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“Engineering responsibility should not require the stimulation that comes in the wake of catastrophe.”

— S. C. Florman
1.1 What Is a Safety Instrumented System?

Safety interlock system, safety instrumented system, safety shutdown system, emergency shutdown system, protective instrument system—the assorted names go on and on! Different companies within the process industry still use a variety of names for these systems. Within the ISA SP84 committee there was continual discussion (and constant changes) over the term used to describe these systems. The most generic term might be considered *safety system*, but this means different things to different people. For many chemical engineers, “safety systems” refer to management procedures and practices, not control systems. One very common term has been *emergency shutdown system* (ESD), but to electrical engineers ESD means electro-static discharge. Many don’t want the word *emergency* in the name at all, as it tends to have a negative connotation. Others don’t like the word ‘safety shutdown system’ for the same reason. Anything appearing in print with the phrase ‘safety’ draws immediate attention.

When the American Institute of Chemical Engineers, Center for Chemical Process Safety (AIChe CCPS) published “Guidelines for Safe Automation of Chemical Processes” in 1993, the term it used was *safety interlock system*—SIS. Some members of the ISA SP84 committee felt that *interlocks* were only one subset of many different types of safety control systems.
The ISA committee settled on the term *safety instrumented system* in order to keep the same acronym used in the AIChE text—SIS. A related AIChE CCPS text titled “Layer of Protection Analysis” released in 2001 also uses the acronym SIS, but uses the more recent definition of “safety instrumented system.”

So just what *is* a safety instrumented system? The ANSI/ISA-91.00.01-2001 (Identification of Emergency Shutdown Systems and Controls That Are Critical to Maintaining Safety in Process Industries) uses the phrase *emergency shutdown system* with the following definition, “Instrumentation and controls installed for the purpose of taking the process, or specific equipment in the process, to a safe state. This does not include instrumentation and controls installed for non-emergency shutdowns or routine operations. Emergency shutdown systems may include electrical, electronic, pneumatic, mechanical, and hydraulic systems (including those systems that are programmable).” In other words, safety instrumented systems are designed to respond to conditions of a plant, which may be hazardous in themselves, or if no action were taken could eventually give rise to a hazardous event. They must generate the correct outputs to prevent or mitigate the hazardous event.

The international community has other ways of referring to these systems. International Electrotechnical Commission Standard 61508: Functional safety of electrical/electronic/programmable electronic safety-related systems (IEC 61508) uses the term safety related systems, but also introduces the combined acronym E/E/PES. As used in the title, E/E/PES stands for electric, electronic and programmable electronic. In other words, relay, solid-state, and software-based systems.

The standards generally focus on systems related to personnel safety. However, the same concepts apply to systems designed to protect equipment and the environment. After all, there are more things at risk to a company than just people. Similarly, while this text focuses on personnel safety-related systems, many of the concepts can be utilized when addressing asset and environmental applications.

As with any subject, there are a variety of acronyms and technical terms. Some terms to not have complete agreement or common usage in industry and different texts. This naturally adds to the confusion. Unless otherwise noted, all the terms used in this text are defined in ANSI/ISA-84.00.01-2004, Part 1, Clause 3. Acronyms are typically defined the first time they are used and other terms are explained where appropriate.
1.2 Who This Book Is For

This book is intended for the thousands of professionals employed in the process industries who are involved with safety systems in any way and who are expected to follow the appropriate industry standards. These individuals are employed by end users, engineering firms, system integrators, consultants, and vendors. Managers and sales individuals will also benefit from a basic understanding of the material presented.

The 1996 version of the ISA SP84’s standard defined the intended audience as those who are involved in areas of “design and manufacture of SIS products, selection, and application, installation, commissioning, and pre-startup acceptance testing, operation, maintenance, documentation, and testing.” Basically, if you’re involved with safety systems in any way, there are portions of the standards and this book of interest to you.

The 1996 version of the standard also defined the process industry sector as, “those processes involved in, but not limited to, the production, generation, manufacture, and/or treatment of oil, gas, wood, metals, food, plastics, petrochemicals, chemicals, steam, electric power, pharmaceuticals, and waste material(s).”

