HMA INSTRUMENTATION

Case Study

INTEGRATING FIRE & GAS SAFETY WITH PROCESS CONTROL SYSTEMS

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If a fire, smoke or gas leak is detected in an industrial facility, prescriptive actions must be taken by the fire and gas safety system, as well as the process control system, to mitigate and control the hazard. Using a certified, documented fire and gas safety system that can communicate appropriate messages to the process control system during an event is vital to the safety of a facility and its occupants. But, specifying and integrating these two systems is no simple matter.

Under certain conditions, the processes in industrial, high-hazard manufacturing or processing plants can be a threat — to the safety of employees, operations and the environment. In these settings, a fire and gas (F&G) safety system is the layer of protection responsible for mitigating the consequences of a hazardous event once it has occurred.

Consider a chemical plant where flammable materials continue to be pumped into an area where fire has been detected. In hazardous situations like this, it is imperative that an F&G safety system communicate with the process control system (PCS). The performance requirements of both of these systems require validation that they are capable of performing to the defined risk reduction target. Methods to help define the performance requirements are available in standards, directives and recommended practices.

But first, here is a simple overview of what makes up the process control system and the safety systems, including the subsystems of the F&G safety system.

Process Control

1. Process control system (PCS)
2. Process instrumentation

Safety

1. Process shutdown system (PSD)
2. Emergency shutdown system (ESD)
3. Fire & gas (F&G) safety system
   - Flame, gas and smoke detection
   - Safety system controller
   - Notification and suppression/activation

In the United States, National Fire Protection Association standard NFPA 72® National Fire Alarm and Signaling Code (2016) dictates that the F&G safety system cannot be ependent upon the PCS, but rather an F&G system must be able to take immediate action to mitigate a detected risk and then report the action to the PCS regarding any process actions required. Independence between these systems is also recommended by two highly regarded international regulatory bodies: 1) NORSOK, whose standards are supported by the Norwegian Oil and Gas Association and the Federation of Norwegian Industries; and 2) the Health and Safety Executive (HSE), an independent regulatory body in Great Britain. (See Resources list.)

Guidelines for F&G safety systems come from standards organizations, regulatory bodies, industry groups and insurance companies. (All trademarks are the property of the companies or organizations named.)

To fulfill the standards of both the Petroleum Safety Authority (PSA) Norway and the International Electrotechnical Commission's IEC 61508 and IEC 61511, NORSOK requires: "...independencies between safety systems, i.e., a failure in one system shall not adversely affect the intended safety function of another, no interaction shall occur from the process control system to any safety system, from the Process Shutdown System (PSD) to the Emergency Shutdown System (ESD), or from the PSD system to F&G."

HSE's guide to the Control of Major Accident Hazards (COMAH) Regulations refers to the Engineering Equipment Users Association's Publication "EEUA 191: Alarm systems: a guide to design, management and procurement," which states, in part, that "the alarm system should be designed in accordance with IEC 61508 to SIL 1 or 2, with the designated reliability," and "the alarm system should be independent from the process control system and other alarms unless it has also been designated safety related."

While standards and recommended practices state that the two systems — F&G safety and process control — must not interfere with each other, the guidance does not specifically prescribe methods for integrating the two systems. The result is several possible approaches for F&G safety system integration and process control system communications.

But before getting into the "how" of control and communications for an F&G safety system, it is important to take a look at why F&G safety systems are necessary as well as the components that make up these systems.

WHY: THE DRIVERS FOR F&G SAFETY SYSTEMS

The overall role of an F&G safety system is to mitigate the results of hazardous events — but the system's first role is to detect hazards, quickly and accurately. According to Dennis P. Nolan, P.E., in his Handbook of Fire & Explosion Protection Engineering Principles, "The overall objective of F&G detection systems is to warn of possible impending events that may be threatening to life, property or continued business operations that are external to the process operation."

Nolan notes, "Process controls and instrumentation only provide feedback for conditions within the process system. They do not report or control conditions outside the assumed process integrity limits. F&G detection systems supplement process information systems with instrumentation that is located external to the process to warn of conditions that could be considered harmful if found outside the normal process environment.

"F&G detection systems may be used to confirm the reading of major process releases or to report conditions that process instrumentation may not adequately report or be unable to report (i.e., minor process releases)."

Myriad regulations require F&G safety systems, and some already have been mentioned. Common regulatory and legislative bodies, standards and industry codes including UL, the Occupational Safety and Health Administration (OSHA), NFPA and the American Petroleum Institute (API). However, other global regulations are in place to ensure the safety of the industrial workplace, from regional- and industry-specific standards, such as NORSOK and the internationally recognized IECEx standards, which pertain to environments with explosive atmospheres.

