



Keys to Improving Safety in Refining

How to protect your facilities, personnel and the environment using the right technologies and strategies for reducing process, occupational, functional and loss of containment safety risks.

Safety First

Safety is of utmost importance in refinery operations due to the inherently dangerous nature of the work environment. Refineries handle various flammable, toxic, and high-pressure substances, which pose significant risks of explosions, fires and leaks. Strict compliance with safety protocols and regulations helps mitigate risks, creating a secure environment where employees can perform their tasks without the fear of injury or fatality.

Safety Standards

Beyond safeguarding human lives, upholding high safety standards in refinery operations is essential for environmental protection. By emphasizing safety, refineries can prevent spills and emissions that would otherwise lead to environmental harm. Implementing thorough safety measures ensures that refineries operate responsibly.

Moreover, a robust safety culture in refinery operations boosts operational efficiency and financial performance. Accidents and incidents can result in costly shutdowns, repairs, and legal liabilities, significantly affecting a refinery's profitability. By investing in safety training, equipment, and procedures, refineries can lower the incidence of accidents, leading to continuous production and reduced operational costs. A dedication to safety also enhances the refinery's reputation, building trust with stakeholders such as employees, regulators, and the public. This trust can lead to better business opportunities and long-term success for a refinery.

A Comprehensive Safety Program

A comprehensive safety solution for refinery operations requires a broad approach that utilizes various technologies to identify potential hazards and detect emerging issues. The system should implement effective measures to correct or at least mitigate these situations while alerting workers that further action may be needed. **Although worker training remains crucial, comprehensive solutions recognize the limitations of human responsibility and enhance safety through advanced technological support.**



FUNCTIONAL SAFETY

OCCUPATIONAL SAFETY

PROCESS SAFETY

CONTAINMENT SAFETY

Safety Lifecycle

In refinery operations, the design of safety systems is primarily guided by **two key standards: IEC 61511 and IEC 61508**. IEC 61511 is specifically tailored to industrial process environments and outlines a series of steps starting with the analysis of potential hazards to determine the safety requirements for a Safety Instrumented System (SIS). **The overall safety strategy employs layers of protection (Figure 1) to build responses proportional to the threat, with increasing severity based on threat escalation.**

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.

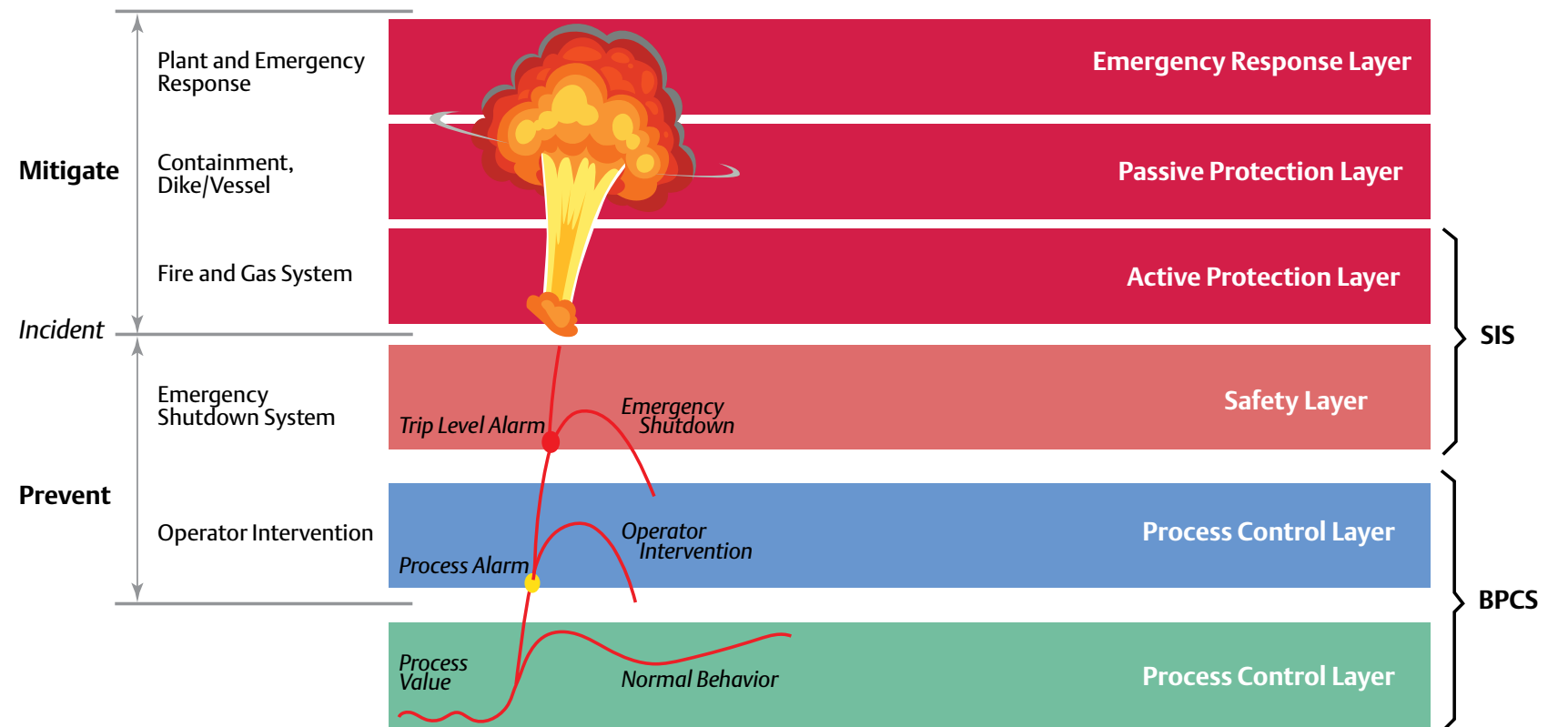


FIGURE 1

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

- 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.



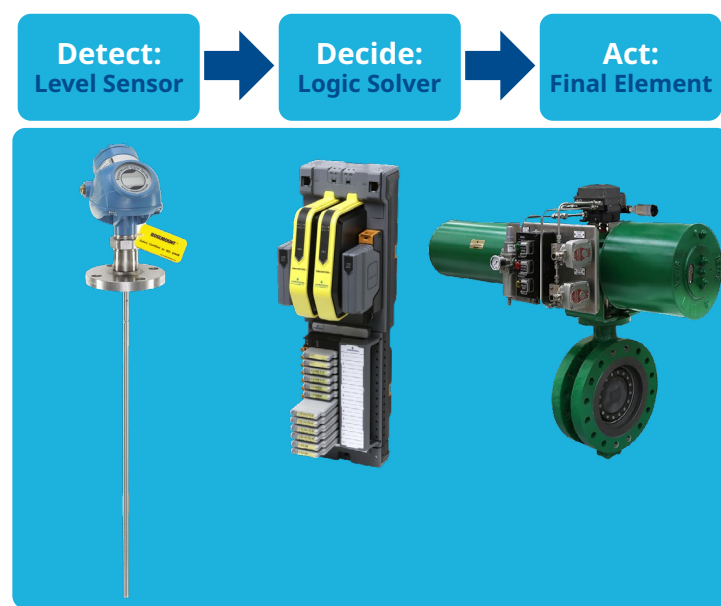
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Functional Safety



Safety Instrumented Functions

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 Safety Instrumented Systems (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 1 to 30,000 I/O that can be individually characterized.