The 2004 version of the ISA SP84’s standard is now a global standard. It has world-wide approval and acceptance for any country utilizing IEC 61511 or ANSI/ISA-84.00.01-2004 as their national process sector functional safety standard. The ISA SP84 worked with the IEC 61511 committee to accomplish this objective. IEC 61511 and ANSI/ISA-84.00.01-2004 are identical except that ANSI/ISA-84.00.01-2004 has a grandfather clause added to it (Part 1, Clause 1). IEC 61511 and ANSI/ISA-84.00.01-2004 are clearly intended for end-users. IEC 61508 is focused for equipment manufacturers. The focus of this text is on ISA-84.00.01-2004, Parts 1-3 (IEC 61511 Mod).

1.3 Why This Book Was Written

We’re engineering industrial processes—and using computer-based systems to control them—that have the potential for large-scale destruction. Single accidents are often disastrous and result in multiple fatalities and significant financial losses. We simply do not have the luxury of learning from trial and error. ("Oops, we blew up that unit and killed 20 people. Let’s rebuild it, raise the set point five degrees and see what happens next time.") We must try to anticipate and prevent accidents before they occur. This has been one of the hard lessons learned from past accidents and why various process safety legislation was passed in different parts of the
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world. Hopefully this book, in its own little way, will help make the world a safer place.

The authors believe this to be the only all encompassing text on this subject. This book is a practical “how to” on the specification, analysis, design, installation and maintenance of safety instrumented systems. It includes practical knowledge needed to apply safety instrumented systems. It will hopefully serve as a guide for implementing the procedures outlined in various standards.

Aren’t the standards alone enough? The answer depends upon you and your company’s knowledge and experience. The “normative” (mandatory) portion of ANSI/ISA-84.01-1996 was only about 20 pages long. (There were about 80 pages of annexes and informative material.) While committee members knew what certain phrases and requirements meant, not everyone else did. Some committee members wanted certain wording specifically vague in order to have the freedom to be able to implement the requirements in different ways. Others wanted clear-cut prescriptive requirements. ANSI/ISA-84.00.01-2004 (IEC 61511 Mod) contains much more detail. Part 1 of the standard—the normative portion—is over 80 pages in length. Part 2—the ‘informative’ portion on how to implement Part 1—is over 70 pages. The committee felt additional material was still needed. At the time of this writing (early 2005), technical report ISA-TR84.00.04—Guidelines on the Implementation of ANSI/ISA-84.00.01-2004 (IEC 61511 Mod)—consists of over 200 pages of further detail. The technical report was deemed necessary as the normative and informative portions of the standard did not include the level of detail to satisfy many of the members. Such is the reality of committee work with several dozen active members and several hundred corresponding members! The two authors co-writing this text did not have the typical committee conflict issues to deal with. This is not to imply that this text is any more correct or thorough than the standards or their accompanying technical reports.

This book covers the entire lifecycle of safety instrumented systems, from determining what sort of systems are required through decommissioning. It covers the difference between process control and safety control, the separation of control and safety, independent protection layers, determining safety integrity levels, logic system and field device issues, installation, and maintenance. The book focuses on establishing design requirements, analysis techniques, technology choices, purchase, installation, documentation and testing of safety instrumented systems. It also covers the technical and economic justification for safety instrumented systems. The focus throughout is on real-world, practical solutions with many actual examples, and a minimum of theory and math. What equations are presented only involve simple algebra.
1.4 Confusion in the Industry

One goal of this book is to clarify the general confusion in the industry over the myriad choices involved in the design of safety systems. Many would have hoped to turn to industry standards for their recommendations. However, the standards are performance oriented and not prescriptive, so there are no specific recommendations. The standards essentially state what needs to be done, not specifically how to do it. For example, what follows are just a few of the choices that need to be made:

1.4.1 Technology Choices

What technology should be used; relay, solid state, or microprocessor? Does this depend on the application? Relay systems are still common for small applications, but would you want to design and wire a 500 I/O (input/output) system with relays? Is it economical to do a 20 I/O system using a redundant programmable system? Some people prefer not to use software-based systems in safety applications at all, others have no such qualms. Are some people “right” and others “wrong”?

