Understanding Fire and Gas Systems Increases Safety

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Although many process plant employees have some understanding of fire and gas systems, the very nature of these systems – isolated and separate from basic process control and acting only during accidents – may cause workers to take them for granted. Like a smoke detector at home, a fire and gas system, once installed, can easily fade into the background. When workers acquaint or reacquaint themselves with the critical roles provided by fire and gas systems, it improves overall safety.

Fire and gas system engineering is a specialized field made more complex as the practices for designing and maintaining systems through their lifecycle have evolved over the years. Much changed with the advent of prescriptive standards developed by the National Fire Protection Association, European Community and most recently, International Electrotechnical Commission (IEC) 61511 and International Society of Automation (ANSI/ISA) 84.00.01. These standards established performance-based criteria for evaluating the performance of Safety Instrumented Systems (SIS). Technical report TR84.00.07, which was developed under an ISA 84 working group, provides guidance on how fire and gas systems can be designed according to IEC 61511.

So, what are those sensors mounted next to the ammonia tank? How do they work and what is supposed to happen if there is a release? What is the procedure if there is a fire? Here are some basic concepts everyone should know.

Understanding Fire and Gas System Functions

Like basic process control and SIS, fire and gas systems use sensors tied to a controller (Figure 1) programmed to execute tasks to mitigate the hazard in response to detecting a specific condition.

Figure 1: While a sensor may be the only visible part, fire and gas detection system logic can be quite complex.

Typical hazards include unignited releases of combustible or toxic gases and liquids, or the presence of an open fire if an ignition source has been found.

Mitigation actions vary according to the nature, location, and severity of the detected hazard. For a fire, there may be several actions. This includes sounding warning alarms for personnel, releasing extinguishant, cutting off the process flow, isolating the fuel source, and venting equipment. All of these may happen simultaneously to extinguish the blaze. For a toxic gas release, alarms may sound to drive personnel to safe mustering areas.

These functions must be able to happen without the support of other systems, but they don't exist in isolation. They are frequently integrated with SIS, emergency shutdown (ESD), and ventilation system controls, extending the ability to mitigate an incident by engaging with these other systems.

The responses reflect function logic generated from process safety studies and summarized in a transparent and well-documented matrix that relates causes to effects. These cause-and-effect diagrams specify the safety system's functional requirements. Some of the control actions are executed autonomously by the fire and gas system, while certain internal trips activate the other systems just mentioned.

Understanding Sensors

The sensors used in fire and gas systems are often the least understood element since they are unlike more familiar process instruments. For starters, they detect what is happening in open space, rather than inside a vessel or pipe. Understanding how they detect a hazardous gas, liquid or a radiant energy source like a fire takes diligence.

Most toxic or flammable gas sensors are point detectors, which means they monitor highly localized conditions. Further, they depend on the target gas reaching the sensor.

A sensor identifies the target gas either because the gas reacts with something inside the sensor in a way that changes an electrical signal (electrochemical) (Figure 2), or the target gas absorbs specific wavelengths of infrared (IR) light. When the gas passes between an IR source and receiver, the change is measurable. IR point sensors may have only a centimeter or two between the two elements inside a single enclosure.

Figure 2: Electrochemical toxic gas sensors, such as the Rosemount™ 928 Wireless Gas Monitor, can be used to detect hydrogen sulfide by creating a reaction between the toxic gas and an internal catalyst.

If a larger area must be covered, it is possible to separate the two halves of an IR sensor and place them several meters apart using an open path approach. The IR beam shines from the source to the receiver, and if a sufficient amount of the target gas accumulates anywhere between the two, it trips the alarm. Naturally, such a sensor must ignore a brief interruption of the beam by a person or other object passing through the space.

Regardless of detection technique, all point and open path detectors are limited to detecting gas at a specific location and can thus be rendered ineffective if placed in a dead spot where air is stagnant and gas does not migrate. Similarly, poorly-placed guards or covers can prevent the target gas from reaching the sensor element. If an observant operator in the plant sees that something has changed with the positioning or surroundings of a gas sensor, it should be reported to an appropriate individual.

Where the target gas is in a pressurized system, it may be possible to use an acoustic sensor (Figure 3) tuned to the ultrasonic range to detect noise made by a leak in the system. Such leaks can make noise within these targeted frequencies, which can be used to warn of an escape before there is sufficient concentration to trip conventional sensors. On the other hand, acoustic gas leak detectors are suitable only for pressurized escapes and may cause a false trip due to an unrelated noise source.

Figure 3: Ultrasonic gas detectors, such as Emerson's Incus Ultrasonic Gas Leak Detector, listen for the sound of escaping pressurized gas.

Detecting Fires

Detectors must respond quickly to prevent potential damage caused by an active fire. At the same time, the actions triggered by a fire alarm, such as shutting down a process and releasing extinguishant, are highly disruptive and must not be prompted by a false alarm.

