What You Need To Know About Safety Instrumented Systems (SIS) and Partial-Stroke Testing of ESD Valves

General Background Information

The phrase, “Safety Instrumented Systems,” or SIS, refers to what used to be known as “Emergency Shutdown Systems,” or ESD. The new term, SIS, was popularized in the ISA S84 Standard, which is entitled “Application of Safety Instrumented Systems (SIS) for the Process Industries.”

The SP84 Committee, whose members include several process safety experts from major North American end users, crafted the ISA S84 standard. The purpose of this committee was to provide an official response to OSHA & EPA federal regulations, which mandated a definition of “Good Engineering Practices,” or GEP, for Process Safety Management (PSM). The ISA S84 Standard was ratified in 1996 and also became an ANSI Standard in 1997.

Subsequently, OSHA stated publicly in March 2000 that the ISA S84 Standard was officially considered “Good Engineering Practice” (GEP) for Process Safety Management; this is significant because OSHA uses other standards, such as those from ANSI, API, NFPA, & ASME as Good Engineering Practice as well. Now, OSHA has accepted the ISA S84 Standard as GEP, which means that it has become one of their blueprints for Process Safety, against which they will compare the Risk Management Plans of end-user companies in the process industries during an investigation.

As a result, many companies in the process industries are updating their Risk Management Plans from a corporate perspective. Once OSHA stated that the ISA S84 Standard constituted GEP, these companies immediately realized that their Risk Management Plans did not incorporate many of the systems architecture, equipment, or testing guidelines that are detailed in the Standard.

Consequently, should they have an OSHA “recordable” accident (such as a fire, vapor release, spill, or explosion) that results in an OSHA investigation, their Risk Management Plan will be compared against the ISA S84 Standard; if any serious differences exist, the company could be found to be in non-compliance with Good Engineering Practice for Process Safety Management, as outlined in the OSHA 29 CFR (Code of Federal Regulation) 1910.119.

In summary, although it is not federally mandated to comply with the ISA S84 Standard, many companies are voluntarily choosing to do so for these reasons.

What’s Driving the Market?

Now that the ISA S84 Standard is being widely recognized by our customers as something that they need to adopt, many of the statistical concepts mentioned in the Standard are being incorporated into the language of the professional Safety community.

The term “Safety Integrity Level,” or SIL, is used to define the overall availability of the components that make up the “Safety Instrumented Function,” or SIF. The three components that make up an SIF are the Logic Solver, the Field Sensors, and the Final Element. It is necessary to examine all three of these components when determining SIL, as the SIL is assigned to the SIF as a whole. Also, it is important to note that the ISA S84 Standard has SIL 1, 2, & 3 defined as Order of Magnitude increases in the availability of a SIF. The higher the SIL, the more dangerous the system, and the more measures that must be employed to mitigate the potential consequences of a runaway process.

The ISA S84 Standard defines example methods for determining SIL and addresses the topics of redundancy and proof testing as viable methods that should be used to attain a higher level of availability; i.e., the overall system is more likely to perform its Safety Function when it is called upon to do so, and the potential dangerous result is averted.

The end user is likely to begin with the Control System, which is generically referred to as the “Logic Solver.” There are several approaches to this, most of which employ a combination of redundancy and diagnostics to achieve a higher SIL. This is known as the principle of separation, or removing control of the most critical points (Sensors & Final Elements) away from the Basic Process Control System (BPCS), which is less available and more prone to failure, and bringing the SIS under the control of a more reliable, safer style of Logic Solver.
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Much like the Control Systems used for the critical systems in an airplane, today's modern Logic Solvers are highly redundant, and perform self-diagnostics routinely to ensure a higher degree of availability and overall safety. The dominant market leader in the world today is Triconex, which was one of the early pioneers of the Triple Modular Redundant (TMR) architecture for Safety PLC's.

Most of the major companies in the process industries have standardized on Triconex; however, there are now several other companies that offer similar systems. However, since the SIL is comprised of three components, it is not enough to simply replace the control system of the SIS with a TMR; the end user is also required to improve the availability of the Sensors & Final Elements, as well.

According to the OREDA-97 report, which is considered to be the most complete analysis of Safety Loop Failures in the world today, 92% of the time these failures were due to the Sensors and Final Elements not performing their Safety Function upon demand! To be exact, the Sensors (Pressure, Temperature, Level, or Flow) were responsible for 42% of the failures, and the Final Elements (ESD Valves) were at fault 50% of the time!

Therefore, it is crucial to understand that since the Safety Instrumented Function, or SIL, of a Safety Loop is comprised of the Logic Solver, Sensors, and Final Elements, all of these components contribute to the attainment of the Safety Integrity Level, or SIL. In other words, the most reliable Logic Solver in the world will not get you to the SIL target in and of itself without similar significant improvements in availability in the Sensors and Final Elements.

In response to this, many end users have begun to employ voting arrangements to their Sensors, such as, an increased level of redundant inputs from those critical points of measurement in the SIS. For example, in a 2oo3 (two-out-of-three) voting scenario, the Logic Solver would receive inputs from three level switches; once two of these measurement inputs suggest a dangerous condition, the Logic Solver would initiate a shut-down of the appropriate system. In this way, higher availability and reliability is achieved.