Many feel that the use of redundant PLCs (Programmable Logic Controller) as the logic solver is the be all and end all of satisfying the system design requirements. But what about the *programming* of the PLCs? The same individuals and procedures used for programming the control systems are often used for the safety systems. Should this be allowed?

1.4.2 Redundancy Choices

How redundant, if at all, should a safety instrumented system be? Does this depend on the technology? Does it depend on the level of risk? If most relay systems were simplex (non-redundant), then why have triplicated programmable systems become so popular? When is a non-redundant system acceptable? When is a dual system required? When, if ever, is a triplicated system required? How is such a decision justified?

1.4.3 Field Devices

A safety system is much more than just a logic box. What about the field devices—sensors and final elements? Should sensors be discrete switches or analog transmitters? Should ‘smart’ (i.e., intelligent or processor-based) devices be used? When are redundant field devices required? What about partial stroking of valves? What about field buses? How often should field devices be tested?
1.4.4 Test Intervals

How often should systems be tested? Once per month, per quarter, per year, or per turnaround? Does this depend on technology? Do redundant systems need to be tested more often, or less often, than non-redundant systems? Does the test interval depend on the level of risk? Can systems be bypassed during testing, and if so, for how long? How can online testing be accomplished? Can testing be automated? How does a device’s level of automatic diagnostics influence the manual test interval? Does the entire system need to be tested as a whole, or can parts be tested separately? How does one even make all these decisions?!

1.4.5 Conflicting Vendor Stories

Every vendor seems to be touting a different story line, some going so far as to imply that only their system should be used. Triplicated vendors take pride in showing how their systems outperform any others. Dual system vendors say their systems are just as good as triplicated systems. Is this possible? If one is good, is two better, and is three better still? Some vendors are even promoting quad redundant systems! However, at least one logic system vendor claims Safety Integrity Level (SIL) 3 certification for a non-redundant system. How can this even be possible considering the plethora of redundant logic systems? Who should one believe—and more importantly—why? How can one peer past all of the sales ‘hype’? When overwhelmed with choices, it becomes difficult to decide at all. Perhaps it’s easier just to ask a trusted colleague what he did!

1.4.6 Certification vs. Prior Use

Considering all the confusion, some vendors realized the potential benefit of obtaining certifications to various standards. Initially, this was done utilizing independent third parties. This had the desired effect of both proving their suitability and weeding out potential competition, although it was an expensive undertaking. However, industry standards in no way mandate the use of independently certified equipment. Users demanded the flexibility of using equipment that was not certified by third parties. How might a user prove the suitability of components or a system based on prior use and “certify” the equipment on their own? How much accumulated experience and documentation is required to verify that something is suitable for a particular application? How would you defend such a decision in a court of law? How about a vendor certifying themselves that they and their hardware meet the requirements of various standards? Considering how hard it is to find your own mistakes, does
such a claim even have any credibility? The standards, annexes, technical reports and white papers address these issues in more detail.

1.5 Industry Guidelines, Standards, and Regulations

“Regulations are for the obedience of fools and for the guidance of wise men.”

— RAF motto

One of the reasons industry writes its own standards, guidelines and recommended practices is to avoid government regulation. If industry is responsible for accidents, yet fails to regulate itself, the government may step in and do it for them. Governments usually get involved once risks are perceived to be ‘alarming’ by the general populace. The first successful regulatory legislation in the U.S. was passed by Congress over 100 years ago after public pressure and a series of marine steamboat boiler disasters killed thousands of people. Some of the following documents are performance—or goal—oriented, others are prescriptive.

1.5.1 HSE - PES


This document was the first of its kind and was published by the English Health & Safety Executive. Although it focused on software programmable systems, the concepts presented applied to other technologies as well. It covered qualitative and quantitative evaluation methods and many design checklists. Part 1—“An Introductory Guide”—is only 17 pages and was intended primarily for managers. Part 2—“General Technical Guidelines”—is 167 pages and was intended primarily for engineers. They were both excellent documents, although they did not appear to be well known outside the U.K. However, considering the material covered, they would appear to have been used as the foundation for many of the more recent documents.

