Industrial^{IT} System 800xA
Safety Lifecycle Services
Overview

Features and Benefits

- **Create Value by Protecting People, Property and Environment.** ABB provides a portfolio of tools and services for the full asset/safety life cycle:

  - **Safety Requirements:** Conducting the right analysis at the right time in the right way by providing front end hazard and risk analysis and safety requirements/SIL analysis.
  - **Safety Systems Implementation:** Designing safety systems that meet customers' needs, specific SIL requirements, and fulfill regulatory requirements and providing support for installation, commissioning and operations.
  - **Maintaining Safety Performance:** Providing methods and tools to optimize operations and maintenance regimes and maintain safety performance.
  - **Functional Safety Management:** Providing clients with a total life cycle safety capability, mapped to the IEC 61508/61511 asset and safety life cycle. ABB's experience and standing in the international safety market provides clients with a total solution – a unique blend of safety consultancy, systems, services and supporting tools.

Functional Safety – Regulatory Compliance and Good Practice

Statistics are published and compared, incidents make headline news and many management incentives are based on safety performance. Today's industry strives to improve performance and profitability while maintaining and improving safety. The challenges include unremitting pressure to reduce costs, shorter product life-cycles, the need to reach the marketplace faster than ever, pressure to maximize the use of the asset base and plant availability, and pressure to reduce spurious alarms. In addition, there are increasing regulatory and social requirements for safety, reliability, full documentation at all times and decision traceability.

With increasing reliance placed on 'smart' equipment, the process industries are demanding closer integration of their control and safety solutions, reusable safety components and subsystems, safety system certification, automated tools and functional safety.

ABB offers a complete Safety Instrumented System (SIS) that complies with IE Complementing its safety system offerings, ABB Safety Lifecycle Services provide a wide range of offerings that are founded on a proven knowledge of the safety engineering issues from an end user/operator perspective. ABB Safety Services assist in the practical implementation of all phases of the IEC 61508/61511 safety lifecycle for both existing and new facilities by applying proven techniques, working methods, and tools including safety assessments, safety lifecycle audits, safety validation and verification, and safety training.

Industrial^{IT} enabled

ABB

Introduction

ABB's Safety Lifecycle Services, as described in this document, include a portfolio of trusted methods, tools and techniques to support the safety life cycle concept. This enables organizations to cost effectively meet international regulations, codes of practice, and comply with industry 'best practice' international standards and safety management systems.

Profit and safety are inextricably linked. ABB, with 800xA Safety Systems and its associated Safety Lifecycle Services, supports a company's strategic goals of maintaining safety performance, increasing profitability, shareholder value, and limiting liability and exposure.

The International Standard, IEC 61508 covers the functional safety of electrical, electronic and programmable electronic systems and constitutes good practice for instrumented protective systems. The standard, increasingly used as a 'good practice' benchmark, is a pre-cursor to a more robust approach for industry to demonstrate that appropriate reliability, functionality and performance are built into equipment and that it is maintained effectively. IEC 61511 is used as the vehicle to interpret the framework of IEC 61508 specific to the process industries. There are four key concepts involved in IEC 61508 (Figure 1):

- **The safety lifecycle.** A sequence of phases providing a logical path through to commissioning, operation, maintenance and finally decommissioning.
- **Safety management.** A formal safety plan produced to ensure that everything is in place in order to prepare for and manage each phase of the safety life cycle.
- **The design of safety related control and protective systems.** Comprehensive technical guidance is given on appropriate measures and techniques for achieving specified levels of integrity in the systems, including the safe application of modern programmable electronics.
- **Competencies.** Guidance on the appropriate skills and knowledge for those involved in each phase of the safety life cycle.

