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Process Safety in Specialty Chemical – White Paper

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Process Safety in Specialty Chemicals: Turning Industry Challenges into Opportunities

The need: Lower life cycle costs and better information flow. The solution: New standards offer more choices for integrating safety and process control

The specialty chemical industry is facing a number of difficult challenges, including increasingly stringent safety and compliance mandates, higher energy and feedstock prices, and aging plants and equipment – all intensified by global competition. Compounding these challenges is the expanding breadth of specialty chemical product categories, forcing manufacturers to dedicate major resources and continuously innovate to maintain market share and capitalize on new opportunities.

Despite the size of the industry and the increase in worldwide demand for all types of specialty chemicals, margins must be managed closely due to rising costs, more demanding customers, and the fact that all products – no matter how innovative – eventually go off-patent and face stiff competition. While operating a chemical plant is tough business, opportunities exist for companies to optimize their investments and improve both productivity and their financial performance.

Risks prevail wherever people store, process or handle hazardous or toxic materials. In the specialty chemical industry, these risks are compounded because the hazard has the potential to impact a numerous of people. A spill of a toxic agent or explosion could be hazardous to a population within a plant or the surrounding area. One growing area of focus in recent years is the critical value of safety in protecting people, and helping safeguard the environment and plant assets, as well as reducing lifecycle costs.

This paper explores how changes in industry standards and technology developments are expanding how safety systems are applied in specialty chemical applications. It also examines the operational and competitive advantages driving the trend toward separate yet interoperable safety and process control platforms with common development tools. These benefits include reduced life cycle costs, expanded access to process data and improved plant-wide integration.

Changing Requirements

Safety is not a new issue for specialty chemical manufacturers, but industry standards, such as IEC 61511, include specific performance and life-cycle criteria that quantify system reliability through failure rates. These failure rates are based on three key criteria: fault detection, fault tolerance and PFD_d (Probability of Failure on Demand), which quantifies dangerous undetected failures.

Risk assessment processes defined within these standards typically take a life-cycle approach in clarifying how to implement an effective process to identify hazards. This is where the HAZOP (Hazard and Operability) analysis often plays an important role in the process design. Central to the HAZOP is assessing the risk associated with the hazard. Unlike machinery assessments, risk assessments in specialty chemical applications employ a vaster, more encompassing focus due to the potential for accidents to impact a much wider area, such as an entire facility or community.

Performed by a multidisciplinary team, the HAZOP analysis identifies hazards and operability problems, and investigates and considers how the plant might deviate from the design intent. This systematic, highly structured assessment relies on HAZOP guide words and team brainstorming to generate a comprehensive review and help make sure proper safeguards against accidents are in place. A risk analysis is integral to this process to quantify the level of risk in terms of severity of consequence, frequency of exposure and probability of avoidance. The risk assessment quantifies the risk into one of four possible Safety Integrity Levels (SILs). The designated SIL represents the amount of safety that must be available to mitigate the risk.

Once the different hazards have been identified, the next step is to determine a way to help reduce the risk within those hazards to a tolerable level. A variety of ways exist to do this as outlined in standard IEC 61511. For example, one effective way to reduce risk is through Layers of Protection Analysis (LOPA). The method starts with data developed in the HAZOP and accounts for each identified hazard by documenting the initiating cause and the protection layers that prevent or mitigate the hazard. The LOPA methodology allows the determination of the appropriate SIL for the Safety Instrumented Function (SIF).

Safety Control Challenges

Specialty chemical manufacturers employ many types of control systems that continuously manage parameters, such as temperature, flow, pressure, weight and viscosity. Plants need to keep some processes going for practical and financial reasons. For example, shutting down a distillation column could cause the liquid to fall to the bottom and solidify, damaging expensive process equipment. Therefore, critical devices – such as exhaust fans, pumps, valves and motors – must remain on if the Basic Process Control System (BPCS) fails.

Since processes can create hazardous situations when they are out of control, the BPCS – historically a DCS, but today possibly a Process Automation System (PAS) – may not be able to keep the process under control in the event of a failure. This is where the Safety Instrumented System (SIS) comes into play. The goal of the SIS is to maintain control, and if necessary, shut down the process in an orderly way that protects the people, equipment, and plant, as well as helps minimize production losses. Common types of safety systems include emergency shutdown, fire and gas monitoring, critical process control, burner management, and turbo machinery control.

Since the goal is to maintain process control, maximum availability is a core requirement of safety instrumented systems. High availability from a process controls perspective simply means the control system will be available to perform its function regardless of changing conditions or operational malfunctions. The system is designed to tolerate failures, allow changes, repairs and replacements without significantly affecting the mission. The designer must accept the fact that components and system might fail and design the application around this assumption.

However, even the most robust system might not be the most available. To achieve maximum availability, a system must be easier to troubleshoot, modify and repair during the life of its mission, which could exceed a decade or more. Additional features that can keep the control system on its high availability mission, such as state-based control and self-learning diagnostic routines, improve the controller's ability to detect, annunciate and describe problems within the process. For many applications, the ability to maintain and revise the system without shutting down offers an acceptable level of availability, especially if the change or repair can be made quickly.

Critical process control applications are those in which the process must be maintained during a fault state to help minimize the potential for loss of life, damage to the environment or loss of production. Triple Modular Redundant (TMR) technology often is employed to achieve the highest level of fault tolerance and safety. These systems are designed with three parallel systems running in a redundant design. All three systems process the input information and vote to affect a result. That is, a two-out-of-three vote is required to effect a change or stop a process. The system is capable of running in a reduced safety state if under a faulted condition and must be repaired, or if the process must be systematically shutdown.