1.5.2 AIChE - CCPS

Guidelines for Safe Automation of Chemical Processes, AIChE, 0-8169-0554-1, 1993
The American Institute of Chemical Engineers formed the Center for Chemical Process Safety (CCPS) after the accident in Bhopal, India. The CCPS has since released several dozen textbooks on various design and safety-related topics for the process industry. This particular text covers the design of Distributed Control Systems (DCS) and Safety Interlock Systems (SIS) and contains other very useful background information. The book took several years to write and was the effort of about a dozen individuals who were all from user companies (i.e., no vendors).

1.5.3 IEC 61508


The International Electrotechnical Commission released this ‘umbrella’ standard which covers the use of relay, solid-state and programmable systems, including field devices. The standard applies to all industries: transportation, medical, nuclear, process, etc. It’s a seven part document, portions of which were first released in 1998. The intention was that different industry groups would write their own industry-specific standards in line with the concepts presented in 61508. This has happened in at least the transportation, machinery and process industries. The process industry standard (IEC 61511) was released in 2003 and was focused for end users. The 61508 standard is now viewed as the standard for vendors to follow. For example, when a vendor gets a product certified for use in a particular Safety Integrity Level (SIL), the certification agency typically uses IEC 61508 as the basis for the approval.

1.5.4 ANSI/ISA-84.00.01-2004 (IEC 61511 Mod) & ANSI/ISA-84.01-1996

*Functional Safety: Safety Instrumented Systems for the Process Industry Sector*, ISA Standard 84.00.01-2004, Parts 1-3 (IEC 61511 Mod) and the previous Application of Safety Instrumented Systems for the Process Industries, ISA Standard 84.01-1996.

The ISA SP84 committee worked for more than 10 years developing this standard. The scope of this document underwent many changes through the years. It was originally intended as a U.S. standard focusing only on programmable logic boxes (and not the field devices). The scope eventually expanded to include other logic box technologies as well as field devices.

During the development of the ISA SP84’s standard the IEC committee started on its 61508 general standard. The ISA SP84 committee believed its
standard could be used as an industry-specific standard for the process industries under the scope of the IEC. The IEC developed its 61511 standard using ANSI/ISA-84.01-1996 as a starting point. In fact, the chairman of the ISA SP84 committee served as the chairman for the IEC 61511 standard.

ANSI/ISA-84.01-1996 stated it would be re-released in five-year intervals to account for new developments. Rather than rewrite the ISA SP84’s standard from scratch, the committee decided to adopt the IEC 61511 standard with the addition of a ‘grandfather clause’ from the original 1996 version of the ISA SP84’s standard. The new three-part standard is designated ANSI/ISA-84.00.01-2004, Parts 1-3 (IEC 61511 Mod).

1.5.5 NFPA 85


NFPA 85 is the most recognized standard worldwide for combustion systems safety. This is a very prescriptive standard with specific design requirements. The standard covers:

- Single Burner Boiler Operation
- Multiple Burner Boilers
- Pulverized Fuel Systems
- Stoker Operation
- Atmospheric Fluidized-Bed Boiler Operation
- Heat Recovery Steam Generator Systems

The purpose of NFPA 85 is to provide safe operation and prevent uncontrolled fires, explosions and implosions. Some of the key requirements of this standard relate to the burner management system logic. The NFPA is not involved with the enforcement of this standard. However, insurance companies, regulatory agencies, and company standards often require compliance. Many countries and companies require compliance with NFPA 85 for burner management systems.

There is considerable debate as to whether a Burner Management System (BMS) is a Safety Instrumented System. There are naturally those that believe it is (as the definitions of both systems are very similar). The NFPA standard does not address Safety Integrity Levels. However, members of the various standards committees are trying to harmonize the various standards.
1.5.6 **API RP 556**

*Recommended Practice for Instrumentation and Control Systems for Fired Heaters and Steam Generators*, American Petroleum Institute, 1997

This recommended practice has sections covering shutdown systems for fired heaters, steam generators, carbon monoxide or waste gas steam generators, gas turbine exhaust fired steam generators, and unfired waste heat steam generators. While intended for use in refineries, the document states that it is “applicable without change in chemical plants, gasoline plants, and similar installations.”