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. The Rosemount 8800DQ040 Quad Vortex Flow Meter is rated for operating temperatures of -330°F to 842°F (-200°C to 450°C).



Safety Certified Devices

There is a wide category of components (Figure 4) certified for SIS applications. Sensors, instruments, logic solvers, 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, logic solvers, 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.

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 manufacture like Exida / TUV Rheinland.

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.

Safety Integrity Level	Probability of Failure on Demand Per Year <i>(Demand mode of operation)</i>	Risk Reduction Factor
SIL 4	$\geq 10^{-5}$ to $< 10^{-4}$	100,000 to 10,000
SIL 3	$\geq 10^{-4}$ to $< 10^{-3}$	10,000 to 1000
SIL 2	$\geq 10^{-3}$ to $< 10^{-2}$	1,000 to 100
SIL 1	$\geq 10^{-2}$ to $< 10^{-1}$	100 to 10



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



Safety Certified Devices

Proof Testing

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 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 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.

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 (**Figure 5**) for SIFs can reduce production disruptions associated with proof-testing procedures, with no negative impacts to safety.



FIGURE 5
The Rosemount™ 5900S 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 result i.e. Pass/Fail.





Safety Certified Devices

SIL Certified Non-Intrusive Flow Meters

Emerson is the sole global provider of clamp-on ultrasonic systems for non-intrusive flow measurement of liquids and gases that have SIL certification.

These SIL certified non-intrusive ultrasonic meters are often used for the overflash circulation and residues from an atmospheric distillation unit and vacuum distillation unit (Figure 6).

General applications with protective functions within oil refineries include:

- Ensuring heat dissipation
 - from exothermic reactions
 - from heat recovery boilers
 - from other heat generating sources, such as distillation columns, cokers, etc.
- Dry-running protection of pumps in potentially explosive areas
- Leak detection during transport of hazardous media
- Monitoring of minimum or maximum flow rates in critical supply and return lines

To particularly ensure the safety of exothermic processes in a refinery, it is essential to dissipate heat from the reactor. This can be effectively monitored using a SIL 2 certified non-intrusive Flexim™ FLUXUS™ ultrasonic flow meter, installed on the return line. As a component of

the SIS, regular checks are conducted to verify measurements and document their operational reliability.

Functional Safety with Flexim™ Non-Intrusive Ultrasonic Flow Meters

Non-Intrusive Measurement Without Media Contact

- Shortened prior-use method excluding the media influence

Simple Retrofitting During Ongoing Operation

- Ideal for a subsequent increase in safety
- Ideal for maintaining the protective function should an inline measurement fail

Comprehensive Certification

- Transducers, mounting device, and electronics are part of the FMEDA

Straightforward Retesting

- Easy functional tests in no time at all
- Employee training as well as services for regular inspections
- Step-by-step documentations for easy execution

Transparent Evaluations

- Publication of FMEDA report
- Full information on certification procedures and scope

Extremely Wide Range of Applications

- Transducers and measuring transmitters for the flow measurement of liquids and gases
- SIL certification also covers WaveInjector® technology for the flow measurement of liquids at extreme temperatures from -190 °C up to +650 °C

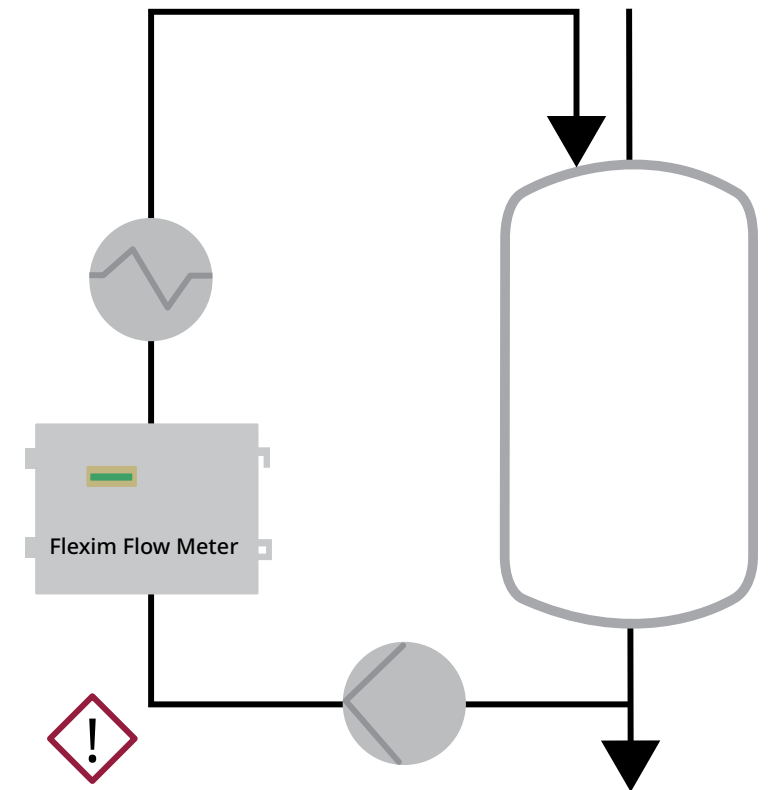


FIGURE 6 Illustration depicting the use of a Non-Intrusive Flexim™ FLUXUS™ Ultrasonic Flow Meter on a return line to measure heat transfer during an exothermic reaction.

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Occupational Safety





Safety Culture

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

Many aspects of occupational safety extend beyond the process safety system or equipment safety. Safety begins with effective training for new hires as well as veterans, and with “safety moments” often included in company meetings to build a safety culture.

Training and Automation

Training is critical because human factors are often the cause of incidents. Consequently, managers look for ways to keep people out of harm’s way as much as possible. They automate procedures (Figure 7) that would have called for manual rounds to avoid this potential source of incidents and worker exposure. Options to avoid potential worker exposure 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 WirelessHART® networks** to support wireless sensors in locations that are not practical or cost-effective to hardwire
- **Utilizing Bluetooth® wireless technology** to perform configuration, device status, and diagnostic tasks to avoid unnecessary operator exposure to hazards

Bluetooth® Connectivity

Safety is paramount in any refinery. Minimizing personnel exposure, injury, and illness instills employee confidence of the workspace safety and can deliver significant financial benefit to the organization. Bluetooth® connectivity offers a new level of safety, in addition to higher levels of flexibility, ease, and convenience. It meets the challenges of maintaining good plant practices and procedures by enabling one to quickly locate field devices and perform tasks related to configuration, device status, and diagnostics without the need for a physical connection and from a safe location using the AMS Device Configurator application. This can limit personnel exposure to harmful chemicals, volatile organic compounds (VOCs), or dangerous operating conditions.

