KEYS TO IMPROVING SAFETY IN CHEMICAL PROCESSES

EMERSON

Many facilities handle dangerous processes and products on a daily basis. Keeping everything under control demands well-trained people working with the best equipment.

Safety within chemical processing plants is truly a life-or-death issue for many companies due to the presence of toxic, flammable, and potentially explosive products. Even if the products themselves are fairly benign, steam, compressed air, high-voltage electric power, and combustion equipment can injure workers due to a malfunction or mistakes stemming from inadequate training. In addition to personnel injuries, safety incidents can damage equipment, cause releases with environmental impact, and damage a facility's relationship with its surrounding community.

Incident-related costs add up quickly as well. Medical and legal costs for injured workers, repair and replacement of damaged equipment, higher insurance rates, and fines from regulatory agencies are made worse by income loss from production interruptions. Less-tangible costs result from personnel problems as current and future hires are reluctant to work in what they perceive as a dangerous environment.

In many respects, the first line of defense for personnel safety is **the people themselves**, along with a **strong safety culture**. Plant personnel must have **sufficient training** to understand their environment, including the potential hazards presented by equipment, processes, and substances around them. This minimizes potential for injury. However, in most facilities, many potential hazards go far beyond what any individual can control, no matter how safe his or her actions.

A comprehensive safety solution calls for a broad approach built on a variety of technologies to identify potential hazards and detect when a problem may be developing. The system should take effective measures to correct or at least mitigate the situation, while warning workers that additional action may be necessary. Worker training is still critical, but comprehensive solutions acknowledge the limitations of human responsibility.

SAFETY LIFECYCLE

For process industries, designing safety systems is guided by two standards: IEC 61511 and IEC 61508. The former applies most directly to industrial process environments and outlines a series of steps, beginning with analysis of potential hazards to determine safety requirements for a safety instrumented system (SIS). Overall safety strategy uses layers of protection (Figure 1), to build responses proportional to the threat, increasing in severity based on threat escalation.

