WHITEPAPER

A Case for Competence: Global Process Facilities Need to Increase ISA/IEC 61511 Functional Safety Expertise

International Society of Automation
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The Challenges Are Real, and the Stakes Are High

The Center for Chemical Process Safety (CCPS) developed the Process Safety Incident Database to collect, track, and share details about important process safety incidents and experiences. According to the database's website, there are more than 700 incidents tracked currently, with more added every month.

As of January 2020, the US Chemical Safety Board and Hazard Investigation Board had eight investigations open, including explosions, toxic chemical releases, and fires in facilities and refineries in Texas, Oklahoma, Wisconsin, West Virginia, and Missouri.

Just because your facility hasn't had an incident yet, doesn't mean it can't happen or won't happen.

In fact, process industries are facing unprecedented challenges and roadblocks to maintaining consistently safe facilities and processes, including:

Aging Infrastructure

- Plants rely on proprietary infrastructure to run their operations. Much of this infrastructure is aging rapidly, increasing the risk of system failure and exposing reliability and security issues. Several years ago a study conducted by The Economist, entitled *The impact of aging infrastructure in process manufacturing industries,* surveyed 366 global executives in the oil and gas, utilities, chemicals and natural resource industries. According to the report, "a substantial majority (87%) of executives report that aging infrastructure has had an impact on their operations in recent years; one in ten say problems related to aging infrastructure have caused severe problems in their operations that they are still trying to address successfully."[1]

- It is estimated that about 66% of the Programmable Electronic Systems (PES) running in the process industry were installed before the publication of today's commonly used safety standards, based on a report released by ARC Advisory Group several years ago.[2] In order to keep using a system that is not certified according to IEC 61508, the user must demonstrate "Proven in Use," a grandfather clause detailed in the ISA84 standard.

Aging Workforce

- In 2000, the median age of the US manufacturing workforce—at 40.5—was 1.1 years above the median age of the total non-farm workforce. By 2012, this gap doubled, with the median age in manufacturing being 44.7 years versus 42.3 years for the total non-farm workforce.[3] Now, eight years later in 2020, process industries are bracing for the rapid-fire retirement of the so-called "baby boomer" generation. Plants will face increasingly significant workforce shortages—of people and, perhaps even more importantly, of knowledge.

Ever-Increasing Financial Pressures

- Preventive maintenance, safety audits, and proactive employee training are investments of time and money; these critical functions compete with the constant pressure on plant managers and business leaders to increase profits. If a plant hasn't had a safety incident, and if business leaders are not properly educated in functional safety requirements, it can be easy to delay projects focused on maintenance of assets or people.

Reliance on Outsourcing

- A significant amount of labor is regularly being outsourced to contractors and engineering firms who may not have proven qualifications to manage the functional safety lifecycle, or who may not fully understand individual plant methodologies and environments. The inconsistencies between external resources and internal employees can result in communication breakdown, costly mistakes, and dangerous policy breaches. A standards-based approach enables teams to speak the same technical language and have a shared understanding of requirements.

These market factors are not uniquely applicable to a plant's safety posture; they present challenges for nearly every facet of the enterprise.

In the sphere of process safety, however, the consequences of failure are potentially disastrous. Destruction of assets and property, environmental impacts, and loss of life are realistic outcomes of safety incidents, not to mention devastating financial losses and long-term public relations issues.

Predictable Errors: The Perfect Storm Is Never Far Away

Every single system, process, and facility on the planet is vulnerable to human error. When assessed on a case-by-case basis, these errors end up costing a few seconds of efficiency or wasting a small amount of resources. Many human errors go unnoticed or unaddressed, however, building up over time to become significant.

