IN SAFE HANDS

Marcelo Carugo, Emerson, USA, shares how the right technology and safety strategies can protect personnel, facilities, and the environment.

The risk of storing, processing, and transferring toxic, hazardous, and flammable materials is undeniable. And although the refining and petrochemical industries have always been focused on safety – and overall rate incidence reports have been decreasing – there is still room for improvement. According to the Concawe Safety Management Group, the top three leading causes of Tier 1 incidents in 2018 were due to issues with piping, atmospheric tanks, and pumps, and manufacturing Tier 1 events rose over 20% from 2017 to 2018.[1]

In addition to putting personnel and nearby communities at risk, safety incidents also have an impact on a plant's finances. In fact, insurance industry data indicates significant property damage losses for the refining industry over the past 30 years. Losses were huge between 2017 and 2019, totalling US$2.25 billion.[2]

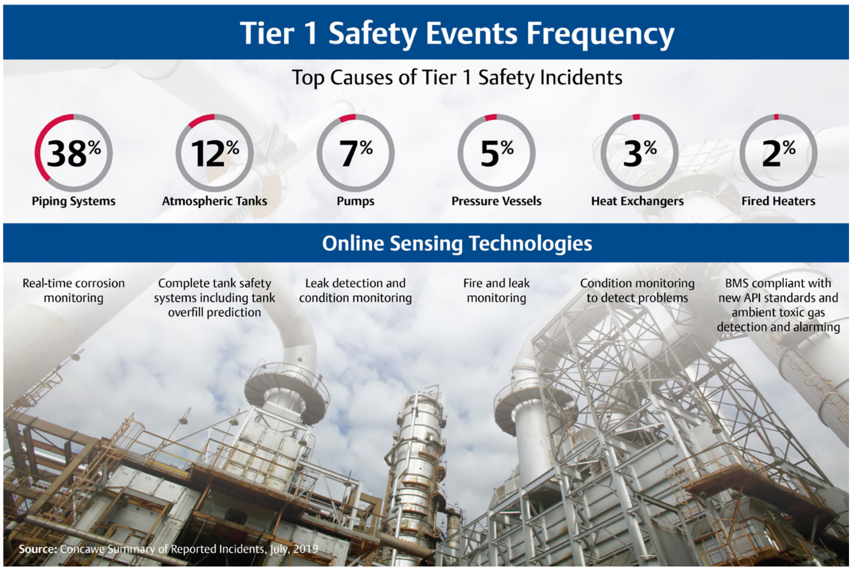

Figure 1. Top Tier 1 safety incident causes.

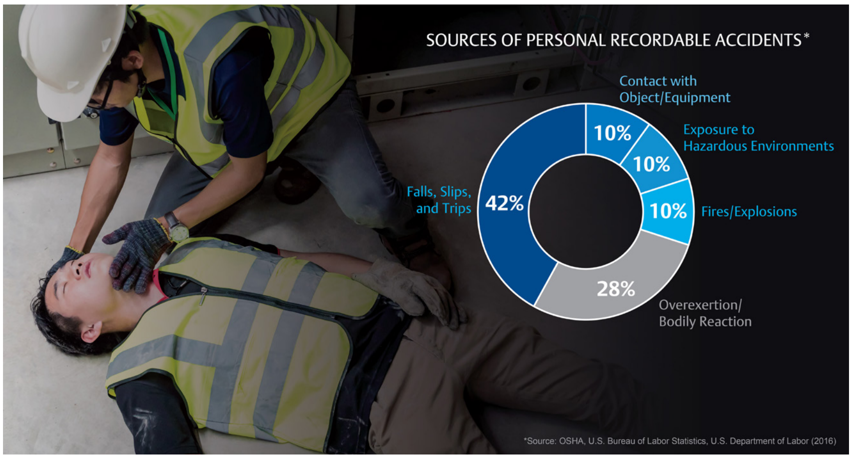

Figure 2. Personal recordable accident sources.