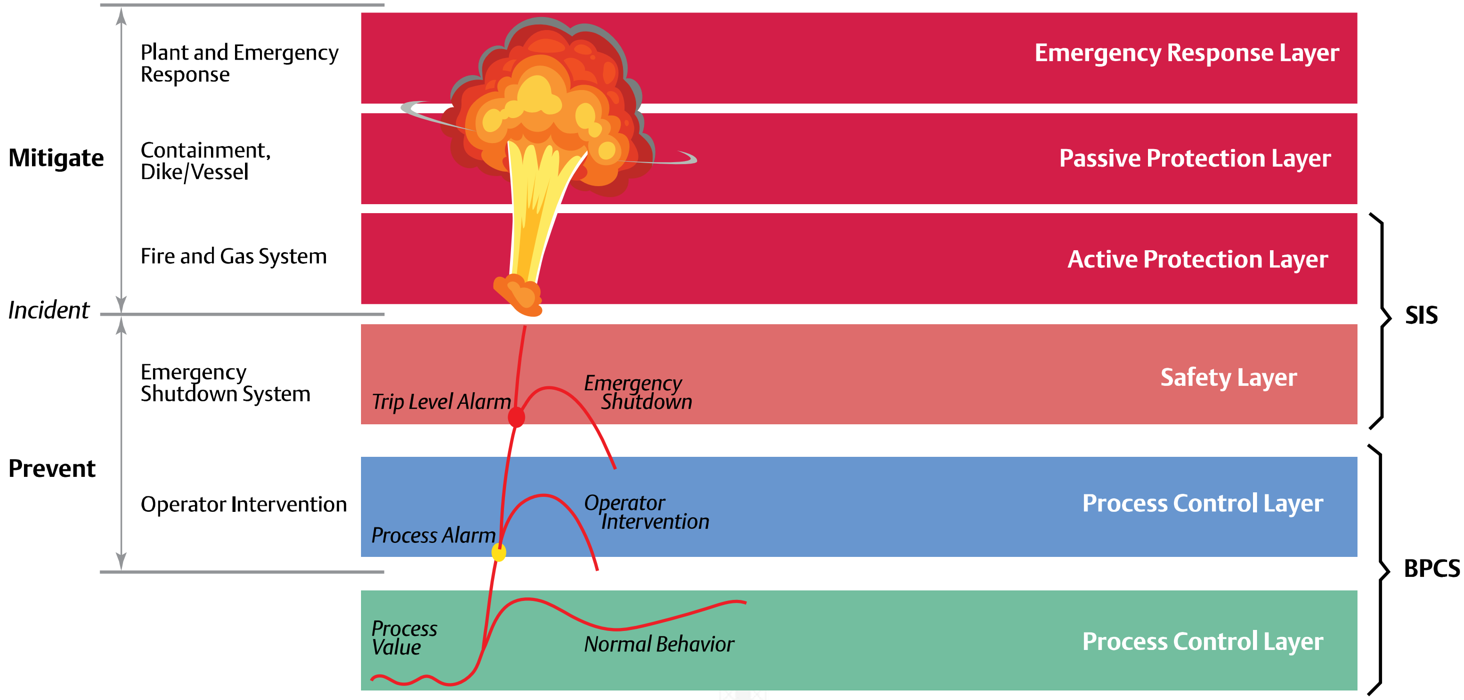

Figure 1: Comprehensive safety systems use layers of protection proportional to the threat's severity, to avoid needlessly disruptive responses.

It is important to view safety holistically, but this can be overwhelming. One practical approach keeps the full scope in mind but divides the solution into more manageable parts. For purposes of this eBook, we will examine three areas:

- Occupational safety—emphasizing the interaction of people with the processes and equipment
- Process safety—concentrating on what goes on within the vessels and piping
- Containment safety—sound process piping and vessels, along with safe storage of feedstocks and finished products.

In some respects, these are distinct, but they also overlap, as we will show. Safety goals within a facility must address all three since any one can be the root cause of an incident. For example:

- A facility might have a very thorough training program for occupational safety to avoid accidents and injuries, while having an outdated and poorly maintained SIS, capable of allowing a process upset to escalate into a fire or chemical release.
- Dependence on operator rounds and poor accessibility to critical equipment can put people at risk, rather than automating such tasks.
- Poor maintenance of vessels and piping can allow corrosion to cause leaks or major containment failures, even with an effective process control system in place.

The lesson is that no aspect of safety can be ignored if a facility is to be considered safe, defined as having hazards managed well enough to create an environment with tolerable risk. Employees must believe they will be going home at the end of the shift without experiencing an incident or injury. Let's look at how this can become an everyday experience.

1 UNDERSTANDING FUNCTIONAL SAFETY

UNDERSTANDING FUNCTIONAL SAFETY

Before examining the three areas, we will review basic functional safety concepts, and how safety systems work. A fundamental concept relates to safety instrumented functions (SIF) which have as their objective to take a specified action during a hazardous condition. A SIF has three components: sensors, logic solver, and final elements.

A sensor or instrument serving as a detector is the first element of a SIF. For example, a pressure instrument installed on a reactor sends its data to a logic solver which reads and processes the data and sends a specific command to a final control element (FCE). In this case, it might activate a valve to release pressure. It probably also sends a signal to the control room to alert operators of the situation, and an alarm may be triggered.

The SIF elements must have no other duties. The sensor must not be part of the basic process control system (BPCS) and the FCE must only relate to the safety function. A SIF cannot have another function that might put it into conflict with its primary duty.

SIFs are implemented in SISs, which execute dozens and even hundreds of independent SIFs. Functionally, each individual SIF must be independent, but that doesn't mean they can't communicate with each other to reinforce safety efforts (Figure 2). Large-scale SIS deployments benefit from distributed architectures.

Figure 2: The DeltaV™ Smart Logic Solver provides flexibility for safety instrumented systems with scalability from 12 to 30,000 configurable I/O.