1.5.7 **API RP 14C**


This prescriptive recommended practice is based on “proven practices” and covers the design, installation, and testing of surface safety systems on offshore production platforms. It is intended for design engineers and operating personnel.

1.5.8 **OSHA (29 CFR 1910.119 - Process Safety Management of Highly Hazardous Chemicals)**

The process industry has a vested interest in writing their own industry standards, guidelines, and recommended practices. As stated earlier, if industry were to be viewed as being unable to control their own risks, there would be the possibility of government intervention. This, in fact, happened due to several significant process plant disasters in the U.S. during the 80s and 90s. 29 CFR 1910.119 was released in 1992 and, as the name implies, is directed at organizations dealing with highly hazardous substances. OSHA estimates over 25,000 facilities in the U.S. are impacted by this regulation—much more than just refineries and chemical plants. There are over a dozen sections to this legislation. A number of the sections have requirements specifically detailing issues related to the selection, design, documentation, and testing of safety instrumented systems.

*For example:*

*Section d3: Process safety information: Information pertaining to the equipment in the process... (including) safety systems... “For existing*
equipment...the employer shall determine and document that the equipment is designed, maintained, inspected, tested, and operating in a safe manner.” (Emphasis added.)

People tend to have more questions after reading the OSHA document than before. For example, just what is ‘a safe manner’? How does one ‘determine’, and in what way does one ‘document’, that things are operating ‘safely’. How safe is safe enough? The OSHA document does little to answer these questions. This statement in the OSHA regulation is the basis for the ‘grandfather clause’ in the ISA SP84’s standard. The previously mentioned standards and guidelines do address these issues in more detail.

Section j: Mechanical integrity: Applies to the following process equipment: ..., emergency shutdown systems, ... Inspection and testing: “The frequency of inspections and test of process equipment shall be consistent with applicable manufacturer’s recommendations and good engineering practices, and more frequently if determined to be necessary by prior operating experience.” Whose experience?! Whose good engineering practices?! The previously mentioned standards and guidelines address these issues in more detail as well.

Section j5: Equipment deficiencies: “The employer shall correct deficiencies in equipment that are outside acceptable limits before further use or in a safe and timely manner when necessary means are taken to assure safe operation.” (Emphasis added.) What is the definition of a ‘deficiency’? This sentence would seem to contradict itself. It first introduces the idea of ‘acceptable limits’. (If I stand ‘here’, it’s acceptable, but if I step over an imaginary boundary and stand over ‘there’, it’s no longer acceptable.) This seems harmless enough. But the very same sentence then goes on to say that if anything goes wrong, you obviously didn’t ‘assure’ (guarantee) safe operation. In other words, no matter what happens, you can’t win. OSHA’s ‘general duty’ clause can always be brought into play if anything goes wrong and people are injured.

Section j6: Quality assurance: “In the construction of new plants and equipment, the employer shall assure that equipment as it is fabricated is suitable for the process application for which they will be used.” (emphasis added) The employer shall ‘assure’?! Benjamin Franklin said the only thing we can be ‘sure’ of is death and taxes. ‘Suitable’?! According to whom?! The vendor trying to sell you his system? Measured against what? The industry standards address these issues in more detail.

Appendix C: Compliance guidelines and recommendations: Mechanical integrity: “Mean time to failure of various instrumentation and equipment parts
would be known from the manufacturer’s data or the employer’s experience with the parts, which would then influence the inspection and testing frequency and associated procedures.” Hopefully companies are aware that they are expected to be keeping records of this sort of information. Just how would this ‘influence’ the test frequency of various systems? How does one even make this determination? Some manufacturers have and do provide failure rate data, some do not. Again, the industry standards address these issues in more detail.

It’s worth noting that OSHA addressed a letter to ISA in 2000 stating that it recognizes ANSI/ISA-84.01-1996 as “a recognized and generally accepted good engineering practice for SIS” and that if a company is in compliance with the standard “the employer will be considered in compliance with OSHA PSM requirements for SIS.”