Insurance companies such as Factory Mutual (FM) Global and Lloyd's of London provide guidelines for specific risks found within industrial processes. Manufacturing companies may also draft and enforce mandates related to safety, while local authorities having jurisdiction (AHJs) often enforce legislative and their own standards specific to the location involved.

WHAT: THE FLAME AND GAS SYSTEM

An F&G safety system is composed of several subsystems that can include, but are not limited to, flame, gas and smoke detection, a safety system controller, and notification and/or suppression-activation devices.

Industrial processes, usually controlled by a PCS, also need to be protected by an F&G safety system that can detect and provide a warning of hazardous conditions.

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DETECTION — THE BACKBONE

Flame and gas detectors must be performance certified by product certifiers, and capable for use in hazardous applications, following guidelines such as NFPA 72 (2016) and NFPA 70® (2017) The National Electrical Code® (NEC®). Third-party product certification is critical, as it validates the expected performance of the F&G safety system. Product performance-certifying organizations include Factory Mutual (FM), UL and other Nationally Recognized Testing Laboratories (NRTLs).

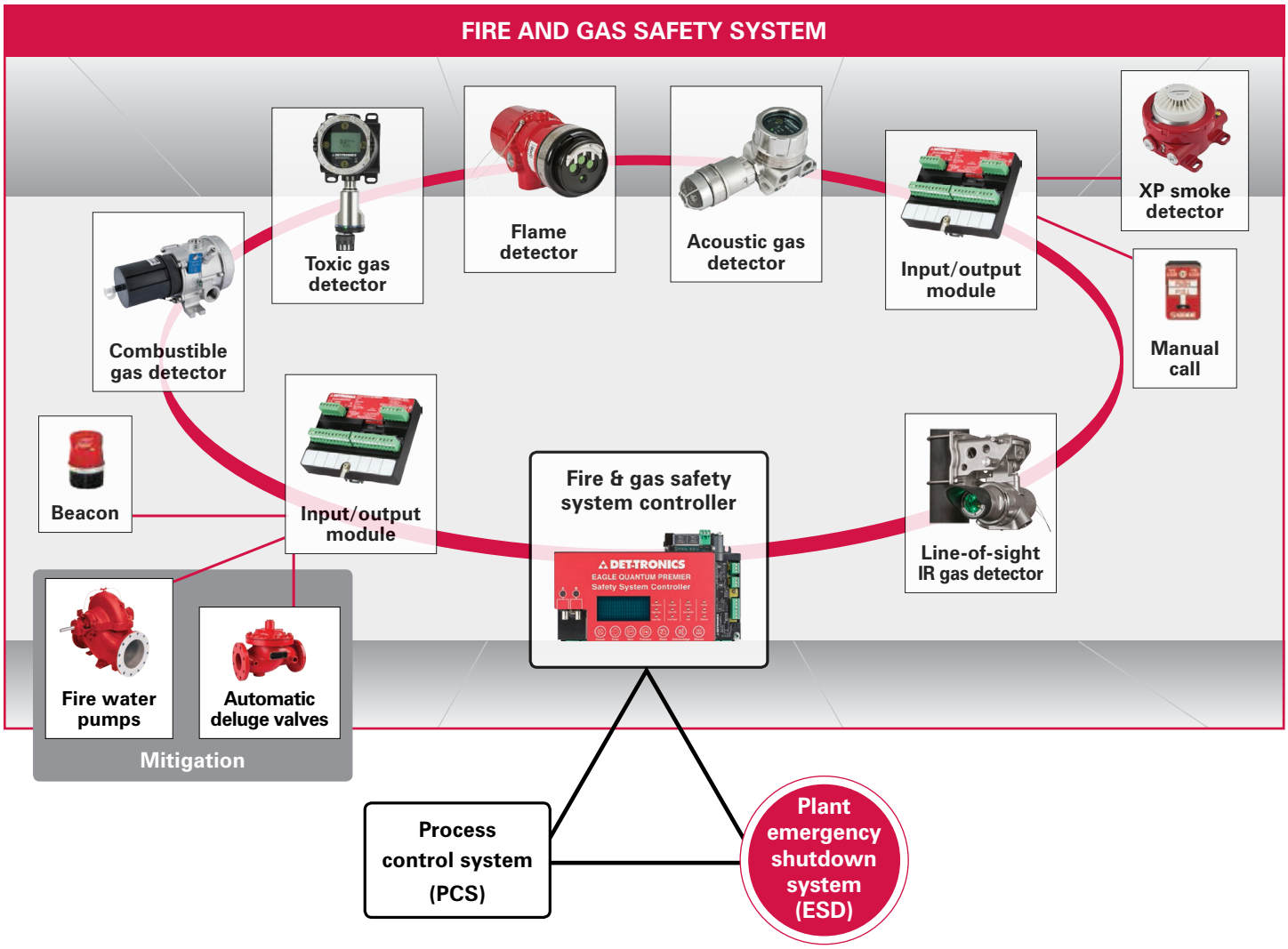
In addition to product performance certification, functional safety product certification is essential for validation of product reliability for high-hazard plant safety. Product functional safety certification organizations include exida, TÜV Rheinland and UL. Product certifiers must be accredited to assess and audit products, services and systems to ensure they meet functional safety requirements.

