Simon Pate, Det-Tronics, USA, looks at the role of fire and gas detection and suppression systems in LNG plants.

Mitigating risk at LNG facilities

Worldwide growth in the use of natural gas has increased the need for transporting it – and the most economic method of transporting natural gas is in its liquefied form, which is 600 times denser than its gaseous form. The several proprietary processes used to make LNG involve refrigerating the gas and then expanding it to turn the gas into a cryogenic liquid. At almost every stage in these processes, there are inherent risks of toxic or flammable gas leaks that require protection by a fire and gas detection and suppression system.

LNG is non-flammable as a cryogenic liquid, but as it warms and vaporises back into a gas, it becomes more volatile. A concentration of just 5 – 15% methane-to-air can form a flammable mixture. If LNG leaks into the environment, it quickly vaporises and forms a rising cloud of methane gas, which becomes a hazard once the cloud reaches a flammable concentration, creating risk for ignition. Leaks that occur within a confined area pose the additional threat of explosion. In addition to flammable hazards in LNG facilities, there are also non-flammable hazards, such as the presence of refrigerants and other chemicals used in the gas treatment process.

An LNG facility's fire and gas detection system must be able to produce a safety warning, identify the hazard, indicate its location, and take appropriate action whenever a hazardous condition is recognised. Each type of hazard must be properly assessed and assigned appropriate response actions, recognising that no two LNG facilities are exactly the same.

Incorporating detection technology

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

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

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). Doing this requires an in-depth knowledge of the process and sensor technologies.

For example, an infrared (IR) gas detector will not detect hydrogen sulfide. Also, the correct mechanical and electrical properties of the detectors must be carefully selected to ensure that they are appropriate for the environment and location where they will be mounted. A 3D model can be used to verify

Figure 5. Cheniere Energy's Sabine Pass LNG terminal, permitted to build six liquefaction trains, is currently shipping product from Trains 1 and 2. Each train houses 150 detectors of various types (photo courtesy of Cheniere Energy, Inc.).

the location and aiming of detectors, and to help document a fire and gas system's design (Figure 1).

Detector types used in LNG applications

- Multispectrum infrared (MSIR) flame detectors – MSIR flame detectors are often preferred in LNG environments since background infrared (IR) noise is quite common, and this interference tends to desensitise single-spectrum detectors that are set to detect one specific wavelength somewhere between 1 and 5 µm. 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.
- Fixed-point toxic gas detectors – Fixed-point toxic gas detectors detect toxic gases using electrochemical or nanotechnology metal oxide semiconductor (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 IR 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 – LOS gas detectors continuously monitor combustible gas levels between two points at ranges of up to 120 m. They 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 recognise unique acoustic 'fingerprints', and are ideal for areas where there is a risk of pressurised 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).

It is important to evaluate the potential for false alarms before making a final technology decision. False alarm sources are typically flares and open fire heaters. Electromagnetic interference (EMI) and radio-frequency interference (RFI) can also impact the performance of poorly installed systems. Remember that false alarms can trigger emergency shutdowns. To reduce the probability of false alarms and unintended activations, performance-certified detection systems should be properly installed. This is especially important when a facility uses electric drive technologies.

Liquefaction process and detector requirements

The specific configuration of the liquefaction process depends on the quality of the feedstock gas. Unfortunately, some clean-up typically has to occur. Therefore, the first process step (Figure 2) is for the gas to go through an inlet scrubber to remove particulate and liquid contaminants to make the gas suitable for the next stage, which is acid gas removal (H_2S and CO_2). H_2S is particularly poisonous and flammable, which means that toxic gas detectors are used in those locations, as well as IR gas detectors, to guard against natural gas leaks.

Liquefaction occurs through a refrigeration stage, where the gas goes through a series of compression and cooling steps incorporating the use of different refrigerants. As mentioned above, these cooling cycles are proprietary to each LNG process owner. In general, the refrigerants used are ethylene, methane, or a mixture of gases. There are many potential leak points and ignition sources in this area of an LNG facility. Therefore, point and LOS (open-path) IR gas detectors are configured to identify the spectral signature of the processor's refrigerant gases used. 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 LNG. From this point forward, IR gas detectors are configured to look specifically for methane leaks.

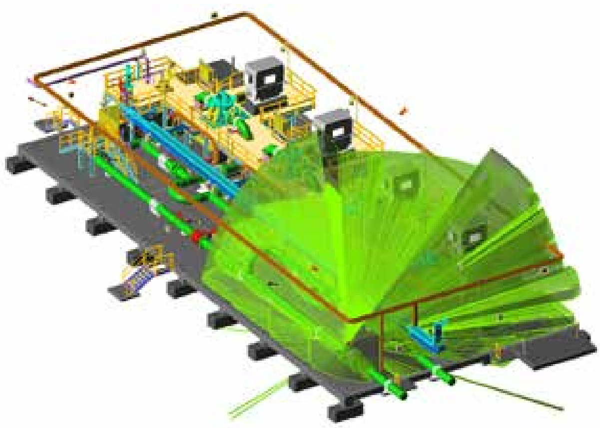

Figure 1. 3D mapping can be used to show obstructions in an individual detector's field of view.

The LNG is then stored in insulated tanks at -162°C before being shipped. Finally, IR gas detectors are placed along the piping, loading racks, or jetties, as well as other LNG facility hazard zones, such as storage tank process areas, cross-site transfer trenches, and emergency impounding basins. Detecting flame hazards throughout the process is also important. The multispectrum infrared (MSIR) flame detector offers optimum performance for this purpose.