Hurdles to optimizing plant safety are numerous and include having reduced or inexperienced staff, frequent shutdown and startups, production run rate changes, and extended turnaround schedules. Bluetooth® technology allows plant personnel to configure, maintain, or troubleshoot

field instruments on- the-go to quickly perform rounds, resolve simple issues, and address what needs immediate attention. They can perform routine tasks without the need for a physical connection, allowing them to work smarter, faster, and more efficiently with:

- No hot work permits
- No climbing tanks or scaffolding
- No guesswork

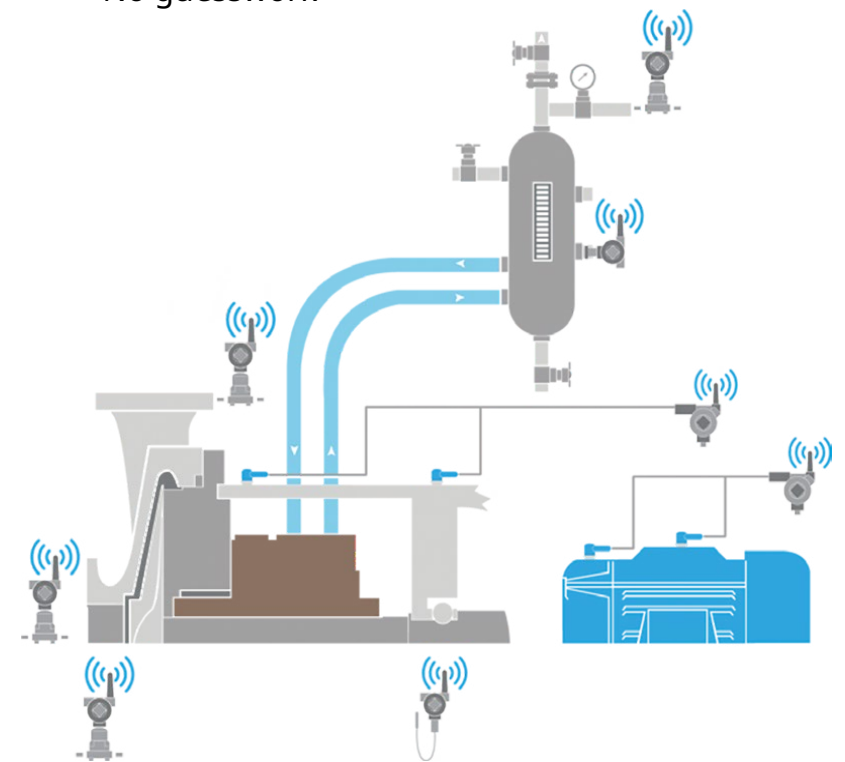


FIGURE 7

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.





Safety Culture

Bluetooth® Connectivity

Emerson's technologies with Bluetooth® Connectivity (Figure 8) include:

- AMS Device Configurator Application for Emerson Field Devices
- Rosemount™ 3051 Pressure Transmitters
- Rosemount™ 3408 Level Transmitter – Non-Contacting Radar
- Micro Motion™ 4700 Configurable Inputs and Outputs Transmitter



FIGURE 8

Emerson technologies with Bluetooth Connectivity enable users to perform configuration, device status, and diagnostic tasks without a physical connection to avoid unnecessary operator exposure to hazards.

Safety Shower and Eyewash Station

Mishaps in a plant may result in a worker being splashed or sprayed by hazardous chemicals. To minimize potential injury, plants have safety shower and eyewash stations, but they are not always monitored. A worker needing attention may have to call for help on the plant radio or hope to be spotted by a colleague. With a simple *WirelessHART*® valve monitoring device (Figure 9), any activation immediately reports the situation and location to the control room, and to first responders in the plant.

Wireless instrumentation and accompanying apps simplify the installation, configuration, and maintenance of equipment monitoring systems. These systems can be brought online at a fraction of the cost of traditional wired transmitters and complex enterprise-wide analysis software.



FIGURE 9

Adding a Rosemount™ 702 Wireless Discrete Transmitter can tell the control room which safety shower or eyewash station has been activated.

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Process Safety



Process Safety

Protection Layers

Process safety is the most complex given the number of possible hazards and potential for damage from incidents. Dozens and even hundreds of individual SIFs must be coordinated to provide the necessary layers of protection, calling for comprehensive systems.

Yet, in many respects, the most critical systems in a plant or process unit are an effective distributed control systems (DCS) combined with reliable SISs. If the process has sound control strategy built using modern hardware and software (Figure 10), and if it is supported by adequate instrumentation, it will be able to keep the process stable, even in the face of potential upsets and feedstock inconsistencies. In the event the DCS cannot control the process, the SIS will take the process to a safe state. Tight integration between DCS and SIS provides multiple benefits through the lifecycle of the systems. Proper integration between DCS and SIS does not compromise the independence of the two layers of protection.

When well-trained operators have deep visibility into process conditions, and are assisted by carefully managed alarms, they can deal with abnormal situations before they escalate into incidents. Under these conditions, an effective SIS remains critically important, but it will have little to do.

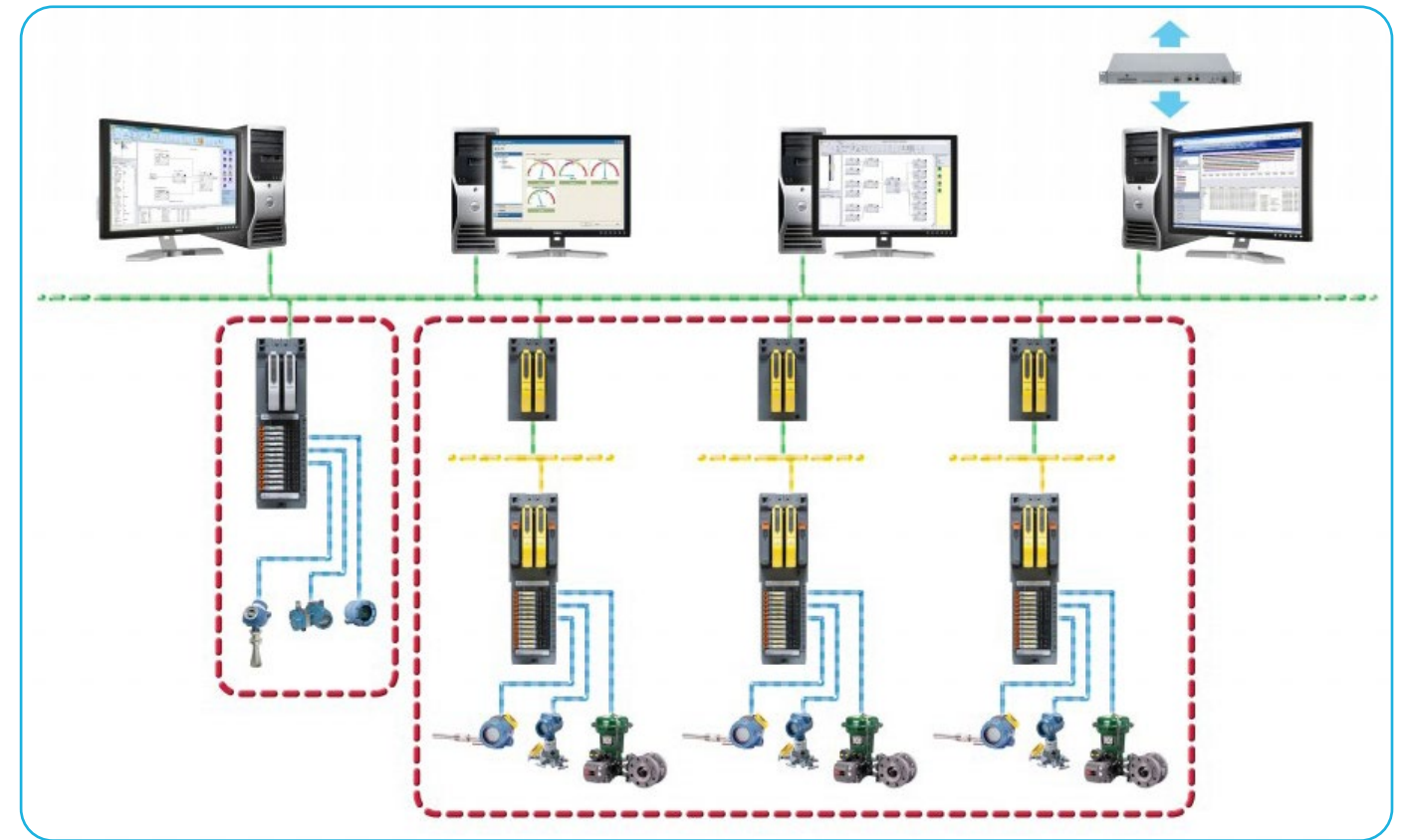


FIGURE 10

An effective Integrated Control and Safety System (ICSS), such as the DeltaV™ ICSS Platform, combined with traditional and WirelessHART® instrumentation and field devices, will provide dependable and stable production.

