WHITE PAPER

Compliance Tips: Fire and Gas Detection and Suppression Systems for LNG Facilities

Planning for functional safety requires an understanding of process hazards, relevant industry standards and local codes, and available product and system solutions.

Liquefied natural gas (LNG) is 600 times denser than the gas form, making the economics to transport LNG more attractive (and more feasible) than transporting natural gas in pipelines over great distances across oceans. There are several proprietary processes used to make LNG, all of which involve refrigerating the gas and then expanding it to turn into a cryogenic liquid. Inherent in these processes are the risks associated with spills and leaks as well as other process hazards.

Non-flammable as a cryogenic liquid, when LNG warms, it vaporizes (re-gases) and may form a flammable mixture upon reaching a concentration of between 5% and 15% methane-to-air. If LNG should leak to the environment, it will quickly vaporize and form a rising cloud of methane gas, without leaving a residue. The hazard is created when the cloud forms a flammable concentration that presents a risk for ignition. If the leak occurs within a confined area, there is a potential for ignition with explosion. The heat release rate from an LNG pool fire is approximately 60% greater than that of a gasoline pool fire of the same size. There are also non-flammable hazards in LNG facilities due to the presence of refrigerants and other chemicals used in the gas treatment process.

It is the job of the facility's fire and gas detection system to detect these hazards and take appropriate action.

System objectives

In the event of loss of LNG containment, the process facility's fire and gas detection system must rapidly identify the hazard and indicate its location. Each hazard must be assessed and assigned a detection scheme with appropriate response actions that are documented.

No two LNG facilities are exactly the same. Each conforms to its local surroundings, and is laid out and custom-designed to meet specific material, throughput, storage and transport objectives. However, they use common technologies and perform similar processes.

System performance

There is a direct correlation between the performance of a fire and gas detection system and:

- The appropriateness of the detection technology selected
- The number and location of the detectors
- Environmental conditions

Determining which types of detectors to use and where to place them requires a review of the process and the hazards presented, as well as fire and gas detection expertise.

In order for a system to be designed appropriately, system performance must be clearly defined and documented in terms of the hazards present in each process unit (or zone).

Detector coverage

The required coverage of hazards by a flame and gas detection system needs to be specified. This should include specifying the appropriate technology for the detection of the hazard and the required coverage of each hazard. For example, infrared (IR) gas detectors will not detect hydrogen sulfide. The correct mechanical and electrical properties of the detectors must also be carefully selected to ensure that they are appropriate for use in the environment and location in which they are to be mounted.

3D models help document a fire and gas system design, and provide calculations for the coverage afforded by a particular detection scheme to ensure that coverage targets are attained. 3D mapping is also valuable for showing individual detectors' obstructed fields of view. (See Figure 1.)

Reliable detection without false alarms

A detector with a greater detection range is generally considered an advantage, since it means greater ability to detect the hazard either earlier or from greater distances. However, it is important that the detector does not lead to an increased incidence of false alarms.

The system may be configured to automatically initiate corrective actions, including engaging the emergency shutdown (ESD) system, when gas or a flame is detected. However, false alarms that trigger emergency shutdowns are expensive in terms of cleanup costs, lost revenue, and time-consuming reviews, paperwork and reporting. In order to reduce the probability of false alarms and unintended activations, it is imperative to use a performance-certified detection system that provides immunity to false alarm sources, and is unaffected by electromagnetic interference (EMI) and radio-frequency interference (RFI). This is especially important when a facility uses electrical drives.

