KENEXIS

TECHNICAL SAFETY ENGINEERING

SERVICES

Services Overview

Processes can get out-of-control and containment can fail. Relying on basic control systems, alarms, and operator judgement instead of automatic shutdown can be dangerous. We must understand and document each hazard, select the appropriate performance target for the hazard, and implement a reliable safeguard solution to reduce the hazard to a manageable level.

Independent defense-in-depth strategies are used to provide oversight of the process or containment to ensure that an out-of-control situation that could result in a hazard can be returned to a safe state. Independent defense-in-depth strategies can be implemented using different independent protection layers including mechanical, electromechanical, and Safety Instrumented Systems (SIS) relying on completely independent control logic, sensors, and final control elements as well as redundancy and diagnostics to ensure their availability when needed.

To implement these safeguards, we go through a process to establish the Safety Instrumented Functions (SIF) necessary to be implemented using an independent safety system. We will also assign a Safety Integrity Level (SIL) to ensure the SIF's integrity or reliability when it is needed.

Safety Instrumented Functions (SIF) are typically implemented using a Safety Instrumented System (SIS). The SIS is designed to detect an out-of-control process condition and automatically return the process to a safe state. SIS is usually the last line of defense and is not a basic process control system (BPCS).

All of this is performed using the PHA, QRA, and SIS services listed below and ultimately rolling up into a Safety Requirements Specification (SRS). The SRS defines both functional and performance related requirements including critical design decisions, preferences, and requirements in enough detail that another group can complete the design, construction, installation, and commissioning.

After construction, installation, and commissioning, a Pre-Startup Acceptance Test is performed typically by a third party to verify that the installed equipment and software conform to the SRS.

Once operational, periodic functional testing is carried out as defined in the SRS. Faults and repairs are necessary throughout life using identical functional devices to ensure the SIFs perform as designed.

Management of Change (MOC) occurs when changes are proposed that are not like-in-kind changes. These changes must be evaluated prior to implementation in order to identify any potential hazards that could result from the change. This step is crucial to ensure modifications are consistent with the SRS and preserve the SIL requirement.

Fire and Gas Mapping service performs similar tasks to those listed above for the hazards associated with the loss-of-containment that could result in a fire, flammable gas, or toxic gas hazard. The FGM services include hazard assessment, hazard frequency, risk reduction requirements (performance grading), consequence modeling, detector layout design and coverage assessment to meet the performance grading requirements for geographic-based fire and scenario-based gas analysis. Kenexis also performs computational fluid dynamics (CFD) analysis of enclosed environments.

Process Hazards Analysis

PHA is a structured qualitative multi-discipline assessment(s) of the potential hazards associated with a chemical process.

PHA identifies potential causes and consequences of unwanted or unplanned releases of hazardous chemicals, a loss of containment. It is used to derive a specific list of recommendations associated with safety issues for further evaluation or necessary changes to prevent or minimize the consequences.

In the United States, the OSHA process safety management regulation for hazardous chemicals was put into place in 1992, caused PHA to become much more prevalent, but most PHA methodologies were developed and implemented far earlier.

Process Hazards Analysis (PHA) services include a full range of facilitated/workshop studies like HAZOP, LOPA, HAZID, and a full-range of auditing – primarily using our Open PHA™ and Open Audit™ software.

Hazards and Operability (HAZOP) recommends hazards that require risk reduction. Layer of Protection Analysis (LOPA) assess the hazards identified in the HAZOP to determine the target Safety Integrity Level (SIL) required to reduce the risk to an acceptable level. LOPA uses semi-quantitative techniques to deal with probabilities whereas a complex scenario would be analyzed using Quantitative Results Analysis (QRA) potentially in a fault-tree tool like Arbor™.

Security PHA Review

In addition to process safety, Kenexis has a disciplined approach to reviewing PHAs, especially HAZOPs, for threat vectors that have real significant consequences. The process is called Security PHA Review. You can read more about in our post on the subject or get the book that goes into detail at the ISA.org.

Failure Mode and Effects Analysis

Failure Mode and Effects Analysis (FMEA) falls into a broader category of reliability engineering that we perform. FMEA analyzes all the components of a system to identify failures, probability, and their causes and effects.

Quantitative Risk Analysis

Quantitative Risk Analysis (QRA) services include a full range of fire, explosion, and dispersion modeling using gaussian, analytical equations, and computational fluid dynamics (CFD) techniques, facilitating decision making for facility siting, permitting, and special analysis of high-risk scenarios.

Safety Instrumented Systems

Safety Instrumented Systems are designed to implement the Safety Instrumented Functions (SIF) to safeguard critical processes in the case of an unacceptable deviation in the process. An SIS system is composed of sensors, logic solvers, and final elements and the logic solver is programmed to act on the deviation to place the process in a safe state.

Kenexis provides several types of engineering services from verifying the SIL is met to complete SRS documentation package and continued engineering support to keep the SIS safe and reliable.

SIL Verification includes determination of probability of failure on demand, spurious trip rates, and other performance metrics. SIL Verification considers the type of equipment employed, advanced voting arrangements, diagnostics, and testing frequency. Once SIL Selection (performance target) is completed (usually using LOPA), achievement of the SIL Selection is verified using SIL Verification. SIL Verification can be calculated easily with our database in Vertigo™ SIS Safety Lifecycle software.