1.6 Standards Are Changing Their Direction

Most people want a simple “cookbook” of pre-planned solutions. For example: “For a high pressure shutdown on a catalytic cracker in a refinery, turn to page 35. There it shows dual sensor, dual logic box, non-redundant valves, yearly test interval, suggested logic programming, etc. For a high level shutdown on a high pressure separator on an unmanned offshore platform, turn to page 63. There it shows…” There are reasons the standards will never be written this way. The standards do not give clear, simple, precise answers. They do not mandate technology, level or redundancy, or test intervals.

Prescriptive standards, while helpful, cannot cover all of the variation, complexities, and details of today’s systems. For example, if you purchase a pressure switch at your local hardware store, the switch will likely satisfy the requirements of certain prescriptive standards. However, there will be little, if any, requirements about how well the components have to perform.

Similarly, twenty years ago most safety systems consisted of discrete switches, discrete relay logic, and on-off valves controlled by solenoids. Things were much simpler back then. Sensors today may be discrete switches, conventional analog transmitters, smart transmitters, or safety transmitters. Logic solvers may now be relay logic, solid-state logic, conventional PLCs, or safety PLCs. Final elements may now be on/off valves with solenoids or control valves with smart positioners. Prescriptive standards simply cannot address the selection of such a diverse array of components and technology. However, newer performance based standards do provide the means to make the correct selections.
There is a fundamental change in the way industry standards are being written. Standards are moving away from \textit{prescriptive} standards and toward more \textit{performance}-oriented requirements. In fact, this was one of the recommendations made in a government report after the Piper Alpha offshore platform explosion in the North Sea. Prescriptive standards generally do not account for new developments or technology and can easily become dated. This means each organization will have to decide for themselves just what is ‘safe’. Each organization will have to decide how they will ‘determine’ and ‘document’ that their systems are, in fact, ‘safe’. Unfortunately, these are difficult decisions that few want to make, and fewer still want to put in writing. “What is safe” transcends pure science and deals with philosophical, moral, and legal issues.

\section*{1.7 Things Are Not As Obvious As They May Seem}

Intuition and gut feel do not always lead to correct conclusions. For example, which system is safer, a dual one-out-of-two system (where only one of the two redundant channels is required in order to generate a shutdown) or a triplicated two-out-of-three system (where two of the three redundant channels are required in order to generate a shutdown)? Intuition might lead you to believe that if one system is “good,” two must be better, and three must be the best. You might therefore conclude that the triplicated system is safest. Unfortunately, it’s not. It’s very easy to show that the dual system is actually safer. Chapter 8 will deal with this subject in more detail. However, for every advantage there is a disadvantage. The one-out-of-two system may be safer, but will suffer more nuisance trips. Not only does this result in lost production downtime and economic issues, it is generally recognized that there is nothing “safe” about nuisance trips, even though they are called “safe failures.”

At least two recent studies, one by a worldwide oil company, another by a major association, found that a significant portion of existing safety instrumented functions were both over-designed (37-49%), as well as under-engineered (4-6%). Apparently things are not as obvious as people may have thought in the past. The use of performance-based standards should allow industry to better identify risks and implement more appropriate and cost effective solutions.

If there hasn’t been an accident in your plant for the last 15 years, does that mean that you have a safe plant? It might be tempting to think so, but nothing could be further from the truth. You may not have had a car accident in 15 years, but if you’ve been driving home every night from a bar after consuming 6 drinks, I’m not about to consider you a “safe” driver! No doubt people may have made such statements one day before Seveso.
(Italy), Flixborough (England), Bhopal (India), Chernobyl (Soviet Union), Pasadena (USA), etc. Just because it hasn’t happened yet, doesn’t mean it won’t, or can’t.

If design decisions regarding safety instrumented systems were simple, obvious, and intuitive, there would be no need for industry standards, guidelines, recommended practices, or this book. Airplanes and nuclear power plants are not designed by intuition or gut feel. How secure and safe would you feel if you asked the chief engineer of the Boeing 777, “Why did you choose that size engine, and only two at that?”, and his response was, “That’s a good question. We really weren’t sure, but that’s what our vendor recommended.” You’d like to think that Boeing would know how to engineer the entire system. Indeed they do! Why should safety instrumented systems be any different? Do you design all of your systems based on your vendor’s recommendations? How would you handle conflicting suggestions? Do you really want the fox counting your chickens or building your henhouse?

