Meeting NFPA standards for flame, smoke and gas detection

Fire is one of the most critical hazards in any built environment, and industrial processes and facilities that involve volatile and potentially flammable materials present special challenges for fire protection.

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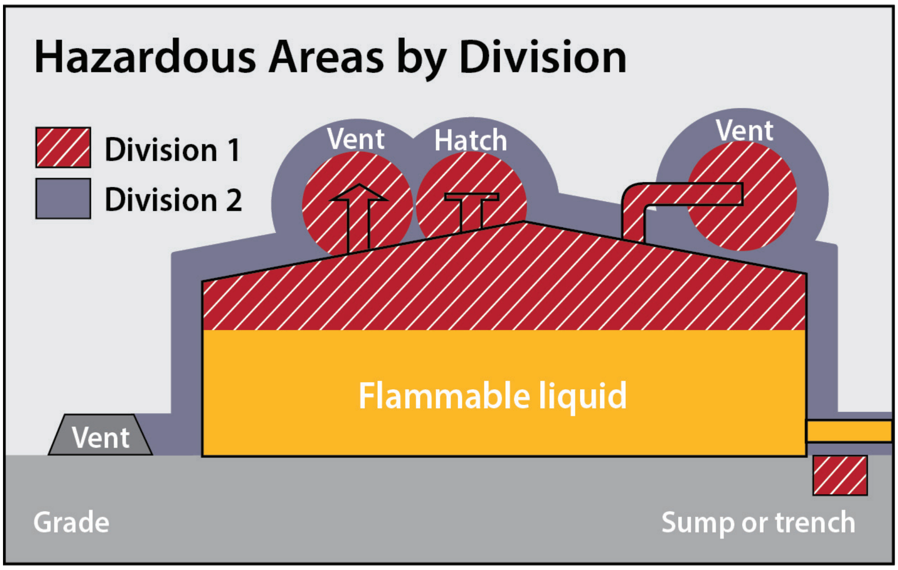
Hazardous conditions can occur in a range of settings across the Middle East, from desert-located oil drilling and refining sites to offshore oil platforms, and from fertilizer and agrichemical processing to petrochemical facilities. Other applications where the risk of fire is high include aircraft hangars, turbine enclosures and garages where buses fueled with liquefied natural gas (LNG) are stored. These types of high-risk locations and operations call for process-specific fire protection.

Fire protection requirements are legislated and subject to numerous codes and standards, such as NFPA (National Fire Protection Association), including NFPA 72: National Fire Alarm and Signaling Code and NFPA 70: National Electrical Code® (NEC®), EN (European Norms) 54 and ISO (International Organization for Standardization) 7240. While each country in the world has established its own regulatory structure that accommodates installation practices within their country, Middle East flame and gas detection performance requirements have been established with both European and North American influence. The U.S.' NFPA standards, along with the European Norms, are the backbone of Middle East fire safety standards for hazardous areas. Before discussing hazardous-area fire protection standards, it's important to understand what attributes make a process or location "hazardous."