Refiners who embrace new strategies and technologies that reduce their personnel's exposure to hazardous environments and materials, and integrate more accurate, reliable, and regulatory-compliant process equipment enhance personnel and site safety. They also improve uptime and production, as well as protect their refinery's reputation and bottom line. A good place to start is by developing strategies to mitigate and reduce safety risk in four primary safety sectors: occupational safety, loss of containment, process safety, and cybersecurity.

Personnel safety first

For the people who make the rounds to enable a refinery to operate smoothly, safety means everything. According to Occupational Safety and Health Administration (OSHA) best practices, first responders have less than four minutes to reach an employee in distress after an incident occurs.

Fortunately, location awareness technology makes refinery-wide safety measures easier to integrate, giving managers a snapshot of the location of everyone in the plant through rechargeable wearable tags. This technology is especially useful for compliance with the COVID-19 social distancing health directive, particularly with activities related to turnarounds when numerous contractors are present. It also signals alerts when someone crosses a boundary or geofence to enter dangerous areas in the plant. But the primary benefit is that an operator can quickly account for any personnel in trouble and dispatch emergency responders to an exact location in an emergency.

Adding a cost-effective monitoring system for safety showers and eyewash stations, featuring a wireless discrete transmitter that releases alerts in emergency situations, adds another layer of protection and simplifies reporting to regulatory agencies by providing historical tracking records.

Studies indicate that major safety incidents caused by operator error have significant financial impact. It is estimated that the average event costs over US$80 million per incident and 70% of those incidents occur during abnormal situations or transient operations, such as start-up and shutdown.[3, 4] ARC Advisory Group estimates that between 3% and 8% of nameplate capacity is lost due to abnormal situations with outdated or incomplete operational procedures and operator error is responsible for up to 42% of unscheduled shutdowns and slowdowns.[4] Equipment failure is often exacerbated by incorrect start-up and shutdown procedures, as well as process upset, requiring significant manual intervention which in turn increases transition times.

Properly designed procedure automation can handle abnormal situations that occur with a consistent response. For example, state-based control – a procedure that transitions through a number of different process states, from shutdowns for maintenance through a variety of normal and abnormal conditions – can optimise the control of the process. This method begins with assessing operations to improve situational awareness, unifying operational understanding, capturing tribal knowledge of experienced staff, and reducing human error to improve overall operational performance.

Emerson successfully executed a number of state-based control implementation projects. One was for a vinyl acetate monomer production facility which was experiencing slow, inconsistent start-ups and a high frequency of operator intervention, which impacted safety and performance. After assessing 26 unit operations, experts designed and implemented the state-based control system on five unit operations to stabilise and replicate predefined operational responses, reduce the influence of human factors on the rate of abnormal situations, and increase the efficiency of response execution. This process resulted in a 67% faster and repeatable process start-up, a 1.5% increase in annual capacity, reduced operator loading, and a 50% reduction in alarms.

Digital solutions mitigate loss of containment risk

Plant managers know that storage tanks pose many inherent risks to personnel, the environment, and equipment if not properly maintained. According to a recent report, 12% of Tier 1 safety incidents involved storage tanks,[1] and a study of storage tank accidents indicated that 74% of tank accidents occurred at refineries and terminals.[5] It is noteworthy that one-third of those mishaps were due to personnel error or equipment failure and that 77% of bulk petroleum storage tank terminal locations are within 1 mile of a densely populated area, making tank losses of containment particularly hazardous.[6]

A comprehensive programme that would maintain tank integrity is therefore desirable. With digital tank solutions, operators can mitigate the risk of tank overfill, prevent a flame event from propagating through the system, and access real-time indications of technical abnormalities. To maintain pressure control in the gas space it is important to implement tank blanketing and vapour recovery regulators, as well as tank vents and flame arrestors for emergency protection. For the liquid space, a tank overfill protection system, hydrocarbon leak detection, and non-intrusive corrosion monitoring technology enhance safety conditions. In addition, API 653 recommends keeping good records to document products in and out of each tank – especially refiners using discounted opportunity crudes. And, if a refiner uses high total acid number (TAN) crude oils, corrosion monitoring should be accompanied by monthly walkarounds to check for stains on steel, which may indicate leaks.