Below is an overview of the detector technologies often used in hazardous industrial applications.

Gas detection technologies

Gas leak detection is usually considered the first line of defense in mitigating risk and helping to prevent fire, explosions and process downtime in hazardous industrial settings. NFPA 72 (2016) defines a gas detector as "a device that detects the presence of a specified gas concentration." The gases detected may be combustible, toxic or both. There are multiple detector types used for sensing gases:

- Fixed point detectors employ electrochemical, catalytic or infrared technologies to detect the presence of a toxic or combustible gas. These detectors measure the gas concentration at the point where the detector is located, and monitor for potential flammable or toxic gas leak conditions.



An effective F&G safety system may include multiple types of detection devices plus a fire and gas safety system controller with inputs and outputs for notification and suppression-activation devices to contain or mitigate an event that may be threatening to personnel or process operations.

- Line-of-sight gas detectors continuously monitor combustible gas levels between two points at ranges as far as 120 meters apart. These detectors are often deployed in and around open areas and harsh environments that are typical of an industrial site, and are perfect for perimeter monitoring for gas clouds and for augmenting point detectors for optimal coverage in large open areas.
- Acoustic detectors use ultrasonic sensors to detect leaks based on noise patterns. This technology is ideal for areas where there is risk for pressurized gas leaks. These are suitable for harsh outdoor applications, unmanned operations and extreme temperatures, and are unaffected by fog, rain and wind.

Each of these types of toxic and combustible gas detection approaches has benefits and limitations depending on environmental and application factors. Therefore, an optimal protection solution may involve using more than one type of technology and placing selected detector types in locations that maximize their effectiveness.

The goal of gas leak detection devices is to detect hazardous vapors before they accumulate to an explosive or lethal level. The information these devices send to the F&G safety system controller can be used in decision making and communication with the process control/ process shutdown systems to take actions, such as closing valves to limit the flow of gas to the endangered area or curtailing electric power in the area of the leaking gas to reduce ignition potential.

Flame detection technologies

Instead of waiting to detect heat or smoke from a fire, hazardous locations often employ optical flame detectors "tuned" to specific fire emissions that can be sensed from a distance in a defined area of coverage. As described in NFPA 72 (2016), these radiant-energy-sensing detectors are line-of-sight devices that can employ several sensing technologies: ultraviolet (UV), infrared (IR), ultraviolet/infrared (UVIR) and multi-spectrum infrared (MIR).

In addition to providing rapid fire detection when response times are critical, these detectors are expected to be highly resistant to false alarms that can be costly in terms of operation shutdowns and plant and equipment damage caused by fire-suppression materials.

Smoke detection technologies

F&G safety systems may also employ smoke detection to perform life safety functions for occupied spaces, as required by OSHA. These devices detect particles produced by combustion using a variety of technologies, including photoelectric, beam and video

A properly designed and certified F&G safety system provides information to the PCS to enable operations to consider both process and environmental conditions.

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smoke. To be effective, smoke detectors should be located and spaced in anticipation of airflow from sources likely to present fire risks, but not to cause false alarms.

As NFPA 72 (2016) states, "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." Smoke detectors in occupied areas can be connected to the overall F&G safety system, depending on the capabilities of the safety system controller.

When smoke alarms are connected to the safety controller, any local annunciation of the smoke detector would be represented in the F&G safety system so that personnel away from the incident are alerted. Adding a timestamp from the controller may also be valuable during incident reconstruction.

Smoke detectors installed in hazardous locations need to be explosion-proof and — like all detectors used in highrisk locations — should have the necessary performance and hazardous-location approvals to ensure safe and effective operation, whether installed in defined areas or inside ductwork.

The F&G safety controller — the brain of the system

A complete F&G safety system is an integrated set of inputs and outputs consisting of flame, gas and smoke detectors, alarm signaling, notification, extinguishing agent release and/or deluge operations designed to warn and contain or mitigate an event that may be a threat to personnel or process operations.