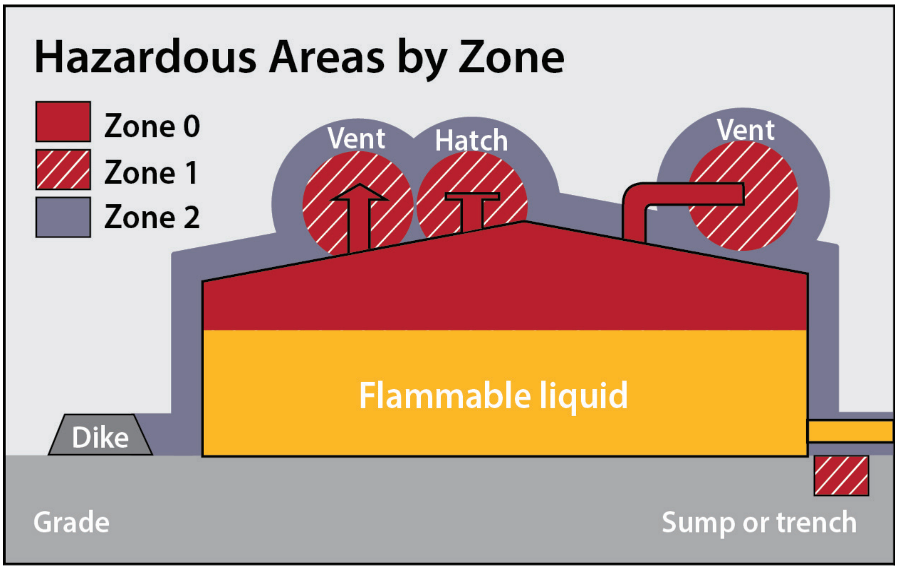
Defining hazardous areas

The definition of hazardous locations is based on a number of factors. The National Fire Protection Association in the U.S. covers these topics in great detail. According to its website, NFPA has published more than 300 codes and standards that affect "virtually every building, process, service, design and installation" with the goal of minimizing the risk and effects of fire. In particular, NFPA 70, Chapter 5 addresses "special occupancies." Within that chapter, Article 500 "Hazardous (Classified) Locations, Classes I, II and III, Divisions 1 and 2" stipulates that locations be classified based on the flammables that could be present, and their concentration or quantity. Hazardous areas are broken down into these three classes:

▼ Per NFPA 70, Division 1 locations are those where combustible materials are routinely present in ignitable concentrations, while Division 2 locations are those in which the same materials are present but are normally confined.



▶ **Per Article 505 of NFPA 70, a Class I, Zone 0 location is one in which ignitable concentrations of flammable gases or vapors are present continuously or for long periods of time. A Zone 1 location includes those in which such gases or vapors are likely to exist under normal operating conditions, while Zone 2 locations are those where ignitable concentrations are not likely to occur.**



- Class I — areas in which flammable gases, flammable liquid-produced vapors, or combustible liquid-produced vapors are or may be present in the air in quantities sufficient to produce explosive or ignitable mixtures
- Class II — locations in which combustible dust is present; dust is defined as solid material less than 420 microns (0.017 in.) or smaller in diameter
- Class III — locations in which easily ignitable fibers or flyings, such as rayon, cotton, jute, hemp and cocoa fiber are present

Within each class, there are divisions based on the concentration of flammable materials, the form of handling and the frequency with which the materials maybe present. For example, in Class I:

- Division 1 is a location where combustible materials are routinely present in ignitable concentrations.
- Division 2 is one in which the same materials are handled, processed, or used, but in which the materials are normally confined and can escape only in case of accident or breakdown or failure of ventilation equipment.

Within Class I, locations are also defined by zones (0, 1 or 2) per Article 505 of NFPA 70. For example, in a Class I, Zone 0 location, ignitable concentrations of flammable gases or vapors are present continuously or for long periods of time.

How to control fire risk in hazardous areas

In order to control fire risk, it's important to understand the components needed for a fire to start. Commonly referred to as the "fire triangle," the essential elements are:

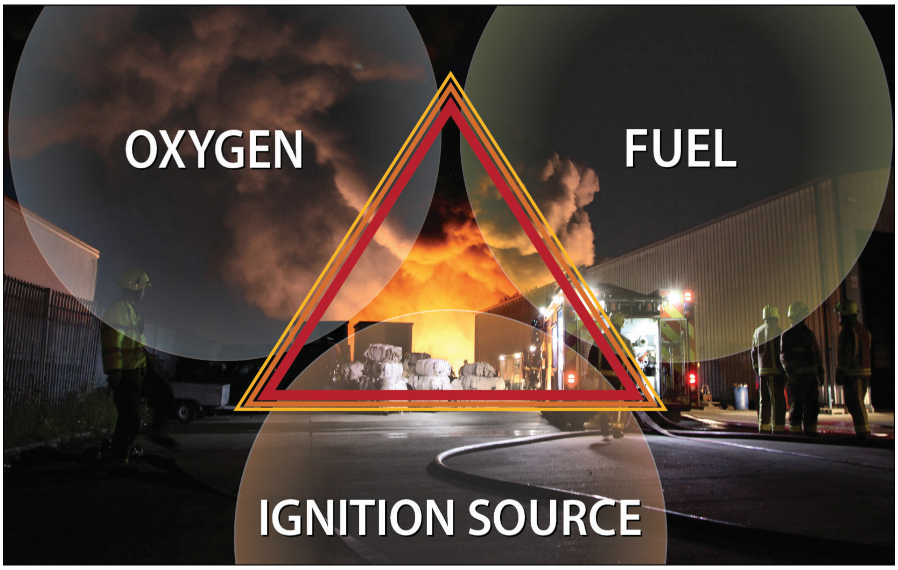
1. Oxygen — which can be a constituent or outcome of various industrial processes, though its primary source is the ambient air
2. Fuel — which is present in structures and used in processes of all kinds, but is of greater concern in locations defined as hazardous
3. Ignition source (i.e., heat) — which, depending on the fuel and conditions, can be as minimal as the spark of an electric switch or motor, or a hot surface