Today, many safety-conscious end users have adopted the aforementioned changes to their SIS. Namely, they have incorporated the principles of Separation of Control, and have gone to voting arrangements for their critical points of measurement. Many others are somewhere in this process at this time. However, one thing is becoming painfully apparent to all involved in this process: the valve is responsible for the majority of SIS failures!

So, while it is fine and good that the latest TMR Logic Solver has been installed, and also that voting arrangements are in place for the Sensors, end users are now realizing that they must address the Final Element’s availability (or lack of same) in order to attain their SIL targets.

Additionally, other factors are coming into the equation, which affect both the methods used and the testing frequencies of ESD Valves. The goal of the Reliability Engineering movement in the process industries over the past few years has been to identify those components in the process that fail frequently and result in lost time production; once the causes have been quantified, the necessary equipment changes are implemented and a more reliable process results. The obvious benefit from such an effort is an increase in uptime production, combined with a decrease in the down time necessary for maintenance. This is the goal for all of our customers: to become a globally competitive low cost producer. At the same time, however, once their SIL Review has been completed, they find out that more frequent testing of their critical ESD Valves is required in order to achieve the SIL Targets.

On the surface, this testing-frequency requirement (potentially semi-annually or monthly!) is in direct conflict with their goal of being a Low Cost Producer, which demands that they run longer between full plant shutdowns.

Benefits of Partial-Stroke Testing

Simply stated, most continuous process plants are testing their ESD Valves only at full plant shutdown; this equates to a testing frequency of approximately once every 24 months on average for the typical hydrocarbon processing plant. However, it is very possible that the required testing frequency for an ESD Valve in a SIL 2 SIL might be as often as twice a year, or more!

So, although many plants with continuous style processes may be testing their ESD Valve population only at full plant shutdown at present, it is now becoming apparent to these companies that some form of on-line testing must be instituted in the very near future.

This dilemma (Run Longer & Test More) is why Neles ValvGuard was created.

Many articles have been written about the scientific aspects of partial-stroke testing, and the links for these technical papers can be found in the appendix of this document. Briefly, most of the SIS experts in North America today agree that by moving the valve from its normal position to a mid-point of travel (usually 20 – 25%) at a regular frequency (depending upon the target SIL) should prove that the ESD Valve is either available, or not available to the SIS.

By frequently testing on-line in this way, end users can meet their objective of running longer between full plant shutdowns and full-stroke off-line testing of their ESD Valve population. However, note that partial-stroke testing does not eliminate the need for full-stroke testing during plant shutdown; it merely extends the allowable intervals between full-stroke testing.

There are several ways to accomplish Partial Stroke Testing of ESD Valves; please refer to the Neles ValvGuard Launch Package for additional information on competitive ESD Valve testing systems from Emerson, ASCO, Dallim Controls, and others. For the purposes of this document, the following list represents the main points of differentiation between ValvGuard and these aforementioned competitors:

- Neles ValvGuard is TUV-approved for usage in SIL 1, 2, & 3 applications
- As certified in the TUV Type Approval Report, no single point of failure within Neles ValvGuard can lead to a dangerous Failure; in other words, no single component failure within ValvGuard would prevent the valve from going to its Fail Safe position.
- Neles ValvGuard gives real-time, on-line indication of ESD Valve Status through two hard-wired relay inputs from its Remote Communication Interface (RCI); alerts can be communicated...
via plant intranet to web-enabled cellular phones and pagers instantly.

- Partial-stroke tests of the ESD Valve as well as the internal solenoid valve in Neles ValvGuard are automatically performed at zero cost to the end user.
- On-board data storage, combined with Neles Valve Manager Software, provides 24/7 Trend Diagnostics to end users automatically, which permits them to maintain their ESD valves in a predictive vs. reactive way.

**Conclusion**

Currently, the North American process industries market is undergoing many evolutionary changes with regard to Process Safety Management.

Major Federal Regulations from OSHA and the EPA concerning PSM have been released within the last decade, and have resulted in the creation of industry-created Standard Practices such as the ANSI/ISA S84 Standard.

Most major end-user companies are now in the process of reviewing their approach to Process Safety Management; their objectives are to identify the Safety Integrity Levels (SIL's) required and implement the hardware, software, and testing-method changes needed in order to comply.

The Safety Instrumented Function (SIF) is made up of the Logic Solver, Sensors, and Final Elements; each SIF requires a SIL calculation, which dictates the necessary changes required in the system architecture, redundancy of components, and test frequency of the Safety Instrumented System (SIS).

Partial-stroke-testing has been generally recognized by SIS experts as being the best overall compromise available to end users today, as it allows them to solve the dilemma of running longer between full-plant shutdowns, while testing more frequently.

Among all of the alternatives available to the end user for on-line, partial-stroke testing of ESD Valves, the Neles ValvGuard System is unequalled. The unique properties of the Neles ValvGuard result in the best-value proposition for those customers who desire to increase safety and profitability at the same time.
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