meet safety standards (such as those in NFPA 70 and 72) is to specify equipment with third-party approval certifications by an accredited certification agency. Performance testing and certification verify both that a device will operate as specified by the manufacturer under a wide-range of conditions—and that it is compliant with applicable standards.

Best practice #3: Start with gas detection

Combustible gas detectors are considered the first line of defense against fire since they are able to alert plant personnel of a gas leak before the gas ignites. A gas detection system should be capable of giving an early warning of both the presence and the general location of an accumulation of flammable gas or vapor. In addition, advanced gas detection systems offer onboard digital intelligence that allows diagnostic functions, historical data logging and digital communications.

Common fixed gas leak detection technologies include:

- Point detectors — using electrochemical, catalytic or infrared technology, these detectors provide gas concentration measurements when they come into contact with combustible and/or toxic gases (See Figure 1.)
- Acoustic detectors — are ultrasonic detectors that detect leaks based on gases' unique sound signatures (See Figure 2.)
- Line-of-sight (LOS) detectors — detect gas along a path between a transmitter and receiver, commonly using infrared (IR) technology (See Figure 3.)

Offering proven performance and reliability, catalytic and IR point gas sensors are the types most often employed in industrial plants. Since IR sensor technology cannot detect hydrogen gas, catalytic sensors are also used in areas where hydrogen may be present. Catalytic sensors are effective for detection of nearly all known flammable gases. Catalytic and IR detectors can typically be fitted with weather shields or dust caps to protect the sensor and potentially lengthen the time between required maintenance.

LOS systems provide continuous monitoring for the presence of hydrocarbon gas concentrations between the transmitter and receiver, typically over long distances. LOS systems are intended to supplement rather than replace point detectors. It is recommended that LOS systems be used with other gas detection technologies.

LOS gas detectors should be designed to withstand industrial conditions, including chemical exposure, precipitation and occasional vibration. Other advantageous LOS features include a wide alignment tolerance and failsafe operation, plus low maintenance and infrequent calibration requirements.

Unlike point and LOS technologies, both of which require gas plumes to move to active sensing regions, acoustic leak detection can respond to pressurized gas leaks the instant they occur. Moreover, acoustic detection capabilities may be less affected by rain, wind, fog, poisoning or obstructions.

Best practice #4: Locate gas detectors carefully

Point detector technologies require gas to travel to the detector, which can require a large number of installation points and a sophisticated placement strategy. Since the detector must come in contact with the gas or vapor cloud, it should be placed adjacent to the equipment being protected. In addition, flow considerations from ventilation, fans, wind, convection, etc., must be taken into account for proper placement of gas detectors and to determine the number of detectors required for adequate coverage.

For detection of gases heavier than air, point detectors should be positioned below the level of exhaust ventilation openings and close to the floor. For detection of gases lighter than air, the detector should be positioned above the level of exhaust ventilation openings and close to the ceiling. Point detectors should be installed in accordance with the manufacturer's instruction manual to ensure proper operation.

LOS detectors should be mounted to a rigid and stable surface so the optical alignment of the transmitter and receiver is maintained consistently. In addition, component placement must be performed carefully as the system requires an unobstructed line of sight between the transmitter and receiver. Many LOS detectors are self-monitoring and will alert users in the instance of a blocked light beam or some other fault that adversely affects detector operation. If possible, gas detectors should be placed in locations that are easy to access. Remote calibration initiation wiring and gas calibration tubing can be installed to help make calibrating difficult-to-access detectors easier.



Figure 2: The Det-Tronics FlexSonic® acoustic gas leak detector includes a high-fidelity microphone capable of continuously checking for the distinct ultrasound emitted by pressurized gas leaks across the widest spectrum of frequencies, while ignoring nuisance ultrasonic sources in the environment that could cause false alarms.

Best practice #5: Combine gas detection technologies

Since each of the gas detection technologies has benefits and limitations, a common strategy is combining the technologies and placing them in locations that maximize their effectiveness. In many industrial plants, for example, LOS detectors work with point detectors to provide optimal protection. In situations like this, the point detectors should be installed at or near high-risk gas leakage points or accumulation areas to provide gas-level information. LOS detectors, on the other hand, are often installed at plant or process-area boundaries where they can monitor the perimeter and track gas cloud movement in and out of an area.

Best practice #6: Calibrate and maintain gas detectors

Before a gas detection system starts operating, point sensors should be calibrated according to the manufacturer's instructions for the gas type(s) to be detected. Once in use, all point-type gas sensors require periodic recalibration using the appropriate calibration method, as well as ongoing maintenance for proper operation and maximum longevity. Specific maintenance instructions for a particular detection device can be found in the product manual and should be followed.

Best practice #7: Use appropriate smoke detectors

While a combustible gas detector can provide warning of an increased fire risk, a smoke detector provides an indication that a fire has actually started. Smoke detectors used in hazardous locations are different from ordinary smoke detectors because they must be hazardous-location rated (either explosion-proof or intrinsically safe).

Hazardous-area smoke detectors use a variety of technologies to detect particles produced by combustion. These include ionization, cloud chamber, photoelectric light obscuration, photoelectric light scattering and video image detection.