Fires can be detected because they generate electromagnetic emissions, heat, and smoke. A comprehensive fire and gas system may have sensors looking for all three.

Electromagnetic sensors (Figure 4) look for emissions in specific wavelengths above and below the visible light spectrum. They are the fastest responding sensors since they can detect these emissions within seconds when flames begin. Different combustible products generate characteristic emissions in the ultraviolet (UV) and IR ranges. For example, detecting burning gasoline requires watching different IR wavelengths than burning hydrogen, so system designers must know what combustible products are likely to be present. Some sensors look for one critical wavelength, while others may look for multiple wavelengths, improving detection accuracy.
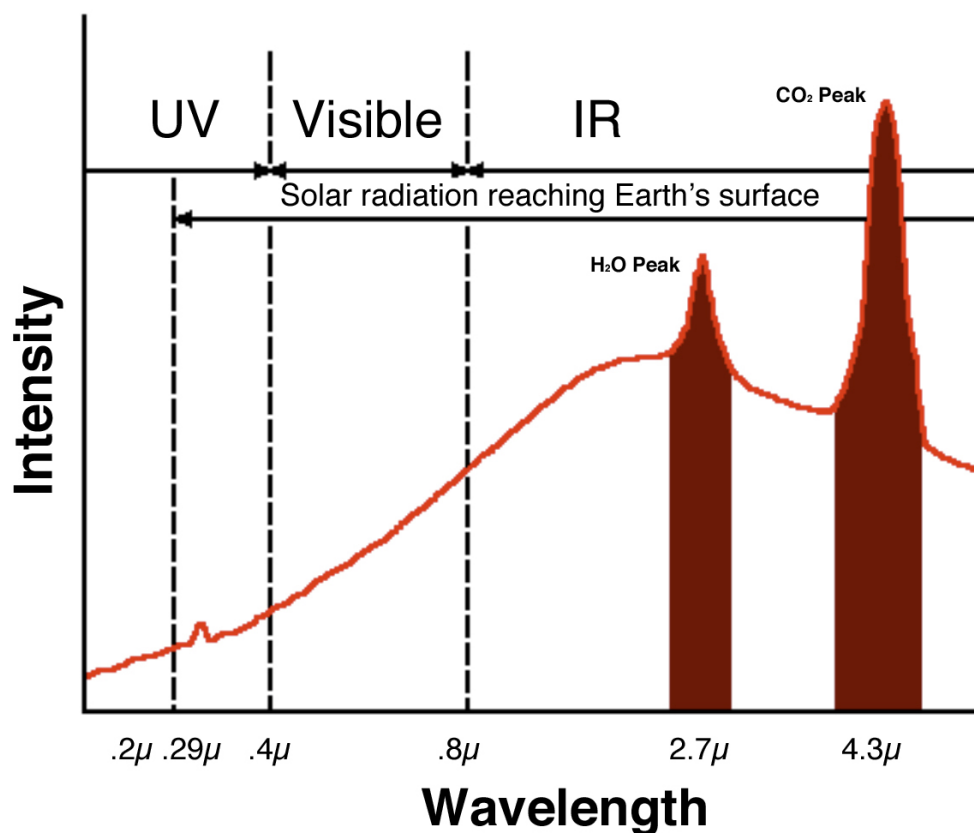

Figure 4: Electromagnetic flame sensors, such as the Rosemount 975HR Multi-Spectrum IR Flame Detector, can detect specific wavelengths of IR light generated by specific fuels.

These sensors work much like cameras and therefore depend on a clear line of sight to the covered area. Consequently, they are usually in a high position looking down at the equipment. Obstructions curtail detection coverage. It is also important to be aware of sources capable of causing a false alarm. For example, if welding has to be performed within sight of a detector, it may be necessary to have an appropriate operator disable the sensor temporarily.

Heat detectors respond to rising temperatures or a change in temperature and can be either point type or linear, spanning several meters in length. By contrast, smoke detectors respond to the density of smoke particles in air. In process areas, smoke detectors are primarily used to protect closed spaces and ducts from exhaust and ventilation systems.

Other supplemental detectors include fusible plugs and frangible bulbs for specialized purposes.

A Systemic Approach

The nature of potential hazards in a given facility depends on the products and processes involved. The design of a fire and gas system must reflect those hazards to make appropriate responses. Alarm horns and strobes are a starting point, but the system may extend to extinguishers and interface with emergency shutdown systems. There can be multiple types of sensors to cover a variety of hazards, avoid common-cause failures, and provide redundancy. All these elements must be tied together to extend the reach and improve overall effectiveness.

At the same time, the response of a fire and gas system is not guaranteed. Its ability to detect a hazardous release or fire in progress depends on many more variables than a typical process safety function. The number and type of sensors and their placement within an area to be monitored influence fire and gas system effectiveness. One-by-one, these variables can be reduced, ensuring greater safety for a plant's people and equipment and the surrounding community.

About the Author

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