A SIF that malfunctions and launches a potentially disruptive action when there is no actual threat, can be very disruptive to production and even cause a process interruption. To minimize this possibility without sacrificing protection, highly critical SIFs can use multiple sensors to measure the same variable, arranged in a voting scheme.

The most common voting scheme is two-out-of-three (2oo3) where three sensors are installed in the same location. A single sensor reporting a problem can't trip the function, so this avoids a disruption caused by a single malfunction. Any two of the three sensors must report the same problem simultaneously for the function to trip. To avoid complex installations, some instruments are configured as multiple units (Figure 3) with a set of fully independent transmitters specifically for this purpose.

Figure 3: Flow meters, such as the Rosemount™ 8800 Quad Vortex Flow Meter, provide the ultimate redundant flow measurement solution to guard against spurious trips using 2oo3 voting, plus a fourth integrated transmitter for process control.

SAFETY CERTIFIED DEVICES

There is a wide category of components (Figure 4) certified for SIS applications. Sensors, instruments, controllers, valves, and others can be purchased with such designations, often including a safety integrity level (SIL) number. Across all of Emerson's products—including instrumentation, controllers, valves, and software—the collection of safety certified products is the largest in the industry, providing a good source of information to begin a new project or upgrade.

Figure 4: Emerson offers the broadest range of safety certified equipment, including instruments, controllers, and valves.

The concept underlying safety certified devices is not that they can't fail. Safety engineers know that anything can fail, but for safety applications, it is important to know how something might fail, along with its probability of failing. To earn a safety certification, a device is subjected to a battery of tests listed in safety standard IEC 61508 to determine the probability of failure on demand (PFD). Such tests are performed by a specialized agency, independent of the manufacturer.

Certification means the testing agency is convinced that the PFD when the instrument must handle an actual problem is low enough that the instrument can be part of a SIS, while providing a reliable layer of protection for the plant. The PFD rating places it into a SIL category, usually either SIL 2 or SIL 3, which must match the criticality of the application.

To ensure that the equipment supporting a SIF actually works, safety standards require periodically putting the equipment through its paces. These verifications are called proof tests, and the frequency of a proof test for a specific SIF is determined by a statistical calculation related to its SIL rating.

Proof-testing involves simulating conditions that cause the SIF to respond, without doing anything actually unsafe. In the case of a SIF where it is necessary to simulate a high-pressure incident, the pressure instrument might be isolated from the process and connected to a compressed air line to push it past the limit and make sure the system responds correctly. Naturally, performing such a test can disrupt production.

The proof-testing process is particularly important if it is the only mechanism to determine the condition of equipment tied to a SIF. However, advanced diagnostics (Figure 5), can tell operators much about the condition of an instrument or smart valve actuator, and how it's operating. This diagnostic information often can be used to extend the time between tests, and/or reduce the most disruptive parts of the test.

Figure 5: The Rosemount 5900 Radar Level Gauge can be proof-tested safely and remotely from the control room using Rosemount TankMaster™ Inventory Management Software that allows an operator to perform one or several proof-tests. Following a guided process, proof-testing can be done in less than five minutes, and afterwards an automatic report is generated which specifies the details of the test and confirms success.

Where an instrument or valve actuator supporting a SIF has few or no diagnostic capabilities, proof-testing procedures will likely call for a disruptive approach, which is resource-intensive and disruptive to production. Instruments with advanced diagnostics for SIFs can reduce production disruptions associated with proof-testing procedures, with no negative impacts to safety.

2 OCCUPATIONAL SAFETY

OCCUPATIONAL SAFETY

Occupational safety is primarily concerned with keeping humans safe in the plant environment. Naturally, all safety systems protect people, but these are less focused on equipment and processes.

Many aspects of occupational safety have nothing to do with systems. Safety begins with effective training for new hires as well as veterans, with "safety moments" often included in company meetings to reinforce safety culture. Requirements for proper use of personal protective equipment (PPE) is part of training in any plant and governed by the immediate hazards present.