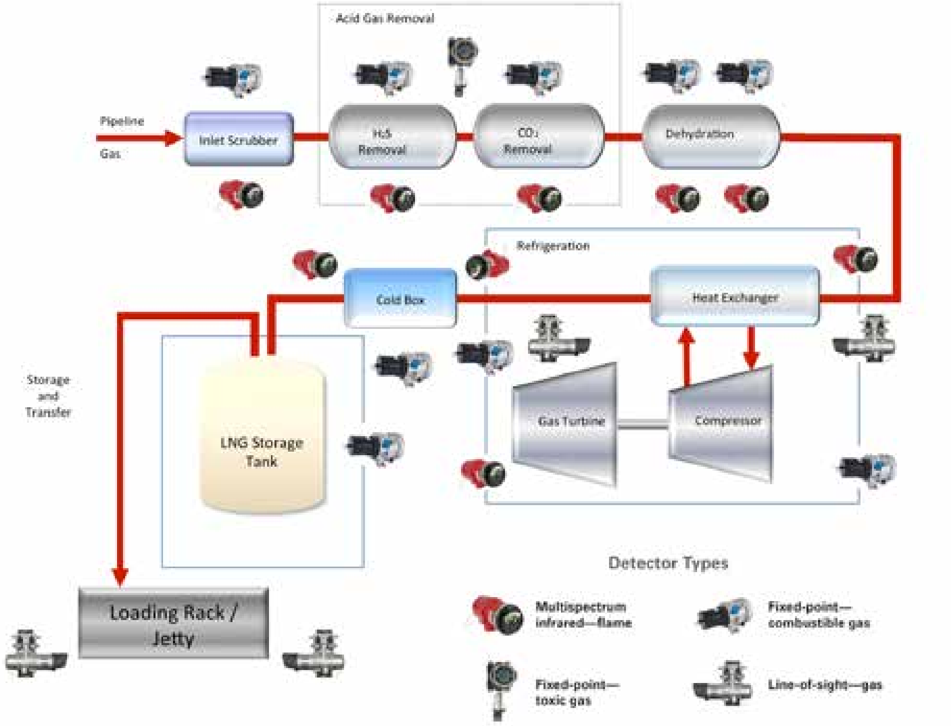

Figure 2. This simplified LNG process drawing indicates where detector technologies can be used.

Redundant systems

Redundancy is often overlooked because of the added expense, but should be considered based upon how critical a particular component is to system operation. If a component's failure would impact safety or production, it becomes a candidate for redundancy. For example, if multiple processing trains are incorporated at a facility, each with its own fire and gas system controller, the loss of one may not be critical to production. However, if the fire and gas controller is managing the entire facility's detection system, then failure would lead to facility-wide loss of production.

It is critical to facility operations that redundant systems and components are provided with diverse routing schemes for wiring in order to eliminate the possibility of common-mode failures caused by using common cables or conduits. 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, environmental factors, such as wind or other sources of air movement, should be considered. An example might be when two gas detectors are installed 5 m apart in a zone that is voted to alarm at 20% lower flammable limit (LFL). It may actually take a large gas cloud to contact both detectors to alarm in a typical outdoor environment (Figure 3).

Figure 3. 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.

Control and integration features

Any effective fire and gas detection and suppression system must be capable of interfacing and integrating with flame, gas and smoke detectors, fire suppression devices, and notification components. A well-balanced control system must be able to reliably detect hazards, provide appropriate audible and visual alarms, and indicate the location of each hazard.

The controls must be online throughout all plant conditions, including shutdowns, turnarounds, and maintenance cycles. They must 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. The system must also be able to route digital outputs to the emergency shutdown system in order to isolate and shut down process equipment.

Finally, the controller must be able to handle voting logic and support user logic that allows correct actions to be taken to mitigate the detected event. An example might be the

Figure 4. The Det-Tronics Eagle Quantum Premier (EQP) fire and gas safety controller provides flame and gas detection, alarm signaling, notification, and suppression release.

Eagle Quantum Premier® (EQP) fire and gas-safety controller by Det-Tronics, which enables the operator to configure, program, monitor, diagnose, and control the entire system from a single point of control (Figure 4).

An installed system overview

The Cheniere Sabine Pass LNG terminal, located on over 1000 acres of land along the Sabine Pass River, is the first operational LNG export terminal in the lower 48 states of the US, and the first facility to ship gas extracted from the country's gas-rich shale fields (Figure 5). The facility is permitted to build six liquefaction trains at that location. Currently, Trains 1 and 2 are shipping product, with Train 3 scheduled to be running by 2Q17. Each train houses 150 detectors of various types.

The Sabine Pass facility incorporates a fire detection and extinguishing agent release system combined with a hazardous gas monitoring system integrated on a fault-tolerant digital communications network. Each train has multiple controllers that report to a redundant facility controller in the main control room.

The controllers (nine Det-Tronics EQP controllers) provide an important management capability. They connect the currently operating trains of liquefaction via an FM Approved communication network, allowing logic to be shared across the network. Additional controllers are already installed to support secondary operations, as well as dock-area monitoring. At the end of the project, there will be 14 sets of redundant EQP controllers on the Sabine Pass facility.

Meeting codes and standards

No matter where in the world a fire and gas system is installed, the design team must be aware of and understand all applicable codes and standards. Legislated codes and standards, such as fire codes or hazardous locations standards become important criteria when evaluating product performance, and provide key information for minimum system requirements.

Again, 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, the facilities' common technologies and similar processes all point to the need to plan for the functional safety provided by a well-designed fire and gas detection and suppression system. **LNG**

This first appeared in the July 2017 issue of *LNG Industry* magazine — Reproduced courtesy of Palladian Publications Ltd.

AR 1120 | July 2017

DET-TRONICS
United Technologies

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

Phone: 952.946.6491
Toll-free: 800.765.3473
Fax: 952.829.8750
det-tronics@det-tronics.com