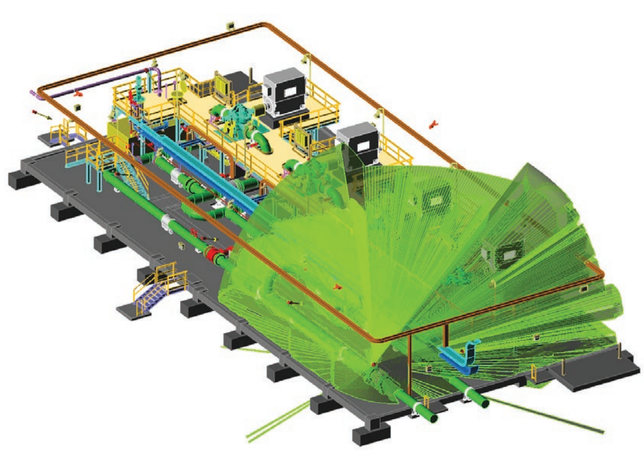


Figure 1: 3D mapping can be used to show obstructions in an individual detector's field of view.

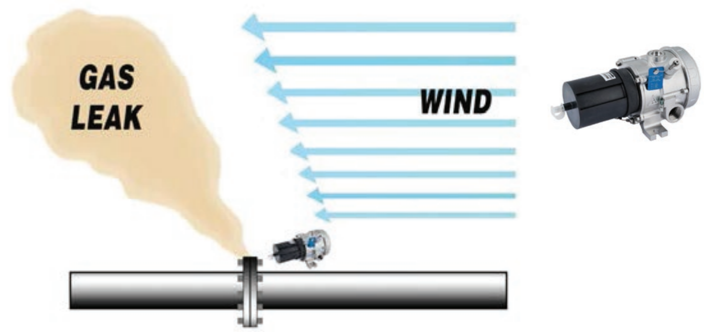


Figure 2: Covering a hazard area with voting detectors can reduce the probability of alarming in the face of a legitimate threat, particularly where environmental factors such as wind may be present.

Redundancy and fault tolerance

Redundancy should be considered based upon the criticality of a component, i.e., the impact of that component's failure. For example, a facility may consist of multiple processing trains, each with its own fire and gas system. In this case, the loss of one controller—and therefore one train—may not be that critical. However, a single fire and gas controller could be managing an entire facility's fire and gas detection system. A failure of that controller could lead to facility-wide loss of production; therefore, redundancy of this critical component can increase facility availability.

When redundancy is employed, the wiring for the redundant components must be carefully analyzed to remove potential common-mode failures that can be caused by using common cable or conduit. Diverse routing of wiring for redundant components will eliminate these possible points of failure. Redundancy in the detection wiring scheme (Class A) should also be considered for the purpose of reducing the impact of lost alarm capability.

In addition to the wiring architecture, there are also many environmental factors, such as wind or other sources of air movement, to consider. Environmental factors are even more critical with a voted detection design. For example, consider two gas detectors installed five meters apart in a zone voted to alarm at 20% LFL/LEL. A larger gas cloud may be needed to contact both detectors to alarm at a 20% LFL/LEL level in a typical outdoor environment. (See Figure 2.)