When a refinery takes advantage of the increasing number of discounted opportunity crudes, assets are at risk of corrosion in unexpected places. In fact, corrosion may be the largest contributor to loss of containment and increased safety risk. A recent study on major refinery accidents, with losses exceeding US$50 million, identified that 20% were caused by corrosion failures.[7]

The best and most reliable corrosion mitigation programme takes into account industry recommended practices and standards and implements both intrusive and non-intrusive online monitoring solutions to deliver real-time data on wall thickness. It also includes the use of chemical inhibitors, near-infrared (NIR) online characterisation for crude oil feedstock selection, inspections during turnarounds, and prompt repair or replacement of assets damaged by corrosion.

That was the case with a European refinery that operated four similar and parallel stainless steel amine absorber trains which were configured similarly. After retrofitting real-time corrosion monitoring at key locations, experts determined that one of the trains had dramatically higher corrosion rates, which might have led to a safety incident and production losses prior to the next scheduled turnaround. Amine unit feed redistribution was implemented and the corrosion rate was brought under control, with the added benefit of saving US$700 000 in potential lost revenue.

For newer refineries, access to additional information and insight into impending issues make risk mitigation in hazardous environments significantly easier to address, while older refineries must find new methods to retrofit older wiring and instruments to safely operate the plant and reduce risks. Such solutions should include better methods of flame and gas detection in the most hard-to-reach and dangerous refinery environments; the ability to use more cost-effective wireless sensing and data analytics to eliminate the need for personnel to perform manual data collection in dangerous areas; and more accurate, reliable methods of toxic gas detection that further keep personnel out of harm's way.

For example, a large refinery in Southeast Asia learned that its conventional gas detectors were insufficient for detecting most hydrogen releases in its hydrogen storage facility. Two advanced ultrasonic gas leak detectors featuring ultra-sensitive acoustic sensors were installed to improve leak detection in a wide area, and multiple open path gas detectors were added to monitor fence lines and protect nearby residents. Over time operators expressed confidence in the detectors' performance, which led to fewer trips by personnel to investigate the nature of possible leaks.

Another safety consideration is seepage occurring under equipment such as pumps and compressors, which can penetrate the soil and create expensive issues over time. While process monitoring systems can detect a 0.02% leak rate, they do not detect small leakages at a 0.005% rate. However, those undetected releases from equipment connections can build up flammable material, potentially leading to fires or worse –

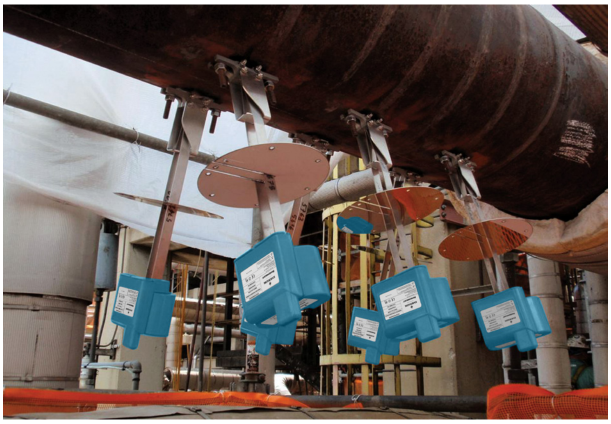

Figure 3. Real-time corrosion monitoring sensors in action.

Figure 4. PRV online monitoring.