The redundancy requirements encompass more than the logic solver. They include all of the elements that make up the SIS including input devices (sensors, switches, instrumentation) and output devices (pump motors, valves and other actuators). All must be selected to meet the required SIL level for the safety loop or function Safety instrumented system must include measures that can detect a failure of one of the critical control elements. Measures such as redundancy, self-monitoring, crosschecking, testing and diagnostics typically are employed in the SIS.

More Control Choices

The primary function of a BPCS is to hold specific process variables and parameters to predetermined levels in a dynamic environment. An SIS, on the other hand, is static, waiting to take action to bring the process to a safe state when the process is out of control and the BPCS is unable to do so.

As a result, manufacturers traditionally implemented BPCS and SIS as separate systems, with separate operator interfaces, engineering workstations, configuration tools, data and event historians, and network communications. Life-cycle costs, such as spare parts, support, training, maintenance, and service usually are higher with this approach.

Nevertheless, many good reasons remain to put safety and control functions in different controllers. They include:

- Independent failures: minimizing the risk of simultaneous failure of a BPCS along with the SIS
- Physical separation: preventing changes in a BPCS from causing any change or corruption in the associated SIS
- Different requirements: an SIS is normally called on only in the event the BPCS fails. An SIS needs to have higher levels of security and typically doesn’t change much once it’s implemented, unlike a BPCS, which is usually designed for accommodating changes

For years, DCSes have been the staple platform for process control, delivering powerful, reliable service. But as these systems age, manufacturers are faced with the arduous task of maintaining proprietary, dedicated hardware and software platforms. These systems lack multi-disciplined control capabilities. To meet efficiency and profitability goals, companies need systems that can help meet the diverse control applications within their facilities, including sequence, process, batch and drive control, along with the ability to integrate with information systems.

Until recently, users had little choice other than to use separate, independent and diverse systems for control and safety. Some users even required the BPCS and SIS be supplied from different vendors. Today, however, users are finding a number of business and financial reasons for using more integrated platforms for safety and process control in their plants. For example, PASs offer a more cost-effective solution because of their ability to provide a common infrastructure with common bases or tag bases, alarms and events, networks, software and development tools. This helps simplify asset management and reduce operation, maintenance and training costs.

Specialty chemical manufacturers today need improved information flow across the enterprise, with the ultimate goal of controlling or reducing life-cycle costs. Perhaps the biggest advantage of integrating the process control platform is the potential for expanded information sharing capabilities between BPCS and SIS. The ability to leverage the data streaming from the plant floor is increasingly critical in today’s competitive environment – particularly in the specialty chemical sector where production must be tightly integrated as part of the supply chain so companies can be as efficient and productive as possible.

The Technology Forefront

Advances in control technology now allow companies to combine the reliability advantages of DCS technology and safety control without the historic limitations tied to each. Some BPCS and SIS suppliers offer common systems for both functions that incorporate the same configuration tools, programming software and components. The key is to help make sure the two systems are functionally separated, but share common hardware, software, and networks. This allows users to achieve the operational benefits of a common platform while meeting the functional safety requirement for separation.

The desire for better information sharing and coordination is driving specialty chemical companies toward more integrated platforms. But not all control platforms are created equal. Likewise, not all specialty chemical companies are at the same stage in their control system lifecycles where one solution will meet their diverse needs. Still, it's important that the BPCS and SIS you deploy offer the necessary attributes to contribute to a more cost-efficient, information-enabled environment.

Some manufacturers, like Rockwell Automation, offer choices for the level of integration, diversity and performance required. Whether it's SIL 1, SIL 2, SIL 3, fail-safe or fault tolerant, Rockwell Automation has a solution to meet the safety and availability required and the level of integration desired. For those that require more integration and a common hardware platform, RA has the fail safe and fault tolerant Logix platform, which can be used for both BPCS and SIS up to SIL 2. All solutions are part of the Integrated Architecture, which allows users to employ the same visualization, information, networks and development tools for reduced training costs and easier maintenance.

CONCLUSION

Like any industry, the specialty chemicals sector is evaluating new approaches to best increase performance while helping mitigate production risk. Manufacturers are looking to gain a competitive edge through the advantages offered by using common systems for process and safety control. These benefits include helping reduce the problems associated with multiple programming requirements, including increased operation, maintenance and training costs. This approach allows manufacturers to achieve the operational benefits of integration while meeting the safety requirement for separation.

Value of an Experienced Partner

While companies continue to reduce their engineering staff, advancements in technology and manufacturing are increasing the complexity of most automation projects. That requires more intensive engineering support and innovative knowledge for safety system implementation. Rockwell Automation’s proven track record in the process industry gives it a keen insight into the issues facing specialty chemical manufacturers, as well as an in-depth understanding of the tools needed to address these needs. The company’s global resources, advanced technologies and strategic alliances already are helping increase efficiency for companies of all sizes and helping reduce operating costs, while facilitating regulatory and environmental compliance.

With its recent acquisition of ICS Triplex, a leading global supplier of critical control and safety solutions to process industries, Rockwell Automation has expanded its process safety solution and consulting capabilities to help meet the most demanding high availability requirements. Now with the largest available suite of safety components, products and services to address discrete and process applications, the company offers a range of solutions options for integration and commonality. As a result, Rockwell Automation is able to recommend the best one to meet each customer’s unique application requirements.

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