On the other hand, a poorly controlled process will be unstable and generate too many demands for the SIS.

Cybersecurity is a critical aspect of automation systems since a malicious attacker can exploit a vulnerability to find a way to either disrupt

the process or create a hazardous condition. Today's automation system architectures, such as DeltaV™ ICSS v15 and WirelessHART®, have many built-in protections, but companies still must be aware of potential threats, and tighten up work practices to minimize vulnerabilities.



Process Safety

Advanced Diagnostics

Advanced instruments used for SIFs can recognize a variety of equipment and process problems. For example, the Rosemount™ 3051S with Advanced Diagnostics (Figure 11) can detect unusual conditions early and send messages to operators of an abnormal condition developing. This can happen without interfering with the basic safety function.

If the diagnostics are fully enabled to take advantage of their capabilities, reliability and maintenance technicians can fix these undetected failures before they escalate to the point of creating a false trip.

A safety-certified Rosemount™ 3051S with Advanced Diagnostics can recognize and report:

- Changes in the process noise signature that could be indicative of an issue, such as furnace flame instability or pump cavitation
- Plugged impulse lines or other process connection issues
- Water in the transmitter housing
- Wiring damage or corroded terminals
- Poor power quality or improper grounding



FIGURE 11 Safety-certified transmitters have the same Advanced Diagnostics as their conventional counterparts.

Rosemount™ Magnetic Flow Meters and Micro Motion™ ELITE™ Coriolis Flow Meters (Figure 12) are available with Smart Meter Verification, a specialized set of diagnostics that monitor the entire flow meter's performance and integrity continuously while the process is running. This meter diagnostic software provides information in real-time to ensure flow measurement accuracy and when it is time to schedule calibration. When combined with a digital control network, this diagnostic tool can eliminate the need for scheduled visits to the field, and it can extend testing intervals.



FIGURE 12 Smart Meter Verification is a specialized set of diagnostics that monitor the entire flow meter's performance and integrity continuously.

In addition, Emerson's Micro Motion™ line of ELITE™ high temperature Coriolis flow meters (Figure 13) offer the highest temperature rating available in the market, providing reliable, safe, and accurate measurements for a range of refining applications. These applications include cokers, heavy product run down lines for crude distillation towers (both atmospheric and

vacuum), heater passes, residual processing, and cracking.

All these diagnostic capabilities can indicate something might be wrong with the process or the specific SIF. Some, if left unaddressed, could result in a false system trip. This shows how advanced diagnostics provide a double benefit, improving availability by reducing the potential for a false trip while simultaneously providing insight into equipment condition and even process changes. Taking advantage of the advanced diagnostics is only possible if the SIS can process the diagnostic information. A legacy SIS may only process the 4-20 mA signal, while DeltaV™ SIS can utilize the advanced diagnostics. For example, DeltaV SIS can recognize a malfunctioning device and remove it from the voting architecture.

FIGURE 13 Micro Motion™ ELITE™ Ultra High Temperature Flow Meter Specifications:



- Temperature range of -58°F to 800°F (-50°C to 426°C)
- Mass/volume liquid accuracy of ±0.10%
- Density accuracy: ±0.0005 g/cc
- Smart Meter Verification available with 2" and 3" sensors
- Insulation and heat jackets available



Process Safety

Combustion Control

Process fired heaters pose significant safety risks. Depending on the size of the refinery, the number of fired heaters on site can range from a few to over fifty. These heaters are used for heating, vaporizing, and thermally cracking various process fluids. Heat energy generated by fuel combustion is transferred to a charge or feed in a controlled manner.

The primary functions of a process fired heater are to maintain the desired outlet temperature and charge rate. In addition to temperature and charge rate control, safety systems are designed to ensure efficient fuel combustion and safe operation across all conditions the heater may experience.

Burners within the heater transfer energy into the process through fuel combustion, typically using refinery fuel gas. Fuel can accumulate when burners are off but should be on, as well as under substoichiometric conditions. It is crucial to prevent fuel accumulation in the firebox, as the subsequent introduction of an ignition source could have catastrophic consequences.

Furthermore, fired heater burners are designed to use excess combustion air to ensure complete combustion of fuel gas, as perfect mixing of air and fuel is not achievable. If only the exact amount of air required is supplied, incomplete combustion occurs because not all fuel gas finds the available oxygen. Stable combustion is crucial for safe operation, and deviations in the air-to-fuel ratio can lead to unstable and halted

combustion. Causes for these deviations include changes in fuel gas composition, sudden air flow decreases, and sudden fuel flow increases. Incomplete combustion, or substoichiometric combustion, is undesirable as it can cause flame impingement, energy wastage, afterburning, and flame instability.

As previously mentioned, refineries often use refinery fuel gas, also known as waste gas, as a fuel source due to its low cost, but its variable composition can lead to significant changes in BTU content, potentially leading to insufficient oxygen for complete combustion. **Figure 14** illustrates a potential sequence of events resulting from such a scenario.

Due to safety implications, another critical part of Safety Instrumented Systems is accurate flow measurement in multi-pass fired heaters to prevent damage and false trips. For this reason, the Rosemount™ Quad Vortex Meters are ideal in this application because they are calibrated to provide four independent measurements within a single flow meter, enabling the 2oo3 voting needed for a refinery SIS. The Rosemount™ Quad Vortex Meters ensure consistent and accurate flow data, preventing hazardous conditions such as heater tube ruptures or unnecessary trips. Implementing these meters enhances safety and efficiency in refinery operations by ensuring reliable flow measurements.