Many of the terms used to describe system performance seem simple and intuitive, yet they’ve been the cause of much of the confusion. For example, can a system that’s 10 times more “reliable” be less “safe”? If we were to replace a relay-based shutdown system with a newer PLC that the vendor said was 10 times more “reliable” than the relay system, would it automatically follow that the system was safer as well? Safety and reliability are not the same thing. It’s actually very easy to show that one system may be more “reliable” than another, yet still be less safe.

1.8 The Danger of Complacency

It’s easy to become overconfident and complacent about safety. It’s easy to believe that we as engineers using modern technology can overcome almost any problem. History has proven, however, that we cause our own problems and we always have more to learn. Bridges will occasionally fall, planes will occasionally crash, and petrochemical plants will occasionally explode. That does not mean, however, that technology is bad or that we should live in the Stone Age. It’s true that cavemen didn’t have to worry about The Bomb, but then we don’t have to worry about the plague. We simply need to learn from our mistakes and move on.

After Three Mile Island (the worst U.S. nuclear incident), but before Chernobyl (the worst nuclear incident ever), the head of the Soviet Academy of Sciences said, “Soviet reactors will soon be so safe that they could be installed in Red Square.” Do you think he’d say that now?
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The plant manager at Bhopal, India was not in the plant when that accident happened. When he was finally located, he could not accept that his plant was actually responsible. He was quoted as saying “The gas leak just can’t be from my plant. The plant is shut down. Our technology just can’t go wrong. We just can’t have leaks.” One wonders what he does for a living now.

After the tanker accident in Valdez, Alaska, the head of the Coast Guard was quoted as saying, “But that’s impossible! We have the perfect navigation system?”

Systems can always fail; it’s just a matter of when. People can usually override any system. Procedures will, on occasion, be violated. It’s easy to become complacent because we’ve been brought up to believe that technology is good and will solve our problems. We want to have faith that those making decisions know what they’re doing and are qualified. We want to believe that our ‘team’ is a ‘leader’, if for no other reason than the fact that we’re on it.

Technology may be a good thing, but it is not infallible. We as engineers and designers must never be complacent about safety.

1.9 There’s Always More to Learn

There are some who are content to continue doing things the way they’ve always done. “That’s the way we’ve done it here for 15 years and we haven’t had any problems! If it ain’t broke, don’t fix it.”

Thirty years ago, did we know all there was to know about computers and software? If you brought your computer to a repair shop with a problem and found that their solution was to reformat the hard drive and install DOS as an operating system (which is what the technician learned 15 years ago), how happy would you be?

Thirty years ago, did we know all there was to know about medicine? Imagine being on your death bed and being visited by a 65-year-old doctor. How comfortable would you feel if you found out that that particular doctor hadn’t had a single day of continuing education since graduating from medical school 40 years ago?

Thirty years ago, did we know all there was to know about aircraft design? The Boeing 747 was the technical marvel 30 years ago. The largest engine we could make back then was 45,000 pounds thrust. We’ve learned a lot since then about metallurgy and engine design. The latest generation
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Engines can now develop over 100,000 pounds thrust. It no longer takes four engines to fly a jumbo jet. In fact, the Boeing 777, which has replaced many 747s at some airlines, only has two engines.

Would you rather learn from the mistakes of others, or make them all yourself? There’s a wealth of knowledge and information packed into recent safety system standards as well as this textbook. Most of it was learned the hard way. Hopefully others will utilize this information and help make the world a safer place.

So now that we’ve raised some of the issues and questions, let’s see how to answer them.

Summary

Safety instrumented systems are designed to respond to the conditions of a plant, which may be hazardous in themselves, or if no action is taken could eventually give rise to a hazardous event. They must generate the correct outputs to prevent or mitigate the hazardous event. The proper design and operation of such systems are described in various standards, guidelines, recommended practices, and regulations. The requirements, however, are anything but intuitively obvious. Setting specifications, selecting technologies, levels of redundancy, test intervals, etc. is not always an easy, straightforward matter. The various industry standards, as well as this book, are written to assist those in the process industries tasked with the proper selection, design, operation, and maintenance of these systems.

References