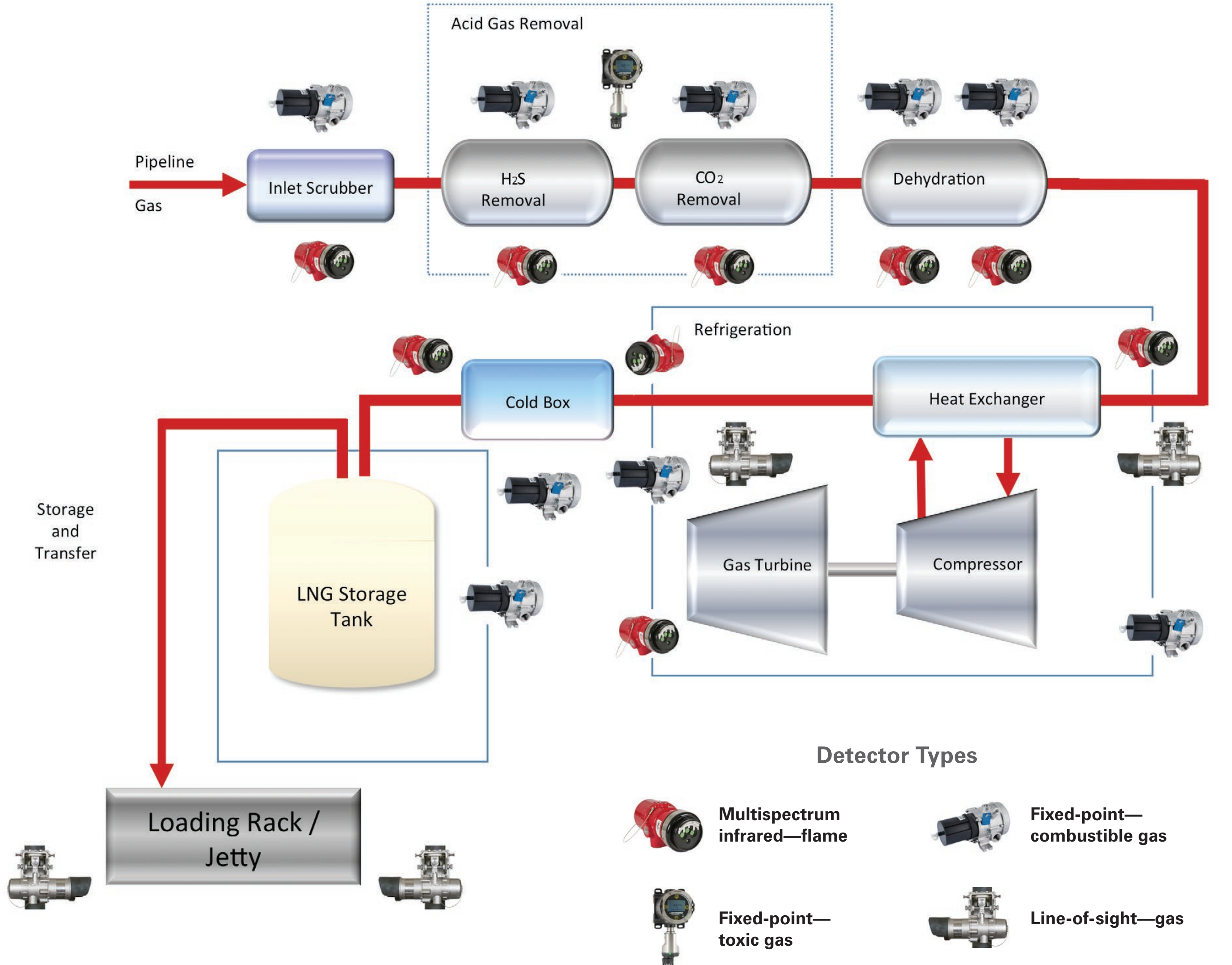


Figure 3: **A simplified LNG process**

Selecting detector types in an LNG process

There are different hazards throughout the LNG process that require different detectors and/or technologies. Figure 3 depicts the detector types suggested at each stage in the liquefaction process. In addition to the need for flame and gas detection throughout the liquefaction stages, detectors are also needed in other LNG facility hazard zones, such as storage tank process areas, cross-site transfer trenches and emergency impounding basins. (See Figure 4.)

The process starts with sour natural gas. As the sour gas passes through the inlet pipes, it enters the inlet scrubber, which removes particulate and liquid contaminants in order to make the gas suitable for further processing. The gas then moves on to the acid gas unit where hydrogen sulfide (H_2S) and CO_2 are removed.

Since H_2S is particularly poisonous and flammable, toxic gas detectors are located in this area as well as IR detectors for natural gas (NG). The gas then moves on to the dehydration stage. With the H_2S removed, detectors in this area are looking only for NG leaks.