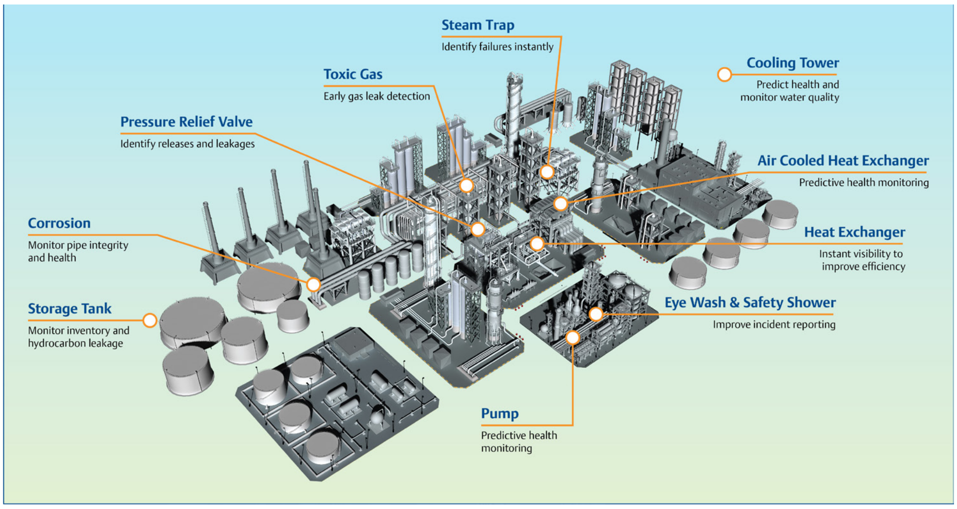

Figure 5. Refinery safety solutions.

environmental damage, expensive soil remediation, and costly fines.

To offset this type of issue, wireless transmitters can connect hydrocarbon sensor detectors to the safety monitoring system, resulting in very early detection or awareness of leakages in their early stages. This gives operators time to respond before it potentially becomes a catastrophic situation or a leakage turns into an uncontrolled spill near communities or water.

Improve process safety

An underlying root cause for site safety incidents often involves process equipment failures, which is the third major safety area of concern. Because insurance rates throughout the industry have dramatically increased due to process incidents, there is a strong need for the modernisation of safety instrumented systems (SIS).

However, if the SIS does not perform properly, it can mean an imminent issue is not detected. Industry data shows the majority of the faults and failures in an SIS occur in field devices such as sensors and actuators. Furthermore, when the SIS is incapable of diagnosing and alerting users to a problem with system faults or sends incorrect alerts, it can cause spurious trips and unplanned shutdowns. This situation can result in serious and potentially life-threatening incidents such as a fire or explosion, resulting in staff injuries and extended shutdowns, as well as lost production, revenue, and fines.

Implementing a smart SIS provides an integrated approach to the entire safety instrumented function – from sensor through logic solver to final control element – to create a complete entity. The use of digital intelligence and predictive diagnostics increases system availability while reducing lifecycle costs and enabling easy regulatory compliance because it helps predict and prevent problems before they affect the process.

A smart SIS continuously monitors the health of the entire safety instrumented function and its ability to perform on demand. Faults can be diagnosed before they cause spurious trips, which increases process availability and reduces lifecycle costs.

Often called the last line of defence – especially when the system is down and nothing else works – pressure relief valves (PRVs) are the most important safety feature on any pressurised system and should remain idle until needed. That means PRVs should never operate when process conditions are controlled. However, if they are called to action, they must operate flawlessly.

Simple by design, PRVs are self-operated mechanical devices designed, sized, selected, and manufactured to meet requirements of specific codes and standards. Because of their application, PRVs are highly regulated and must comply with national and local safety rules and regulations, and require preventive maintenance every 2 – 5 years.

PRVs are not typically monitored, so undetected relief events and leakages may remain unnoticed for years. After analysing data on 10 000 service records from a large North American refining complex, experts discovered that 20% of the valves leaked at pretest before reaching 50% of set pressure. 8% of the valves leaked so badly that the valves did not open. Considering that on average PRVs will operate above 50% of set pressure, this is very concerning because it suggests that a lot of valves are constantly leaking in the field unnoticed.

Because undetected and unreported relief events are usually the main root cause of PRVs starting to leak, the refinery implemented the digital transformation of its PRV operation and lifecycle management, enabling data to travel wirelessly to a control room so operators could correlate real-time PRV information with process data and maintenance records.