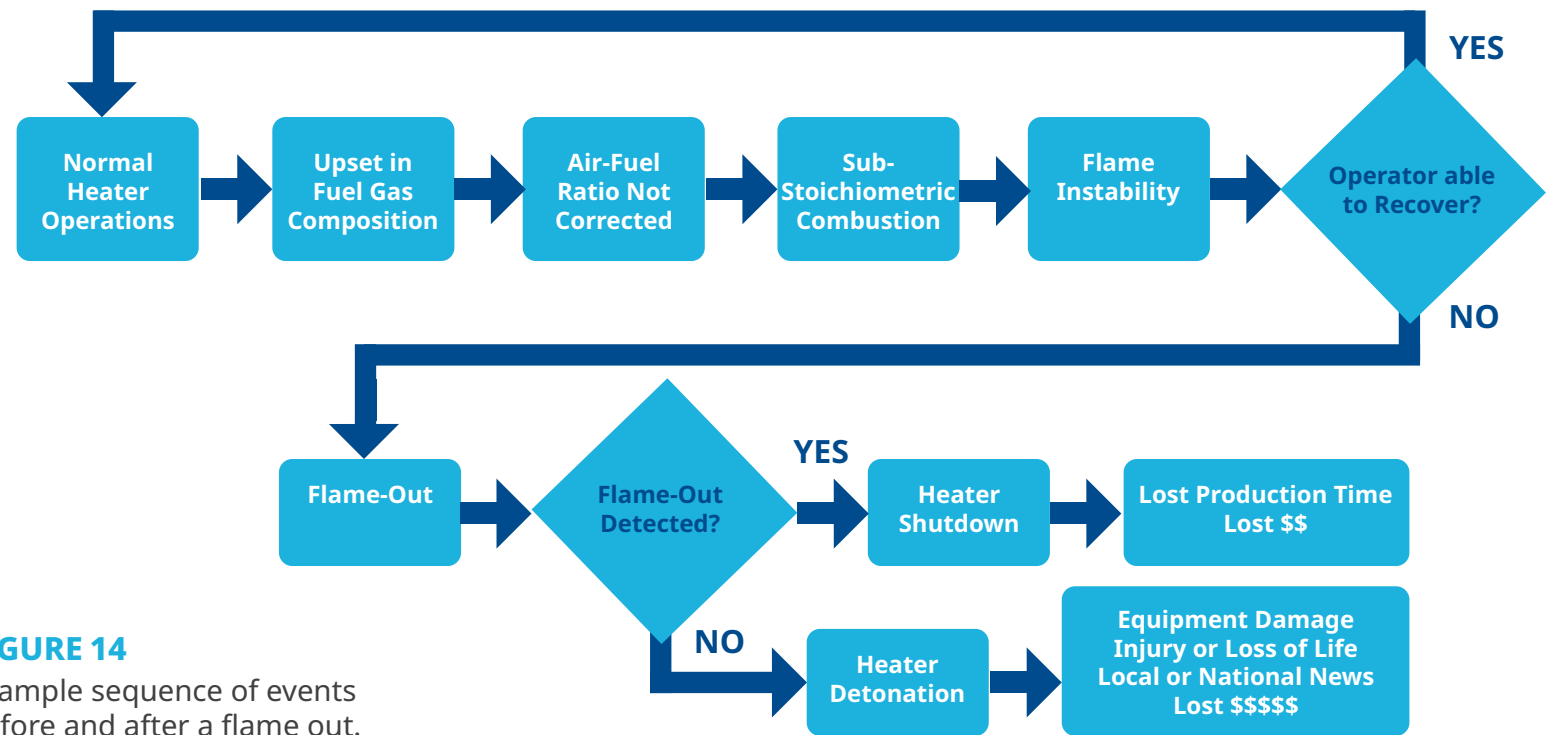


FIGURE 14 Example sequence of events before and after a flame out.

Process Safety

Combustion Control

Since stable combustion is critical to the safe operation of fired heaters, advanced systems are essential to mitigating combustion upsets. **Figure 15** shows Emerson's solutions to help refineries properly and safely operate fired heaters:

- Accurate and reliable flow measurement in multi-pass fired heaters
- Burner Management System (BMS) using Safety Instrumented System (SIS)
- Fuel flow and fuel BTU measurement
- Air flow measurement by direct instrument or pressure drop across heater
- Air damper actuation and position measurement
- Excess oxygen measurement
- Emission parameter measurement
- Optimized combustion control with fuel Btu compensation
- Production rate control with "Single Knob" ramp function
- Flame stability detection
- Equipment and emission constraint protection
- Automatic start-up and shut-down routines
- Product charge and temperature optimization
- Asset monitoring functionality with predictive maintenance alerts

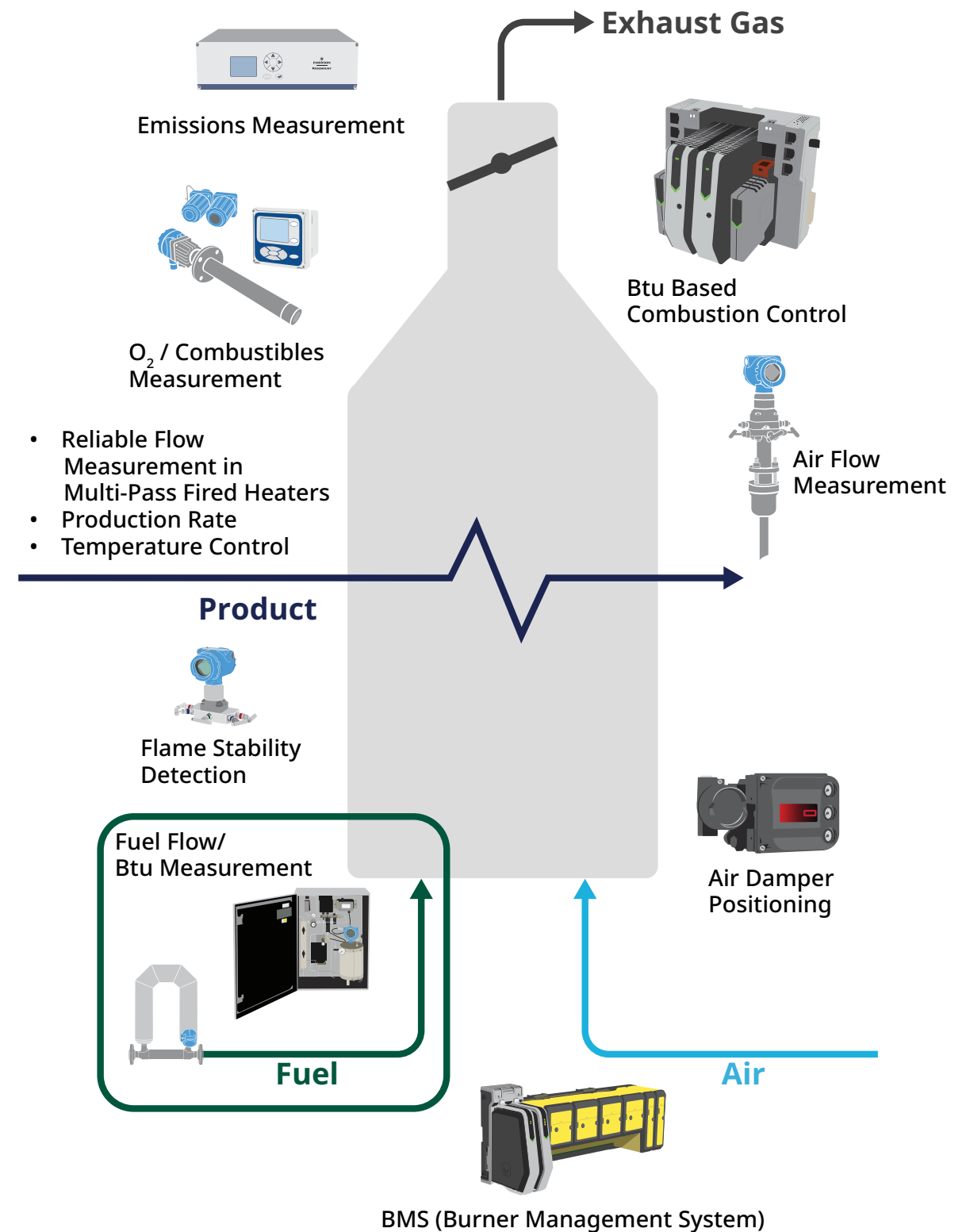


FIGURE 15

Maintaining safe operation and control of fired heaters depends on data and actionable insights from strategic instrumentation.