The final liquefaction stage is the refrigeration of the gas. The gas goes through a series of compression and cooling steps that ultimately create the LNG. There are many potential leak points and ignition sources in this area of an LNG facility. Here, point and line-of-sight (open-path) IR gas detectors are configured to identify the spectral signature of the processor's refrigerant gases—propane, ethylene or methane. If the hazard is a refrigerant gas composed of a mixture of gases, then a careful review of the mixture should be made in order to determine what the IR gas detectors should be configured to detect.

In the final refrigeration step, the chilled gas enters the cold box to be transformed into liquefied natural gas (LNG). From this point forward, IR gas detectors are configured to look specifically for methane leaks. Additional IR gas detectors are placed along the piping as the LNG is transferred to storage tanks, and then finally onto loading racks or jetties for shipment.

In addition to gas detection, it is also imperative to detect flame hazards throughout the LNG process. The multispectrum infrared (MSIR) flame detector offers optimum performance for this purpose in an LNG facility.

Control and integration

Any effective fire and gas detection and suppression system must be capable of interfacing with and integrating flame, gas and smoke detectors, fire suppression devices and notification appliances.

The fire/gas and suppression control system must be able to:

- Reliably detect hazards and provide appropriate audible and visual alarms and location of each hazard
- Be available during all plant conditions, e.g., plant shutdowns, turnarounds, maintenance
- Integrate seamlessly to other plant control systems, which provide control of mitigation actions such as starting water pumps, opening deluge valves and closing heating, ventilating and air conditioning inlet dampers
- Route digital outputs to the emergency shutdown system in order to isolate and shut down process equipment

The controller must also be able to handle voting logic and support user logic that allows the correct actions to be taken to mitigate the detected event.

The Eagle Quantum Premier® (EQP) fire- and gas-safety controller by Det-Tronics is one such platform. The EQP provides access to the local operator network (LON) and empowers the operator to configure, program, monitor, diagnose and control the entire system from a single point of control.

When designing a fire and gas system in any region of the world, the designer needs to know and understand the applicable code and standards. However, some codes and standards must be followed because they are legislated, such as fire codes or hazardous locations standards. Using codes and standards for system design and as criteria for evaluating product performance will meet the minimum requirements for what is considered good engineering practice.