Before embarking on the design of a hazardous-area smoke detection system, plant engineers should review applicable standards such as NFPA 92, which covers the design, installation, operation and testing of smoke control systems. To be effective, smoke detectors in these systems should be located and spaced in anticipation of airflow from sources likely to present fire risks.

As with gas detectors, smoke detectors should be placed in locations that are easy to access in order to simplify maintenance. Smoke detectors should also be kept as free as possible of dust, dirt and other substances that could impair their operation. Additional maintenance requirements for particular models can be found in the product manuals.

Best practice #8: Add optical flame detectors

Though gas and smoke detectors are useful components of a fire-protection system, no such system is complete without flame detectors. These are line-of-sight devices that detect the radiant energy emitted by a flame.

Flame detectors can employ several sensing technologies: ultraviolet (UV), IR, UVIR and multi-spectrum IR (MSIR). When making a selection from these options, system designers must match the spectral response of the detector to the spectral emissions of the fires to be detected. It is also best to choose a flame detector that is performance tested to the fire type of interest in order to determine its effective detection range.

Flame performance testing can determine a detector's coverage area or field of view (FOV). Accurate FOV data allows the designer to locate detectors more effectively and efficiently. In most cases, the greater a detector's range and FOV, the fewer devices a plant will need to achieve its required coverage. Flame detectors require a clear line of sight to the area being protected, so proper detector placement, without obstructions, is important. Consult the product instruction manual to obtain detailed information about the types and sizes of fires a particular detector can detect.



Figure 3: Advanced flame detectors, such as the DET-Tronics X3301 IR flame detector shown, conduct automatic fail-safe checks every 60 seconds to verify the device's optic operation with no test lamp required.

Best practice #9: Plan for minimizing unwanted fire alarms

UV and IR energy is emitted from fire as well as non-fire sources. It is important that flame detection systems do not misinterpret non-hazardous situations as fire — causing a system to signal nuisance or potentially costly false alarms. IR and MSIR detectors typically differentiate fire from non-fire (e.g., false alarm) sources by using optical filters and algorithms that analyze the characteristics of the IR energy detected. In most cases, non-fire IR sources do not qualify under these algorithms.

In order to optimize a flame detector's false alarm rejection performance, it is preferred that the detector's FOV be controlled to the area that requires flame detection monitoring. Sources of intense IR emissions should be eliminated from the detector's FOV whenever possible. Controlling the detector's FOV through careful installation and aiming will also help optimize performance. It is recommended that a flame detector that has an intense IR source within its FOV (e.g., turbine enclosure, fin-fan cooler) be inhibited prior to personnel working on or in close proximity to the detector. The system designer can consult the manufacturer for configurations that can help mitigate the effects of background IR sources.



Optical flame detectors, such as the Det-Tronics X3301 MSIR detector shown above, should be aimed carefully to optimize performance.



Certified F&G safety systems depend on a fault-tolerant safety controller such as the Eagle Quantum Premier® (EQP) controller from Det-Tronics (shown). The EQP can combine gas, flame and smoke detection technologies into a single integrated safety system.

Another way to minimize false alarms is to use multiple detectors to monitor the same area in order to validate flame detection. To support redundancy, this type of system must include algorithms capable of handling "voting" circuits (with each detector's interpretation of an event counting as one vote) and making correct decisions based on input from multiple detectors.

Best practice #10: Manage detection and response with a certified fire and gas safety controller

In addition to gas, smoke and flame detectors, a fire protection system includes a safety system controller (SSC) that receives and interprets input from multiple detectors and takes executive actions regarding notification and fire suppression. A certified safety controller has, at a minimum, third-party certification for the applicable standards including performance and hazardous location, and may have other third-party certifications, such as functional safety and maritime.

The SSC also provides information about detection device status to the plant's process control system (PCS) so personnel in charge of the process are kept informed about important fire-related events. Often the PCS will be programmed to take prescriptive actions that help mitigate and control the hazardous situation communicated by the SSC. Since the fire system and PCS are independent of each other, a PCS failure will not affect fire-protection functions.

Final thoughts

Deploying gas, smoke and flame detectors in hazardous locations can significantly reduce fire-related risks to personnel, processes and facilities. When considering the design of a fire protection system, plant staff are advised to work with professionals experienced with code requirements. Understanding the practical aspects of a fire and gas safety system can help plant owners and operators make informed decisions regarding their system's purchase, installation and maintenance.

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Source

1. Research Report: "Fires in Industrial and Manufacturing Properties" March 2018, Richard Campbell, National Fire Protection Association, nfpa.org

About Det-Tronics

Det-Tronics is a global leader in fire and gas safety systems, providing premium flame and gas detection and hazard mitigation systems for high-risk processes and industrial operations. The company designs, builds, tests and commissions SIL 2 Capable flame and gas safety products ranging from conventional panels to fault-tolerant, addressable systems that are globally certified. Det-Tronics is a part of Carrier, a leading global provider of innovative HVAC, refrigeration, fire, security and building automation technologies.

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