To control the risk of fire, one of the elements of the fire triangle must be eliminated. When possible, flammable materials must be contained and kept away from oxygen, as well as ignition sources such as sparks or hot surfaces. The primary goal should be containment of the fuel source, i.e., preventing leakage. The next step is to eliminate or minimize the risk of ignition. Because oxygen is ever-present in the atmosphere, it is difficult to eliminate this element from the fire triangle. Success in containing or reducing the concentration of fuel determines the Division level of a hazardous area. Any hazardous area, by definition, has some degree of risk due to the presence of flammable materials at combustible levels.

Controlling ignition risk from equipment

Many industrial locations in which hazardous materials may be present are also areas where electronic and electrical equipment could provide sources of ignition. It is therefore necessary to control ignition sources, e.g., heat, arcing or sparking. If electrical equipment (including flame and gas detectors) must be located in a hazardous area, per NFPA they must be designed to limit or isolate potential sources of ignition. NFPA 70 Section 500.7 "Protection Techniques" lists several techniques for protecting

▼ **Figure 3: The fire triangle depicts the three elements a fire needs to ignite.**



▼ Acoustic detectors are non-contact gas leak detectors that recognize unique acoustic "fingerprints," and are ideal for areas where there is risk for pressurized gas leaks. These detectors are suitable for harsh outdoor applications, unmanned operations and extreme temperatures. They are unaffected by fog, rain, and wind. The ideal acoustic detector accurately identifies the sound of a gas leak while ignoring other nuisance environmental sounds.

electrical and electronic equipment used in hazardous (classified) locations. The three acceptable protection methods for Class I Division 1 are:

- Explosion Proof (XP) — sparks or explosions are contained within the housing
- Purged and pressurized — combustible gases and vapors are denied entry into the enclosure
- Intrinsically Safe (IS) — the entire power of the system is limited

In addition to limiting electrical energy as an ignition source, the surface temperature of electrical equipment must also be controlled. Equipment is marked (T1 – T6) to show the suitable maximum surface temperature of the device, which must be below the auto ignition temperature of the fuel hazard.

What makes up a fire protection system

A fire protection system is comprised of several subsystems that can include, but are not limited to: flame, smoke and gas detection; notification and/or suppression activation; and a controller that receives the inputs from the detection devices, makes decisions and initiates appropriate action or actions.

There is no single solution for fire detection in hazardous areas. Effective protection is based on the materials and fuels present, the processes involved, the environment, and other control measures present. Based on these variables, an effective detection and suppression system may require multiple technologies to effectively detect the hazards.