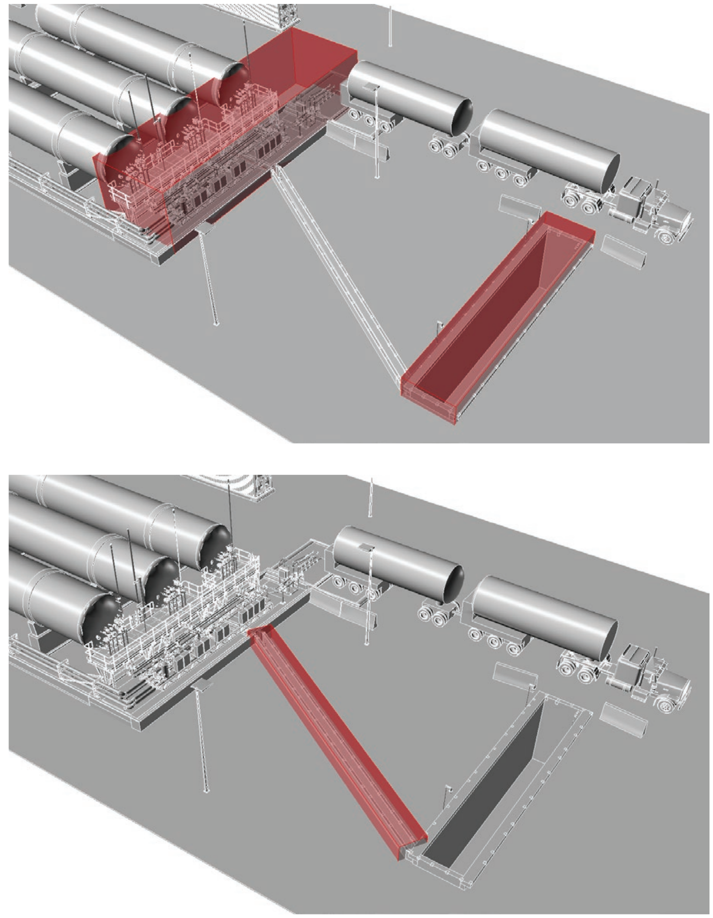


Figure 4: Offloading and storage areas in LNG facilities also require coverage by flame and gas detectors. The diagrams depict three typical hazard zones: an emergency impounding basin, the storage tank process area and a cross-site transfer trench.

In the U.S., the National Fire Protection Association has published NFPA 59A, a legislated document that governs the design of LNG facilities. In turn, NFPA 59A requires that fire systems be in accordance with NFPA 72, The National Fire Alarm and Signaling Code. In Canada, CSA Z276-15 (NFPA 59A equivalent) does the same.

In Europe, some of the EN 54 (Fire Detection & Alarm Systems) series of standards are harmonized under the Construction Products Regulation, which covers the essential health and safety requirements for buildings. Other regions may have their own codes and regulations that must be followed to be in compliance.

Below are some codes and standards that may be applicable to the design of a fire and gas system, or are used in the certification of gas or flame detectors.

Systems level standards:

- EN/IEC 60079-29-1,2 series for Gas Detectors/Controllers
- IEC61508 Safety Instrumented Systems
- U.S. — NFPA 72
- Europe — EN 54-2

Gas performance standards:

- U.S. — FM 6310 and FM 6324
- Europe/International — EN/IEC 60079-29 -1,2

Flame performance standards:

- U.S. — FM 3260
- Europe — EN 54-10

As mentioned above, codes and standards are country specific. It is the designer's responsibility to ensure that selected fire and gas systems and detectors are suitably approved for the jurisdiction in which they are to be used. Given the complexity of standards and variations in their interpretation, LNG plant managers and engineers typically consult experts in the field to help them through fire and gas detection and suppression system design, implementation and management. Det-Tronics provides site analysis, 3D mapping and all the detection technologies and controls needed for complete flame and gas detection systems in LNG processing, offloading and transportation applications.

For a complete explanation of the certification and functional safety approval process, refer to the Det-Tronics white paper titled, "Why Functional Safety Product Certifiers Must Meet Highest Level of Accreditation."

DETECTOR TYPES AND CONTROLLERS USED IN LNG APPLICATIONS

Multispectrum infrared (MSIR) flame detectors

Multispectrum IR flame detectors are often preferred in LNG environments since background IR noise is quite common, and this interference tends to desensitize single-spectrum detectors that are set to detect one specific wavelength somewhere between one and five microns. MSIR detectors use multiple-IR sensors, each set to detect a different wavelength, along with processing algorithms that can differentiate flames from background IR radiation. MSIR detectors vary widely with respect to the sensitivity range and FOV they provide. For example, adequately covering a particular hazard zone using detectors with a range of 50 feet requires six times as many detectors as covering the same zone using detectors with a range of 200 feet.

Fixed-point toxic gas detectors

Fixed-point toxic gas detectors detect toxic gases using electrochemical or NTMOS technology. They measure the concentration at the point where the detector is located and give readings as parts per million (PPM). Toxic gas detectors are placed anywhere there is a potential for a H_2S leak hazard.

Fixed-point combustible gas detectors

Fixed-point combustible gas detectors detect combustible gases using catalytic or infrared technology. They measure the concentration at the point where the detector is located and give readings as the percentage of the lower flammable/explosive limit (LFL/LEL). Combustible gas detectors monitor for potential flammable gas leak conditions.

Line-of-sight (LOS) gas detectors

Line-of-sight gas detectors continuously monitor combustible gas levels between two points at ranges of up to 120 meters. Line-of-sight detectors are often deployed in and around open areas and harsh environments that are typical of an industrial site. This technology is perfect for perimeter monitoring for gas clouds, and it augments point detectors for optimal coverage in large open areas.