Process Safety

Minimizing Hazards

As mentioned earlier, effective automation minimizes manual processes, such as operator rounds to gather data or perform inspections. This serves two important functions, overlapping with occupational safety:

- Operators spend less time in the plant where there is opportunity for exposure to hazards
- Automated data gathering is more effective because it can be continuous and avoids human errors.

A prime example of this concept is continuous monitoring of pressure relief valves (PRVs) and steam traps using an acoustic monitor (Figure 16).

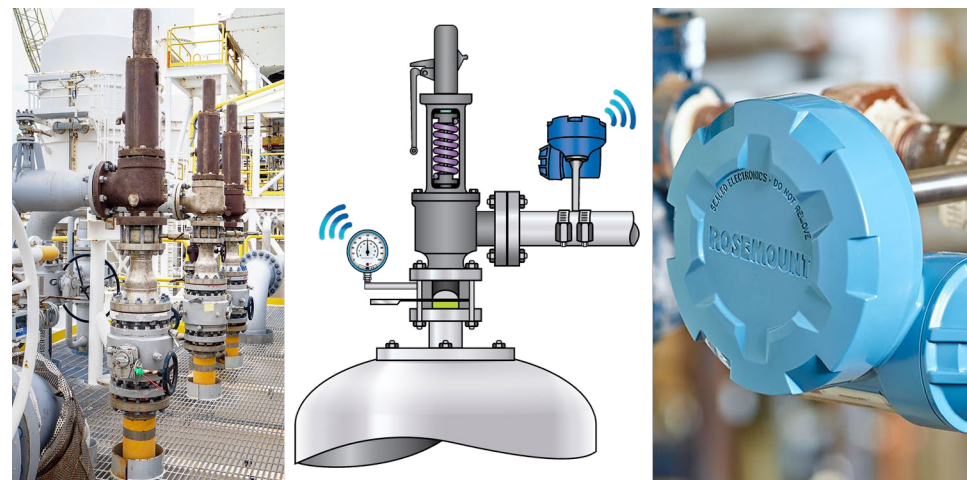


FIGURE 16

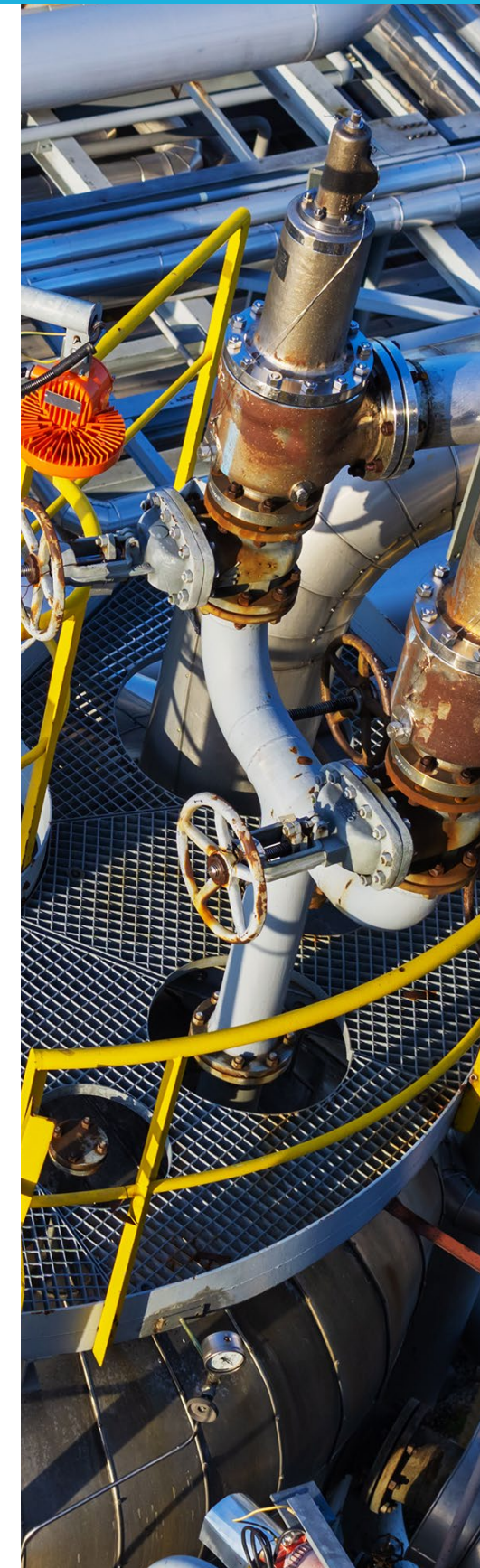
Rosemount™ 708 Wireless Acoustic Transmitters mount on piping adjacent to PRVs and steam traps to detect if they are functioning correctly or might be leaking. They are self-powered and send data via WirelessHART®, so there is no need for any wiring.

PRVs are critical safety equipment, but create operational problems due to a tendency to remain partially unsealed after a release event. This permits simmering, a slow leakage of process fluid into the collection system. Leakage can also interfere with their ability to open correctly during an incident, while wasting energy, and increasing emissions.

Such problems are often difficult to diagnose due to PRV inaccessibility, calling for scaffolding and putting workers into potentially unsafe situations to evaluate their condition manually.

Steam traps are subject to frequent malfunctions in many environments, wasting product and energy. There is also potential for safety-related incidents caused by condensate backing into the steam lines, resulting in piping ruptures and other equipment damage due to water hammer effects.

Replacing dangerous manual inspection rounds with acoustic monitors provides continuous data while allowing operators to perform higher level tasks.





Process Safety

Differential Pressure (DP) Level Systems for Hot Processes

For applications involving extremely hot processes, using specialized fill fluids that can endure high temperatures is essential for safety. Standard viscous fill fluids can gel at normal ambient temperatures, causing DP systems to become sluggish and unreliable. Heat tracing, often used to maintain fill fluid warmth, is not only expensive but also demanding in terms of maintenance.

The Rosemount™ Thermal Range Expander (Figure 17) addresses these issues by allowing DP Level systems to be direct-mounted on processes up to 410 °C (770 °F), providing consistent and reliable measurements across a broad range of ambient temperatures. This solution is compatible with all Rosemount 3051SAL technologies, ensuring safe and versatile application options.



FIGURE 17

Pictured is the Rosemount™ 3051S Thermal Range Expander. For DP level measurements in high pressure applications, Electronic Remote Seals (ERS) are recommended and gold-plated diaphragms are available to prevent hydrogen permeation for hydroprocessing units.





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Containment Safety



Containment Safety

Refineries handle highly flammable and hazardous substances. Ensuring the safety of tanks at a refinery is paramount to prevent accidents and environmental hazards.

Key safety measures include monitoring and maintenance to detect and address potential leaks, corrosion, or structural weaknesses. Implementing robust monitoring systems, such as pressure and temperature sensors, helps in early detection of abnormal conditions. Adhering to stringent operational protocols, including proper filling and emptying procedures, minimizes the risk of overpressure and spills. Tanks should be equipped with safety devices like pressure relief valves and emergency shutdown systems. Additionally, incorporating secondary containment structures, such as dikes or berms, can effectively contain spills and prevent contamination of surrounding areas.

Containment incidents must be prevented by effective safety automation:

- Appropriately selected level instruments and an effective SIS can stop operators from overfilling a tank.
- An effective level instrument and SIS can recognize when the contents in a tank decrease with no corresponding process reason but is instead caused by a leak.
- Automated valves tied to a control program to set up valve lineups during liquid transfers avoid spills caused by incorrect procedures.