Regardless of the application, many NFPA codes and standards for specific processes reference NFPA 72, National Fire Alarm and Signaling Code, including:

- NFPA 15 Standard for Water Spray Fixed Systems for Fire Protection — "The selection, location and spacing of automatic fire detectors for the actuation of fixed water spray systems shall meet or exceed the application requirements of NFPA 72..."
- NFPA 30 Flammable and Combustible Liquids Code references numerous NFPA codes, including NFPA 15, which in turn references NFPA 72.
- NFPA 59A Standard for the Production, Storage, and Handling of Liquefied Natural Gas (LNG) says, "...the detection system shall be designed, installed and maintained in accordance with NFPA 72 National Fire Alarm Code."
- NFPA 70 National Electrical Code has multiple references to NFPA 72.
- NFPA 409 Standard on Aircraft Hangars says, "Listed detection systems shall be acceptable in lieu of heat detection if approved by the authority having jurisdiction and installed in accordance with NFPA 72."

Chapter 17 of NFPA 72 is titled "Initiating Devices" and it provides requirements for the use of various types of detectors — radiant energy-sensing (flame) smoke and gas — that can be used to discover or recognize potential indications of fire. Below is an overview of each detector type and some of the NFPA standards applicable to each.

Flame detectors

NFPA 72 describes a flame detector as "a radiant energy-sensing fire detector that detects the radiant energy emitted by a flame." Flame detectors are line-of-sight devices that can employ several sensing technologies: ultraviolet (UV), infrared (IR), ultraviolet/infrared (UV/IR) and multi-spectrum infrared (MSIR).

Radiant energy-sensing detectors are incorporated into hazardous-area fire protection systems particularly when either or both of two factors are present in the application: 1) when rapid-fire detection and actuation response times are critical; and 2) when the impact of false alarms is potentially disastrous in terms of damage, downtime or both. Flame detectors used in hazardous areas must be hazardous-location-rated and performance-certified.

There are many factors to consider when selecting the type, quantity, location, and spacing of flame detectors, including:

- Matching the spectral response of the detector to the spectral emissions of the fire or fires to be detected.
- Minimizing the possibility of spurious nuisance alarms from non-fire sources inherent to the hazard area.

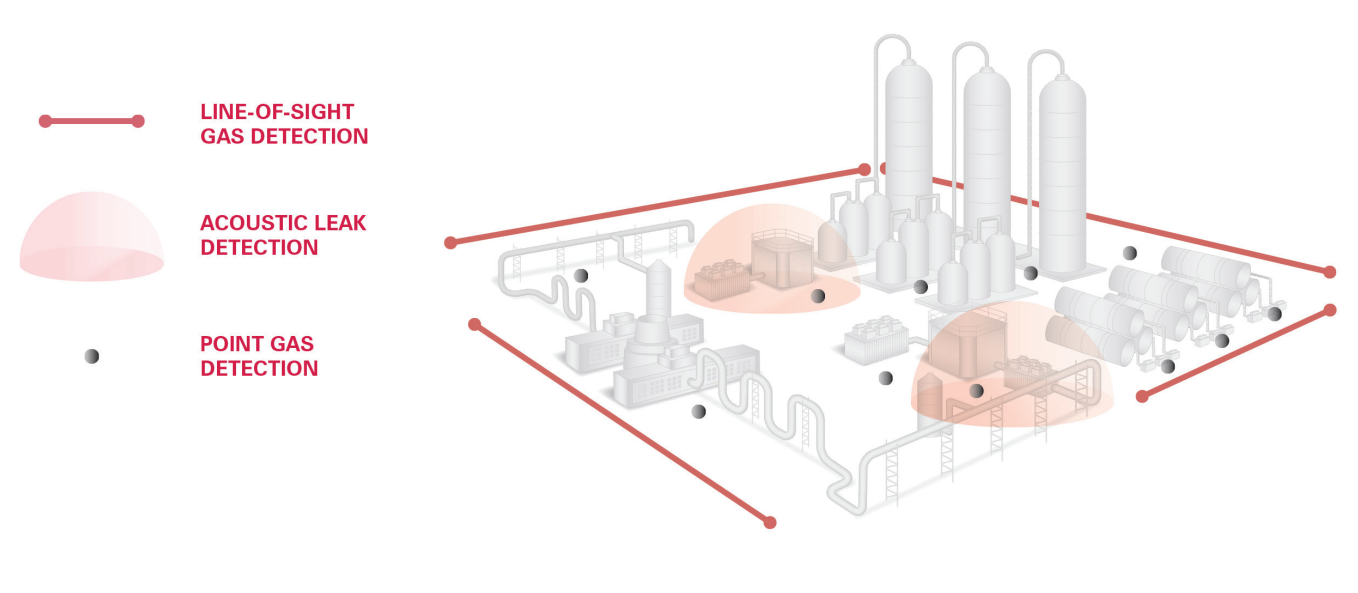
NFPA 72 addresses these selection factors in Chapter 17:

- 17.8.3.2.1 The location and spacing of detectors shall be the result of an engineering evaluation that includes the following:

1) Size of the fire that is to be detected
2) Fuel involved
3) Sensitivity of the detector
4) Field of view (FOV) of the detector
5) Distance between the fire and the detector
6) Radiant energy absorption of the atmosphere
7) Presence of extraneous sources of radiant emissions
8) Purpose of the detection system
9) Response time required

Smoke detectors

A smoke detector detects the smoke particles produced by combustion using a variety of technologies. These can include ionization, cloud chamber, photoelectric light obscuration, photoelectric light scattering and video image detection.



▲ **Figure 5: Employing different gas detection technologies can increase coverage and reduce risk in high-hazard environments.**

To be effective, smoke detectors should be located and spaced in anticipation of airflow from sources likely to present fire risks, but without resulting in unwarranted alarms. NFPA 72 describes the requirement this way:

- 17.7.1.9 The location of smoke detectors shall be based on an evaluation of potential ambient sources of smoke, moisture, dust, or fumes, and electrical or mechanical influences, to minimize nuisance alarms.

Combustible gas detectors

NFPA 72 describes a gas detector as "a device that detects the presence of a specified gas concentration." Detectors are intended for specific types of gas or vapor and should be chosen accordingly, as specified in NFPA 72:

- 17.10.2.4 The selection and placement of the gas detectors shall be based on an engineering evaluation.

Gas leak detection technologies can include:

- Acoustic detection for gas leaks — ultrasonic sensors detect leaks based on noise patterns
- Infrared detection along a line of sight — detects gas along a path providing a large area of detection
- Point detection of a combustible or toxic gas by electrochemical, catalytic, or infrared technologies — gases come into contact with the detector, causing the detector to activate

A challenge related to gas detection is that the origin of gas leaks can often be difficult to predict. Gas leak detection can also be challenging due to varying environmental conditions such as wind and rain, and application factors such as machinery and piping. These environmental and situational factors, as well as the many potential sources of gas leaks, play major roles in selecting the type(s) of combustible and toxic gas detection technology to use, and the placement of the devices. Combining various technologies and placing them in locations that maximize their effectiveness can mitigate the impact of a hazard.

Fire protection system controller

A safety system controller (SSC) receives and interprets input from multiple detectors and makes executive decisions regarding notification and further activity including suppression. While the primary function of detectors is to detect a hazard and then signal to alert that an event has occurred, it is also essential that detectors are capable of maximizing false alarm rejection – so they do not alarm to non-hazardous events, such as arc welding. NFPA 72 defines a nuisance alarm this way: "An unwanted activation of a signaling system or an alarm initiating device in response to a stimulus or condition that is not the result of a potentially hazardous condition. In some cases, in order to prevent nuisance alarms, the SSC may discount information from a single detector if it is not confirmed by other detectors in the area.

As is the case for individual detectors, the SSC, if installed in a hazardous location, must be rated for the location. Alternatively, the SSC can be located outside the hazardous location.

Beyond NFPA

While the NFPA standards are both wide ranging and very detailed, they are a minimum for demonstrating the use of recognized and generally accepted good engineering practices (RAGAGEP).). Local authorities having jurisdiction (AHJ) may have more stringent requirements. Also, standards may not consider the value of the assets being protected, or in some cases, insurance carriers may demand higher levels of protection. System designers, along with process owners and facility managers, need to consider the risks, balance the costs, and consult with experts to optimize process-specific fire protection for high-risk locations and operations.

For more information, go to www.det-tronics.com

References

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