Unlike the PCS, which only reports on conditions within the process system, the responsibility of the F&G safety system is to continually monitor and analyze data collected

by the detectors in the process area(s), make decisions to determine if/how to contain or mitigate the hazard, provide alarm notification, and communicate the event to the PCS.

The brain of the F&G safety system is a certified safety controller, approved by FM or UL to be compliant to NFPA 72 (2016) for flame and gas detection and releasing, and integrated but independent from the PCS.

This controller does more than handle inputs and outputs; it should also have the ability to troubleshoot and provide real-time F&G safety system status and diagnostics. It should facilitate easy programming and configuration of flame and gas detectors and other field devices. And the ideal F&G safety system should also be certified SIL 2 capable with the proper documentation that validates its performance capabilities and fault diagnostics.

An F&G safety controller that is NFPA 72 (2016) compliant for flame and gas detection and releasing will be able to:

- Detect specialized hazardous events (gases or vapors, fires, etc.)
- Minimize responses to false events
- Provide automatic and/or manual mitigation of detected hazardous events
- Annunciate events to personnel
- Provide information on system readiness/health
- Provide historical information, including calibration, alarm and fault logs
- Communicate with third-party systems such as the PCS and emergency shutdown system

HOW: INFORMATION SHARING BETWEEN THE F&G SAFETY SYSTEM AND THE PCS

Integrating complex alarm control and hazard mitigation is critical to life and plant preservation. In the past, F&G safety system controllers were limited to being hardwired together using analog or contact closures in a conventional (i.e., point-to-point) design. Although still acceptable, this design provides limited diagnostics, is inherently not fault-tolerant and is less flexible to configure. While this configuration provides alarm and fault information, specific details of the event are not available to the controller because of the simple, binary nature of the communication path.

An F&G safety system in an addressable loop, on the other hand, has the F&G devices configured on a bi-directional, fault-tolerant loop topology, substantially increasing the amount of diagnostic information that can be shared with the F&G safety controller. This configuration is more reliable, as the controller is in constant communication with each device on the loop for alarm and diagnostic information.

As described earlier, an effective F&G safety system should include the capability to provide detection device status, in defined process areas, to the PCS. This enables the process owner to know exactly what, where and when events are occurring. However, since the F&G safety system and the PCS remain independent, a failure on the PCS will not affect the operation of the F&G safety system.

CONCLUSION

F&G safety systems supplement PCSs by providing critical functions such as warning and containing or mitigating a detected hazard. Although required to operate independently of the PCS, the F&G safety system can be integrated with the PCS to allow communication about an event that may be threatening to personnel or process operations.

Effective F&G safety systems should be properly certified, have the ability to provide real-time safety system status and diagnostics, be scalable and configurable, and have the ability to integrate with the PCS. It is important to consider all of these features when selecting an F&G safety system to integrate with a PCS.

ABOUT DET-TRONICS

Det-Tronics is the 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 a complete line of SIL 2 Capable, globally certified flame, gas and smoke safety products, including the X3301 Multispectrum Infrared Flame Detector and the Eagle Quantum Premier® (EQP) Fire and Gas Safety Controller.

RESOURCES:

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2. 2. Petroleum Safety Regulatory Authority, www.ptil.no
3. "Application of IEC 61508 and IEC 61511 in the Norwegian Petroleum Industry," https://www.itk.ntnu.no/sil/OLF-070-Rev2.pdf
4. Health and Safety Executive, http://www.hse.gov.uk
5. Engineering Equipment & Materials Users Association, https://www.eemua.org
6. Handbook of Fire & Explosion Protection Engineering Principles for Oil, Gas, Chemical & Related Facilities, Dennis P. Nolan, P.E., 2014, Chapter 17 — Fire & Gas Detection and Alarm Systems, William P. Andrews Inc., www.elsevier.com/books/
7. Occupational Safety and Health Administration (OSHA), www.osha.gov
8. American Petroleum Institute (API), www.api.org
9. Underwriters Laboratories, www.ul.com
10. Factory Mutual Global, www.fmglobal.com
11. Lloyd's of London, www.lloyds.com
12. exida, www.exida.com
13. TÜV Rheinland, www.tuv.com

Email: instrumentation@hmagrp.com

Email: instrumentation@hmagrp.com

AUSTRALIA

Tel: +61 (0)2 9428 7300
Fax: +61 (0)2 9428 7399

NEW ZEALAND +64 (0)7 850 2610

INDONESIA +62 21 2278 3377

SOUTH AFRICA +27 13 650 9800

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