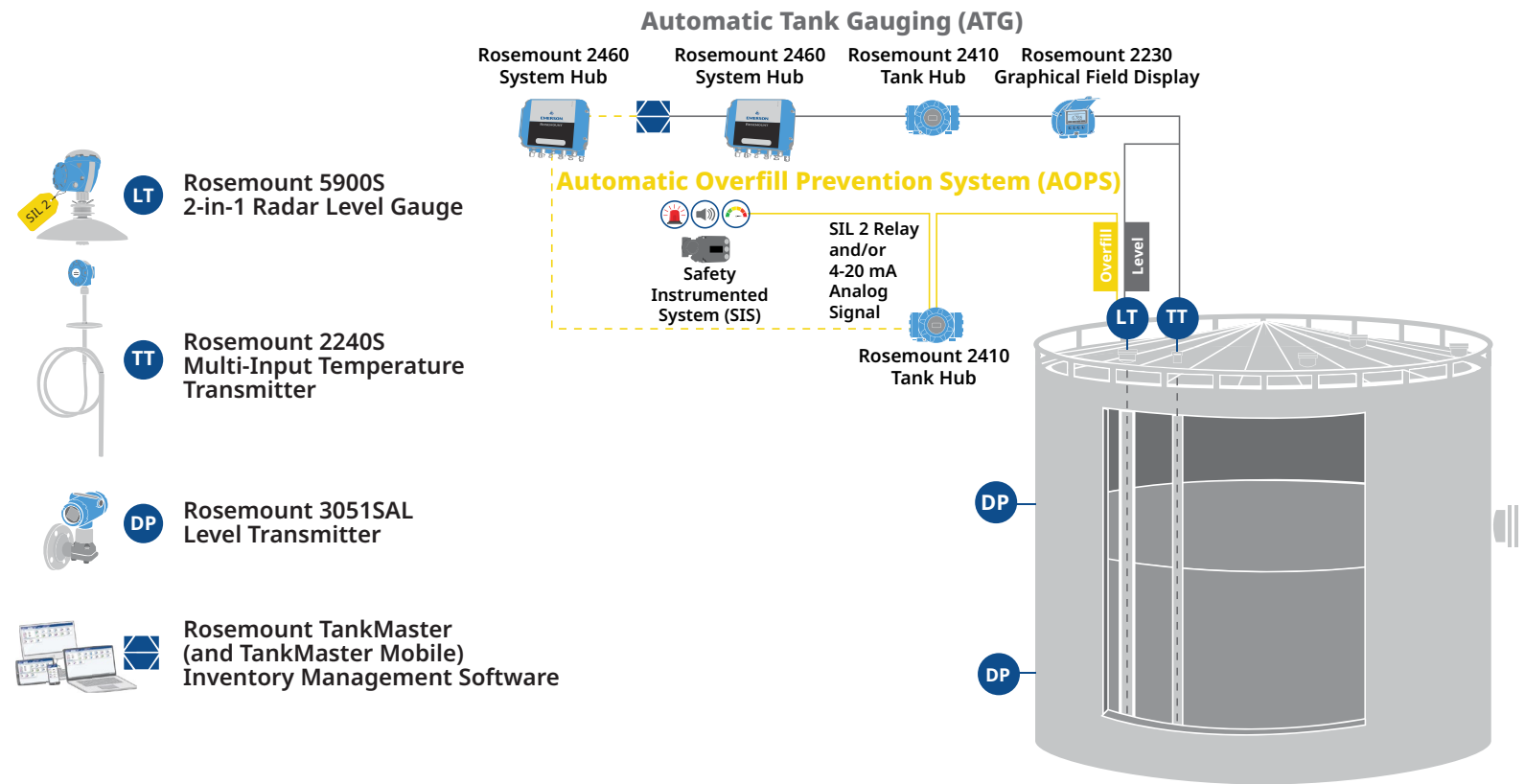


FIGURE 18 The Automatic Tank Gauging and Automatic Overfill Prevention System exist side-by-side but separately so they can function independently. Rosemount™ 5900S Radar Level Gauge is available in conventional and SIL-rated versions for these types of applications.

Containment incidents can have severe consequences, including fires, explosions, and toxic releases, posing significant risks to worker safety and public health. While catastrophic events understandably get attention, smaller incidents are common, but these can be prevented. Safety certified level instruments (Figure 18) are very accurate and monitor their respective tanks continuously, watching for

unexplained changes. They can support SIFs designed to shut down filling actions before tanks reach their limit and detect minute changes in level resulting from leaks. These protect workers, the surrounding community, and the plant itself from potential disasters.



Containment Safety

Early Warnings of Leaks

Gas detectors are crucial safety devices used around tanks in a refinery to continuously monitor for the presence of hazardous gases, such as flammable vapors or toxic substances. These detectors provide early warning of potential leaks, allowing for prompt response and mitigation measures to protect personnel, prevent explosions, and minimize environmental impact.

Gas detectors take two forms (Figure 19), fixed point detectors and open path. Fixed point detectors can monitor critical areas such as valve clusters, while open path gas detection is typically used to monitor perimeters around tanks.



FIGURE 19

Fixed point combustible and toxic gas detectors use multiple sensor technologies, such as infrared, catalytic bead and electrochemical. The Rosemount™ 925FGD Fixed Gas Detector (left) can detect all flammable gases and common toxic gases. Rosemount™ 935/936 Open Path Combustible and Toxic Gas Detectors (right) use infrared and ultraviolet technology to detect hydrocarbon and toxic gases, including methane, propane, ethylene, hydrogen sulfide and ammonia.

Many sites also deploy flame detectors (Figure 20) to cover areas where a process leak may find a source of ignition. Flame detectors generally activate alarms but may also trigger fire suppression equipment to douse strategic areas in foam.



FIGURE 20

Rosemount™ 975 Multi-Spectrum Ultraviolet and Infrared Flame Detectors respond to the specific wavelengths of light produced by a variety of burning fuels.





Containment Safety

Corrosion and Erosion Monitoring

While some incidents are caused by human error, corrosion is also a root cause for safety and maintenance issues. Corrosion can weaken the structural integrity of equipment, pipelines, and storage tanks, leading to leaks, spills, or catastrophic failures. By monitoring corrosion, the elevated risk and damage are detected long before loss of containment, which improves operational safety for the plant, personnel, and the environment.

Since corrosion attacks from the inside, it is difficult to spot by visual inspection. Corrosion monitoring is essential in various key process units within a refinery to ensure safety and efficiency.

- In the **Crude Distillation Unit (CDU)**, high temperatures and corrosive compounds make monitoring necessary to prevent leaks and maintain equipment integrity.
- The **Fluid Catalytic Cracking Unit (FCCU)** and Hydrocracking Unit also demand monitoring due to the high temperatures, chemical reactions, and pressures that can accelerate corrosion.
- Similarly, **Hydrotreating Units, Coking Units, and Alkylation Units** operate under severe conditions and use corrosive chemicals, making corrosion monitoring critical to avoid equipment failure and ensure safe operations.

- **Amine Treating Units and Sulfur Recovery Units (SRU)** handle acidic and sulfur compounds, requiring regular monitoring to prevent leaks.
- **Reformers**, which operate under high temperatures and pressures, have increased corrosion risks in reactors and heat exchangers.
- Additionally, monitoring **storage tanks and pipelines** is vital to prevent leaks and spills, ensuring the safe storage and transportation of crude oil and refined products.