A study by the UK's Health and Safety Executive (HSE) reported that most process safety incidents involved preventable human errors.[4] The causes of accidents were attributed to:

- Incorrect and incomplete design specification (44%)
- Improper design and implementation (15%)
- Changes made after commissioning (21%)
- Errors during operation and maintenance (15%)

Prolific British author and safety expert Trevor Kletz also conducted exhaustive analysis of process plant disasters, and he concluded that all accidents are traceable to human error in some form.[5]

Human error includes skill-based errors—slips of action and lapses of memory—as well as mistakes. Mistakes are decision-making failures and can be rule-based or knowledge-based. HSE attributes mistakes to a) doing too many things at the same time, b) doing too many complex tasks at once, and c) time pressures.

Given the market forces discussed in the previous section, companies should be ready for the inevitable "perfect storm" to strike—it's just a matter of time.

In order to reduce the risk or severity of an incident, everyone involved in process manufacturing must:

- Identify and understand functional safety standards
- Take reasonable steps to apply the standards
- Document, monitor, and continuously demonstrate compliance
- Assess employee and contractor competency, and commit to continuous improvement

"Would you rather learn from the mistakes of others, or make them all yourself? Do you want to see your company in the news with disasters like those that occurred at Bhopal, Pasadena, Texas City, and others? Do you possibly feel that those events could never happen at your facility? Do you say to yourself, 'We've been operating for 20 years without an accident; we are a safe facility?' Please keep in mind, these companies said that just one day before all these accidents. Just because it hasn't happened yet, doesn't mean that it can't, or won't."

Paul Gruhn, P.E., CFSE
Global Functional Safety Consultant, aeSolutions
2019 ISA President

Understand and Apply Functional Safety Standards

Note: For additional background about functional safety standards, please see the addendum to this white paper at the end of the document

International regulations and recommendations, along with investigations of recent incidents, have reinforced the importance of international standards IEC 61508 and ISA/IEC 61511 as a benchmark of acceptable good practice in the management, design, application, and operation of safety instrumented systems.

ISA/IEC 61511 covers the design and management requirements for safety instrumented systems throughout the entire safety lifecycle. The standard includes three parts: 1) Framework, definitions, system, hardware, and software requirements; 2) Application guidelines; and 3) Guidance for the determination of required safety integrity levels.

The standard is written specifically for those who deal with process applications with safety instrumented functions. It requires component devices to be pre-compliant with IEC 61508 or

prove "prior use" with documentation of the system lifecycle activities needed to meet and maintain the functional safety requirements.

The functional safety lifecycle provides a method to analyze, implement, and maintain a safety instrumented system, from project scope definition to decommission. The functional safety lifecycle is composed of three phases:

- Analysis
- Design/Implementation
- Operation and Maintenance

The standard requires documented management of safety instrumented systems. The management system should define a plan to assess, design, engineer, verify, install, commission, validate, operate, maintain, and continuously improve the safety instrumented system. Roles and responsibilities of personnel need to be defined; processes should be developed and documented; regular assessments of competence should be conducted.

Because ISA/IEC 61511 (originally ISA-84) is a performance-based standard, it requires an analysis of the hazards associated with the process, the risk reduction alternatives, and the determination of the performance needed to reduce risk to an acceptable level. Prescriptive standards set these benchmarks within their guidance, while performance standards enable users to define a methodology to apply the requirements of the standard to specific projects and facilities. Successful applications of the standard, therefore, require a skilled and knowledgeable team familiar with both the technical requirements and the facility's needs.

Assess Employee and Contractor Competency, and Commit to Continuous Improvement

Process safety culture has been defined as "the combination of group values and behaviors that determine the manner in which process safety is managed." Like any other environment, the culture of a plant and its people will inevitably trump any policies or procedures. A true safety culture must be made up of committed, knowledgeable, motivated employees whose practices and performance are assessed and monitored regularly.