Safety Requirements Specification

Safety Requirements Specification (SRS) encompass all of the requirements developed during the risk analysis and conceptual design phases of the safety lifecycle, and other safety critical requirements, collected and presented in a design basis document referred to as SRS. The SRS is used for subsequent detailed design engineering of the actual SIS System. All SRS data can be maintained easily throughout an SIS lifecycle with Vertigo™ SIS Safety Lifecycle software.

Test Plan Development and Optimization

Test Plan Development and Optimization, Validation, and Verification ensure the ongoing integrity of a SIS throughout its lifecycle requires vigilant maintenance and testing practices that are aligned with the risk analysis assumptions and requirements specifications.

Functional Safety Assessment

Functional Safety Assessment verifies that the SIS is designed in compliance with the ISA/IEC 61511 and best practices of peer organizations.

Continuing Engineering Support

Continuing Engineering Support service is used by companies to have an independent third-party monitor and track actual equipment performance against assumptions, audit system activity and changes so that system performance and equipment changes are reconciled with initial assumptions and specifications.

Safety Instrumented Systems (SIS) services include SIL Verification, Safety Requirements Specifications (SRS), Test Plan Development and Optimization, Validation, Verification, and Functional Safety Assessment – primarily using our Vertigo™ SIS Lifecycle Management Software, and Open PHA™ HAZOP/LOPA Documentation Software.

Fire and Gas Mapping

ISA TR84.00.07 Guidance on the Evaluation of Fire, Combustible Gas, and Toxic Gas System Effectiveness defines our fire and gas mapping service. Performance-based analysis results in as few detectors as possible for toxic, flammable gas, and fire that will meet the performance target for each area of concern.

We use geographic-based coverage for fire detection and scenario-based coverage assessments for flammable and toxic gas assessments outdoors. Indoors, we use computational fluid dynamics to determine the effects the air handling equipment and other variables will have in the building.

In Scenario Coverage, performance targets are based on the hazard frequency for each piece of equipment before creating the model of the consequence (gas cloud) using gaussian modeling. Wind characteristics are applied, and the detectors are placed to provide the gas cloud coverage required by the performance targets.

In Geographical Coverage, performance targets are based on the hazard frequency for each piece of equipment. Performance targets are applied to equipment like a vessel, pump, or manifold and detectors are placed to ensure the performance target is met by the detector layout design.

Performance targets are created using a semi-quantitative method defined in ISA TR84.00.07. Performance targets require input of characteristics like occupancy and leak rates from private and public reliable sources like the UK HSE. The process results in a performance target and is set using grading ranges. Grades are typically defined as A, B, or C, where grade A would include high pressure and highly flammable contents, grade B includes moderate pressure and flammability, and grade C is mostly at atmospheric temperature and pressure. Grades are determined by your risk criteria, and commonly come close to 90% coverage required for A, 80% for B, and 60% for C.

Qualified engineers then assess where each detector location should be to maximize coverage and consider existing or planned equipment, power, structure, etc. The engineers periodically perform coverage analysis in Effigy™ software to test progress and perform “what if” type analysis. Finally, the final coverage assessment is performed to ensure that the performance target is achieved. The design result includes the coverage analysis achieved and the exact characteristics like location, detector type, rotation, inclination, and settings.

Our fire and gas mapping services are designed to provide the most rigorous analysis against performance targets, which results in the optimal coverage at the best cost for the service. Optimizing coverage, reduces detector numbers while still providing verified coverage and resulting in reduced installation cost and maintenance cost over lifetime.

During a recent project, we performed a brown field coverage assessment where detectors were already installed and operating. It was time to replace and possibly upgrade the detectors. We analyzed the existing coverage and made a few minor recommendations including the removal of 13 of the 27 detectors installed. The reduction in detectors resulted in a minor coverage reduction from 91% to 86% in a grade B area requiring 80% coverage. This eliminated the maintenance cost of 13 detectors that were only providing 5% of the total coverage.

While these results are very good, not every situation produces the same results. In fact, the quantity of detectors can increase to meet your performance targets. Regardless, you will know why and where every detector is necessary.

Fire and Gas Mapping (FGM) for detector coverage is performed with Effigy™ 3D Fire and Gas Mapping Software for both geographic-based and scenario-based analysis.

Consequence Models

Gas dispersion outdoors is normally modeled using gaussian, while gas modeling inside a facility or confined spaces is done using CFD.

Gaussian Modeling is useful in determining how a gas will disperse as it leaves a leak outside, in an unobstructed space. once the leak hits another object, then the dispersion characteristics change, and consideration will be made based on the scenario to use CFD. By modeling a typical leak and then using the model many times at key points in a process, like 360 degrees around a flange, provides a much better analysis for determining what will happen and then the probability of detecting it with a gas detector.

CFD has proven extremely useful in determining the migration of gas in confined spaces like labs, buildings, compressor stations, test stands, battery testing facilities, battery storage facilities, offshore platforms between the decks where space can be confined and finally in drilling rigs where space is getting more confined as rigs get more capable.

Facility Siting

Facility Siting assesses hazards and the potential damage that an explosion, fire, or toxic chemical incident could cause. Obviously, there is a focus on occupied building both inside and outside of the fence.

About

Kenexis, an independent consulting engineering firm that provides technical safety services, performance-based fire and gas mapping, and risk analysis for industries that manage risks related to chemicals or stored energy.

We specialize in analyzing risks of any process under control or material in containment in order to quantify the hazard, design reduction targets, and ensure the selected targets are met.

Analysis is done using a risk-based process where the selected equipment, maintenance, and testing procedures are tailored to specific requirements of an application.

The risk-based approach yields a design that provides the required risk reduction to a manageable level at minimal cost.