Training is critical because people are often the cause of incidents. Consequently, managers look for ways to keep people out of the plant as much as possible. They automate procedures (Figure 6) that would have called for manual rounds to avoid this potential source of incidents and worker exposure.

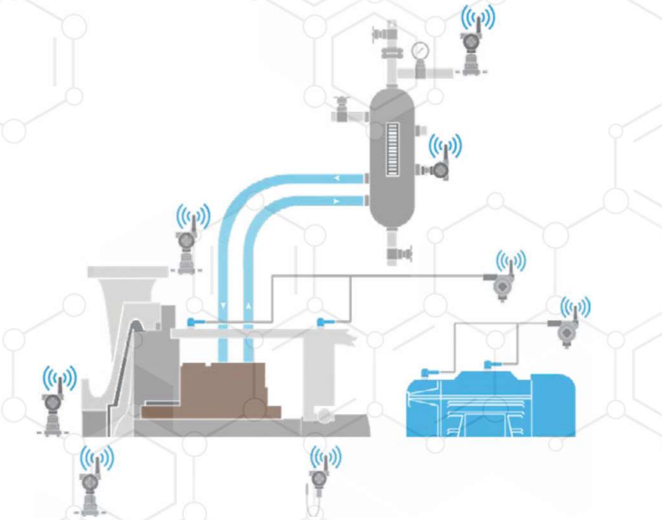

Figure 6: Adding vibration and bearing temperature sensors that communicate via WirelessHART® to a pump installation collects critical data continuously, while greatly reducing the need for manual inspections.

Examples include:

- Installing analyzers at strategic locations to replace manual sample collection
- Mounting vibration sensors on pump or compressor installations to replace routine maintenance inspections
- Placing toxic or combustible gas detectors in areas where hazardous gases could affect workers' health
- Deploying *Wireless*HART networks to support wireless sensors in locations that are not practical or cost-effective to wire.

LOCATION MONITORING

There are situations where sending operators and maintenance technicians into the plant is unavoidable. A key element in protecting those people is simply knowing where they are in the plant, and if they might be in trouble. Many plant managers want just such a mechanism, but implementing this type of system, usually using Wi-Fi, is complex and expensive.

New location-monitoring technology, enabled by *Wireless*HART, supports location monitoring at a much more reasonable cost, and with simpler implementation. Location calculations use information provided by a *Wireless*HART device called a Location Anchor. These anchors communicate with each other and *Wireless*HART gateways, in a similar way as conventional *Wireless*HART instrument transmitters (Figure 7). However, anchors communicate with Location Tags worn by each worker, helping to determine where each worker is located.

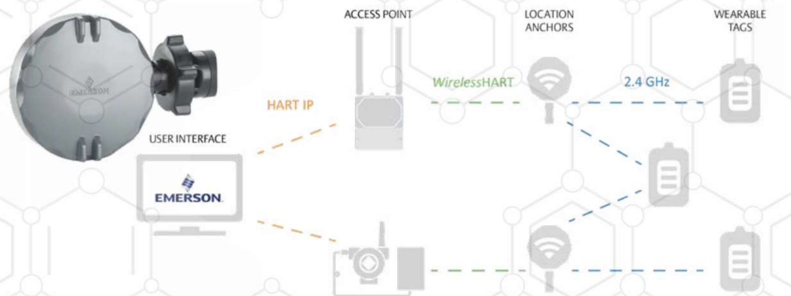

Figure 7: Emerson's Location Monitoring solution extends WirelessHART networks to read individual wearable Location Tags.

Location Anchors are small, light, and self-powered. They are less expensive than systems utilizing industrialized Wi-Fi access points, and their Class 1/Div 1, Zone 0 rating allows them to be deployed throughout chemical plant environments. Rechargeable tags (Figure 8) worn by each worker communicate with the anchors, and the anchors communicate with each other and the gateways or access points. This approach is easily scalable to accommodate the number of employees in a given plant, plus it provides an exceptionally high level of flexibility to achieve the required coverage and resulting overall worker safety.