In addition, wireless monitoring can detect PRV and rupture disc failure events in real-time, pinpointing the bad actor, and use analytics to correlate process data with maintenance records to determine root causes. Such immediate notification keeps workers safer and ensures regulatory compliance with environmental regulations, such as the Refinery Sector Rule EPA 40 CFR 63 in the US.

This digital transformation also enhances occupational safety by eliminating the need to send personnel into the field. In addition, when implemented with asset management tags (radio-frequency identification [RFID]), operators can effortlessly acquire PRV information in hard-to-reach or hazardous areas by scanning the tag from a safe distance.

Situational awareness is another important tenet in disaster preparedness. Operator error is the leading cause of major incidents and there is a safety challenge when operators are inundated with information because alarm floods lead to unsafe conditions. Implementing dynamic alarm management will eliminate alarm floods and ensure operators receive the correct alarm for all modes of operation, including start-up, shutdowns, and transitions between each state.

When an alarm flood with a peak alarm rate of 400 alarms within 10 minutes inundated a large refinery, Emerson implemented alarm management software and a plant-wide dynamic alarm rationalisation design, using a pre-rationalisation process compliant with industry standards including ISA 18.2 and IEC 62682. This resulted in a dramatic reduction in alarm floods – with an average peak of 10 alarms per 10 minutes – and accurate alarm limits for all modes of operation, including transitions.

Mitigate cyber threats

Cybersecurity threats are on the rise, and because they can debilitate plant operations, it is essential to identify vulnerabilities early to secure critical data and operations. Manufacturing has reached the top five cyber-attacked industries over the past five years, and it was predicted that oil and gas and energy companies would be in the top 10 targeted companies by 2021. It has been estimated that cybercrime damage will cost the world US$6 trillion annually by 2021.[8] While this prediction was calculated prior to the impact of COVID-19 on the global economy, cybercrime damage remains extremely high.

That is why choosing control and safety systems, open loop applications, and instrumentation embedded with cybersecurity – including security-based monitoring and wireless technologies – is essential. Conducting a cybersecurity audit to identify potential risks and mitigate those issues, and implement technology to strategically combat security breaches, is the first step towards enhancing protection in this area of operation.

Conclusion

There is a direct correlation between improving asset reliability and equipment health and the effects on personnel safety-related incidents and environmental issues at the refinery. That is why a variety of automated solutions and trusted third-party safety and solutions expertise can help provide a clear path forwards to mitigate challenges in occupational safety, loss of containment, process safety, and cybersecurity. It is important to start with a facility gap analysis to unearth issues that need to be addressed, then implement the technology and site training best suited to reaching a refinery's safety goals.

References

1. Concawe Safety Management Group, 'European Downstream Oil Industry Safety Performance Statistical Summary of Reported Incidents', (2019).
2. Marsh and McLuhan, '100 Largest Losses in the Hydrocarbon Industry report', (2019): https://www.marsh.com/us/insights/research/100-largest-losses-hydrocarbon-industry.html
3. O'BRIEN, L., 'Why We Need a Better Approach to Procedural Automation,' ARC Strategies, (2010).
4. ARC Advisory Group, 'ASM Consortium's Solution Framework Creates Business Value for Adopters,' ARC White Paper, Dedham, Massachusetts, US, (2009).
5. CHANG, J., and LIN, C-C., 'A Study of Storage Tank Accidents,' *Journal of Loss Prevention in the Process Industries*, (2006).
6. US Chemical Safety and Hazard Investigation Board, 'Final Investigation Report, 2009 Explosion and Fire at Caribbean Petroleum Terminal Facility in Puerto Rico,' (June 2015): https://www.csb.gov/assets/1/20/capeco_final_report__10.21.2015.pdf
7. Lloyd's Market Association (LMA), 'Common Causes of Major Losses in the Onshore Oil, Gas & Petrochemical Industries', (September 2016).
8. Cybersecurity Ventures , 'Cybersecurity Jobs Report, 2018-2021', https://cybersecurityventures.com/cybersecurity-market-report/