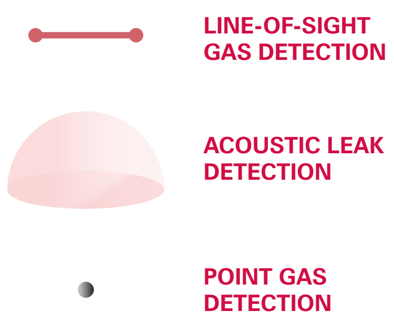
Acoustic gas leak detectors

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.

Certified systems for detection and suppression

Controllers for functional safety systems provide configurable and flexible operation for flame and/or gas detection, alarm signaling, notification, extinguishing agent release and/or deluge operation. It is important that the control platform is certified to all applicable standards by a qualified certifying group(s).

To increase the probability of detection of a hydrocarbon gas leak, multiple gas detector technologies should be used. (See Figure 5.)



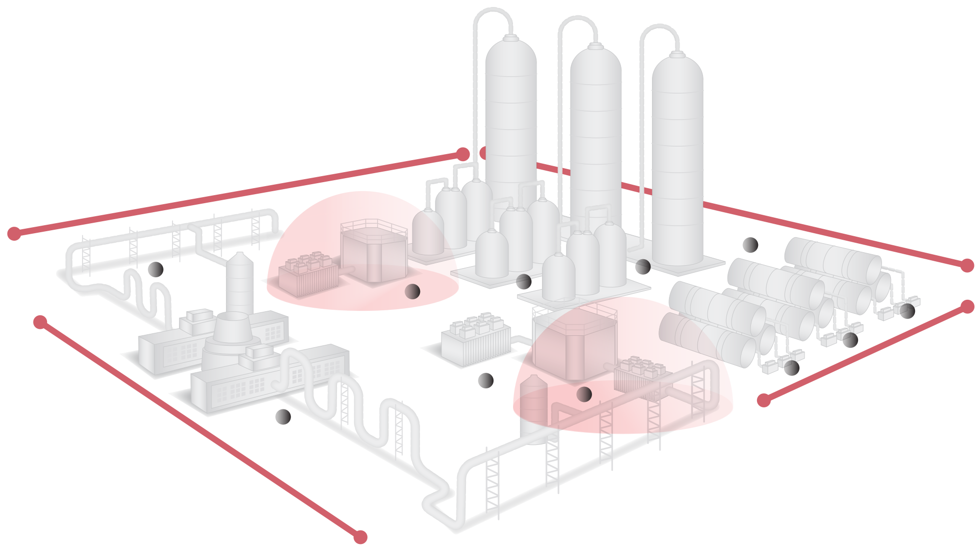


Figure 5: Employing different gas detection technologies can increase coverage and reduce risk in high-hazard environments such as LNG processing facilities.

A final word

Producing, storing and transporting LNG is a multifaceted process with numerous volatile operations and hazards. Designing a comprehensive and effective fire and gas detection and mitigation system to protect an LNG plant is equally complex, requiring thorough analysis and planning. Requirements have to be carefully assessed, sites have to be surveyed and mapped out, and appropriate devices have to be placed, tested and integrated into the detection and suppression network. The system and its components must adhere to the relevant local standards, and be approved by the local accredited certifying organizations such as FM Approvals.

Implementing such a system is a major undertaking, and is typically a team effort involving the owners and managers of the facility, third-party consultants, and device manufacturer experts such as Det-Tronics.

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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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DET-TRONICS

Corporate Office
6901 West 110th Street
Minneapolis, MN 55438 USA
det-tronics.com

Phone: +1 952.941.5665
Toll-free: +1 800.765.3473
Fax: +1 952.829.8750
det-tronics@carrier.com

Carrier