Overall, the use of ultrasonic sensors (**Figure 21**) in corrosion monitoring enhances the safety, efficiency, and cost-effectiveness of refinery operations by providing accurate, real-time data and reducing the need for invasive inspection methods. These clamp on at strategic points, such as a pipe elbow, and send data via WirelessHART® to a central collection and analysis platform. They measure the wall thickness continuously and can detect changes as small as 2.5 microns. Over time, it is possible to recognize periods when metal loss was particularly aggressive.

A data-driven corrosion and integrity management program will ensure that asset conditions are known. As a result, the timing and scope of maintenance and repair strategies can be optimized to avoid unplanned outages or safety issues.



FIGURE 21

Rosemount™ Wireless Corrosion and Erosion Monitoring Systems measure wall thickness continuously so maintenance can determine when pipe must be replaced.



Containment Safety

Pipeline Safety

Oil refiners often have dedicated Pipeline Safety Operations as a core component of their overall safety and environmental management programs. These operations focus on ensuring the integrity and safety of pipelines used to transport crude oil, refined products, and other materials. By implementing rigorous monitoring, maintenance, and compliance procedures, they aim to prevent leaks and spills, protect public safety, and minimize environmental impact.

By adhering to standards set by agencies like the Pipeline and Hazardous Materials Safety Administration (PHMSA) and adopting best practices such as **API RP 1130 for leak detection**, refiners can achieve high levels of safety and environmental protection. Specifically utilizing advanced technology, such as non-intrusive Flexim™ H736 Ultrasonic Flow Meters (Figure 22), allows for accurate, real-time monitoring of pipeline conditions without interrupting operations.

This non-invasive method supports early leak detection and boosts operational efficiency, ensuring that production and maintenance schedules remain uninterrupted. Through these proactive strategies, Pipeline Safety Operations can reach a significant milestone in maintaining pipeline integrity and achieving operational excellence.



FIGURE 22

Completely drift-free, the Flexim™ FLUXUS™ H736 Non-Intrusive Ultrasonic Flow Meter can detect very low flow rates, a critical advantage for identifying small leaks in pipelines.

Integrated Safety Strategy

Elements Filling a Larger Strategy

All the individual topics discussed so far must come together to create a coordinated strategy to link all the protective layers in all the areas. Safety takes many forms (Figure 23), and Emerson has the widest range of solutions in the industry.

The selection of various functional safety devices and how they are integrated to provide occupational, process, and containment safety through larger safety systems must be analyzed, planned, and maintained carefully by experts. Preserving a facility's ability to operate while avoiding safety and environmental incidents calls for the right strategy, equipment, proof-testing, and personnel training. Emerson can provide assistance in all these areas, starting with walkdowns and recommendations, and continuing with a complete array of required products.

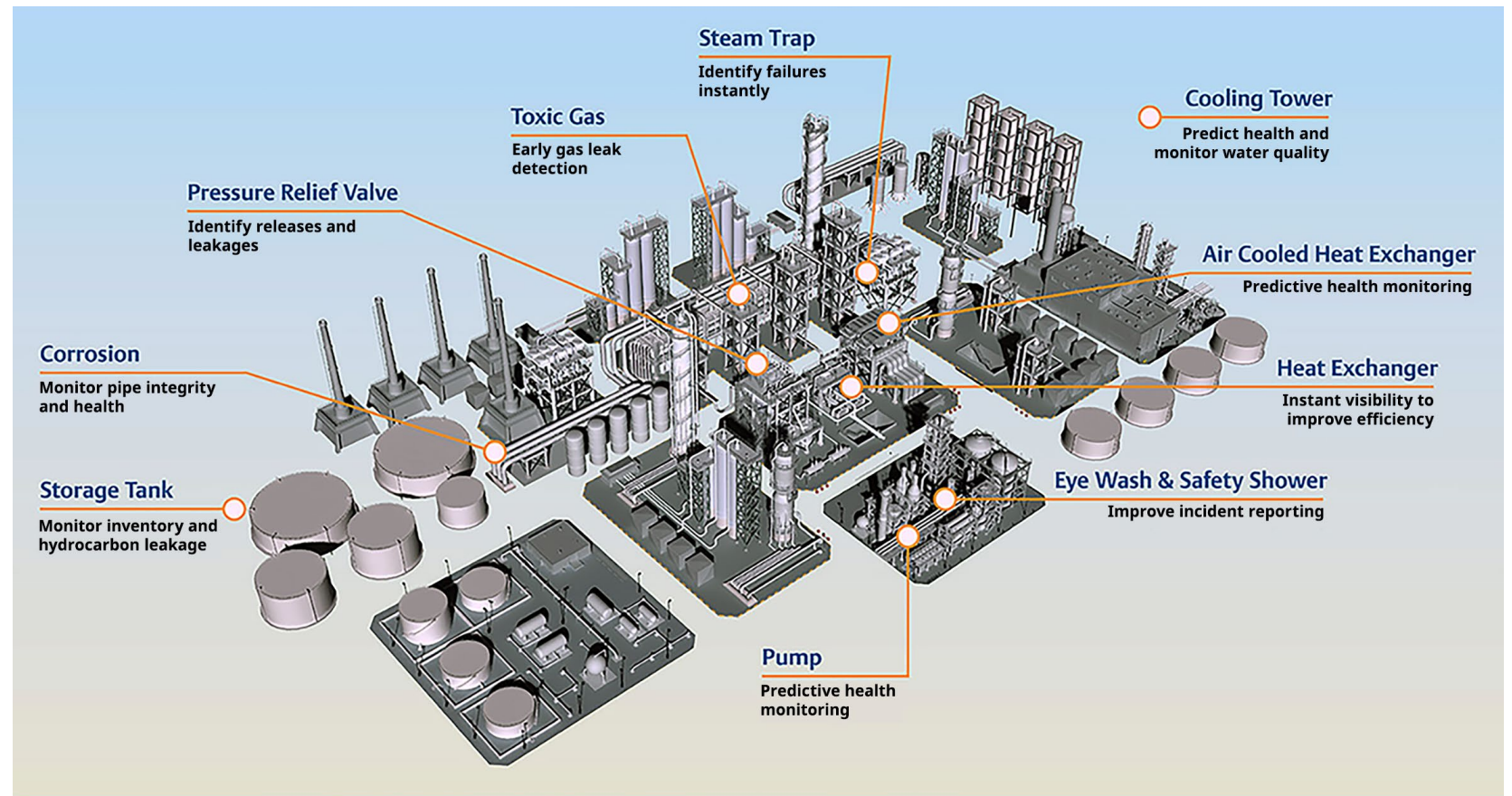


FIGURE 23

Emerson has a comprehensive set of technologies and services to provide early detection and mitigation of potential safety incidents and their consequences.

- Prevent fires, explosions, and other process incidents with modern SIS
- Meet SIL requirements with a portfolio of safety certified devices
- Avoid leaks, spills, and releases with tank management solutions and corrosion monitoring
- Improve personnel safety and reduce emergency response time throughout the facility.

- 🌐 [Emerson.com/SafetyMeasurementProducts](https://www.emerson.com/SafetyMeasurementProducts)
- 🌐 **Case Study: Refinery Ensures Safe Flushing Events During Turnarounds**
- 🌐 **Case Study: Refinery Improves Safety by Solving Long-Standing Toxic Gas Detection Concerns**
- 🌐 **Case Study: Refinery Fulfils Regulations and Saves \$1M with Certified SIL3 Tank Level Measurement Solution**

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