According to the Center for Chemical Process Safety's *Guidelines for Risk Based Process Safety,* "training workers and assuring their reliable performance of critical tasks" is one of the foundations of safety management.[6] The guide identifies the following objectives related to standards-based job performance:

- Ensure consistent implementation of the standards system
- Identify when standards compliance is needed
- Involve competent personnel
- Ensure that standards compliance practices remain effective

While all employees need a foundational knowledge of process safety practices, some key employees that need additional assessment and training include:

- Instrumentation and control engineers, technicians, and managers
- Safety management specialists
- Engineers and managers involved in safety integrity level studies and other aspects of the safety instrumented systems lifecycle
- Hazard analysis teams
- Project managers

The Center for Chemical Process Safety guide also specifies the need to closely manage contractor selection and oversight, with the following objectives identified:

- Establish expectations, roles, and responsibilities for safety program implementation and performance
- Ensure that contractor personnel are properly trained
- Fulfill company responsibilities with respect to safety

Select a Comprehensive Training and Assessment Program for Employees and Contractors

When it comes to understanding and implementing a performance-based standard, context and history are invaluable tools.

ISA is the developer of ISA/IEC 61511 through the work of its ISA 84 standards committee. Hundreds of end users, vendors, government representatives, and system integrators worked together to define requirements, use cases, and best practices to form the standard that has since been adopted worldwide as the de facto best practice for functional process safety.

Is there a better organization to rely on for ISA/IEC 61511-based training and assessment of competency? Courses are taught by real-world experts who were intimately involved in the creation of the standard and have worked to implement it in their facilities. They've led teams and understand the challenges faced by engineers, technicians, and management involved in different aspects of functional process safety.

IEC 61511 Curriculum and Certificate Program

While courses can be taken outside of the certificate program, requiring assessment after each course enables employees and contractors to earn certificates of competence and provides documentation of a company's commitment to safety regulations.

Safety Instrumented Systems—Design, Analysis, and Justification (EC50)

- https://www.isa.org/training-and-certification/isa-training/instructor-led/course-descriptions/ec50
- 4-day course offered at regional locations or brought to your plant;
  8-week online version also available

This course focuses on the engineering requirements for the specification, design, analysis, and justification of safety instrumented systems. Students will learn how to determine safety integrity levels and evaluate whether proposed or existing systems meet the performance requirements.

Individuals who complete the course and pass an exam will earn the ***ISA/IEC 61511 Safety Instrumented Systems (SIS) Fundamentals Specialist*** certificate.

Advanced Safety Integrity Level (SIL) Selection (EC52)

- https://www.isa.org/training-and-certification/isa-training/instructor-led/course-descriptions/ec52
- 2-day course offered at regional locations or brought to your plant

This course focuses on hands-on examples of safety integrity level selection using a variety of different techniques. Students will be more able to develop and implement different SIL selection techniques, including risk matrices, risk graphs, and Layer of Protection Analyses (LOPA). The course covers methods for determining the appropriate level of performance needed of safety systems and preventing over- or under-designing system requirements to save your organization time and money.

Individuals who meet the prerequisite requirements, complete the course, and pass an exam will earn the ***ISA/IEC 61511 Safety Integrity Level (SIL) Selection Specialist*** certificate.

Prerequisites: Successful completion of the *ISA/IEC 61511 Safety Instrumented Systems Fundamentals Specialist* certificate; plus, experience requirements: 5 years of experience in the process industries with a minimum of 2 years of experience in process safety (facilitation or participation in process hazard analysis or performance of safety integrity level selections independently or with supervision).

Advanced Design and SIL Verification (EC54)

- https://www.isa.org/training-and-certification/isa-training/instructor-led/course-descriptions/ec54

This course focuses on more detailed design issues and further hands-on examples of system analysis/modeling. Course work focuses on analyzing any system's technology and configuration to see if it will meet the required safety integrity level; determining if existing systems are safe enough, or if they need to be upgraded; and evaluating proposed systems against performance requirements.

Individuals who meet the prerequisite requirements, complete the course, and pass an exam will earn the ***ISA/IEC 61511 Safety Integrity Level (SIL) Verification Specialist*** certificate.

Prerequisites: Successful completion of the ISA/IEC 61511 Safety Instrumented Systems Fundamentals Specialist certificate; plus, experience requirements: 5 years of experience in the process industries with a minimum of 2 years of experience in specifying instruments and control systems, programming PLCs, safety integrity level verification calculations, creation or modification of instrumentation and control design documents, supporting start-up activities, and operation of process plants/facilities.

ISA/IEC 61511 Safety Instrumented Systems Expert Designation

Individuals who earn certificates 1, 2, and 3 are designated as ***ISA/IEC 61511 Safety Instrumented Systems Experts.***

All certificates are considered current for 3 years and can be renewed. Each course and exam can also be offered in Spanish. ISA also has safety-related courses covering fire and gas systems, boiler control, nuclear setpoints, hazardous location instrumentation, SCADA systems, HMI design, alarm management, and an entire curriculum and certificate program focused on industrial cybersecurity.

Take the First Step

Companies interested in safety training programs have several options—individuals can enroll in courses at convenient regional locations; or ISA can bring an expert instructor and course materials to your plant to train one or more teams at once, saving time and travel costs.

As a comprehensive provider of training for technicians, engineers, and managers in dozens of process automation topics, ISA can also perform a needs assessment with your employees and contractors so that you can develop a customized plan and timeline for upgrading knowledge and skill sets. Additionally, if your plant is hiring new graduates, ISA has several onboarding programs that help to bridge the gap between academic study and real-world job requirements.

It all starts with a conversation. Our small, experienced team can share what's worked for other companies or customize a plan that will meet your specific goals and objectives.

Contact one of our experts today:

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Citations

1 The Economist Intelligence Unit Limited 2013, *The impact of aging infrastructure in process manufacturing industries*

2 The Manufacturing Institute, *Median Age of the Manufacturing Workforce*

3 ARC Advisory Group, INSIGHT# 2010-53EMPH, *The Coming Wave of Process Safety System Migration*

4 U.K. Health & Safety Executive, *Findings from Voluntary Reporting of Loss of Containment Incidents 2004/05*

5 Kletz, Trevor A., *What Went Wrong: Case Histories of Process Plant Disasters Fourth Edition*

6 Center for Chemical Process Safety, *Guidelines for Risk Based Process Safety*

Addendum

Background: The Role of Standards in Functional Safety

Internationally recognized functional safety standards have been developed and adopted to increase equipment and process safety. The primary goal of these standards is to develop a continuous improvement approach to safety system management and enable end users to understand the safety status of their assets.

The International Electrotechnical Commission (IEC) published IEC 61508, *Functional safety of electrical/electronic/programmable electronic safety-related systems,* as a general standard applicable to many different industries. IEC 61508 provides the core requirements for safe system design of hardware and software, and it is the framework for three sector-specific standards—ISA/IEC 61511 (process industries), IEC 61513 (nuclear applications), and IEC 62061 (discrete manufacturing and machineries).

ANSI/ISA84.00.01-2004, *Functional Safety: Safety Instrumented Systems for the Process Industry Sector* was first issued in 1996. The series of standards have been harmonized with IEC 61511.

In 2000, the US regulatory body OSHA issued a letter specifying the ISA 84 standard as "good engineering practice" for safety instrumented system design. Reaffirmed by OSHA in 2005, the guidance effectively makes the ISA 84 standard part of process safety management (PSM) requirements. Paragraph (d)(3)(ii) of the OSHA PSM standard specifies: "The employer shall document that equipment complies with recognized and generally accepted good engineering practices."

The European standards body, CENELEC, has adopted the standard as EN 61511. Each member state in the European Union has subsequently published the standard as a national standard. Recently as a few months ago, ISA/IEC 61511 was adopted into the Canadian Electrical Code as CSA-C22.2 NO.61511:17.

Widespread adoption, however, doesn't guarantee a safer environment. Compliance with the standard requires a focused and continuous approach to functional safety.