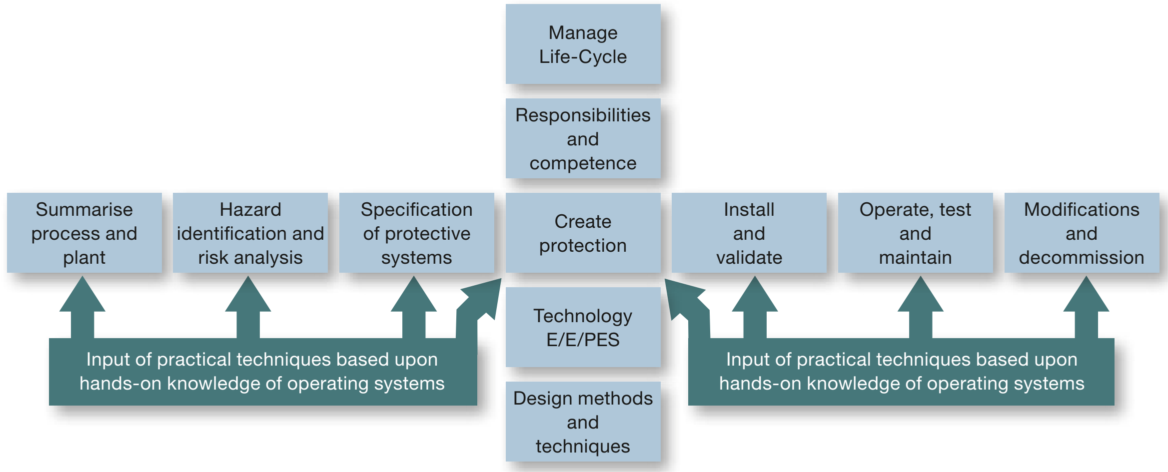

Figure 1. Supporting Techniques for the Functional Safety Lifecycle

The safety lifecycle applies to all organizations in the safety supply chain. ABB's portfolio of products and services map directly across this lifecycle and in so doing automates and streamlines the implementation of all the phases. Studies by regulatory bodies indicate that the dominant factors in the primary cause of system failures are in specification (44.1%), changes after commissioning (20.6%), operations and maintenance (14.7%), installation & commissioning (5.9%), and design and implementation (14.7%).[1]

ABB's Safety Lifecycle Services portfolio is targeted and structured to address and mitigate these primary causes (Figure 2). These portfolios include:

- Safety Requirements
- Safety System Implementation
- Maintain Safety Performance
- Functional Safety Management

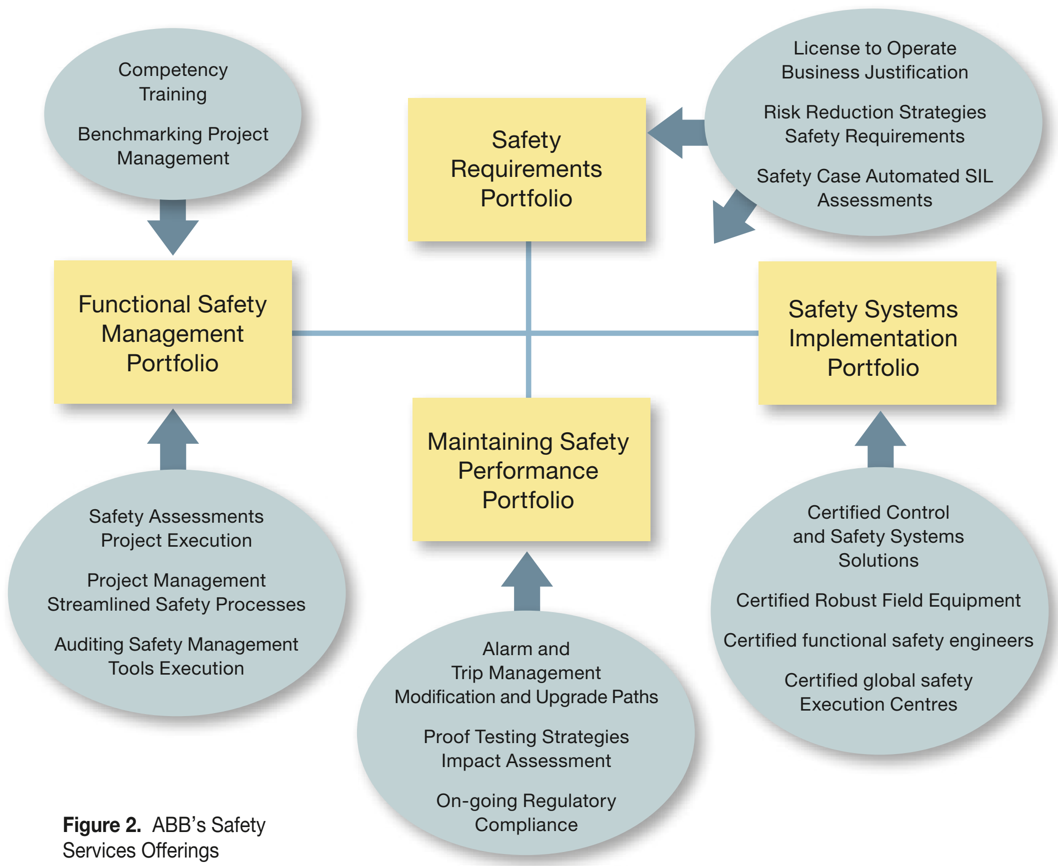

Figure 2. ABB's Safety Services Offerings

Described in the following sections, each portfolio consists of validated Industrial IT products, consultancy services, and packaged solutions. These portfolios have been developed in consultation with industry, regulatory authorities, and government agencies in addition to meeting the requirements of industry 'good practice' standards. The terminology and functionality provided is consistent with standards and regulations.

[1]"Out of Control - why control systems go wrong and how to prevent failure" (2nd Edition), UK Health and Safety Executive - Ref HSG238, ISBN 0-7176-2192-8, 2004.

Safety Requirements Portfolio

Due to the complexity of the hazards in the process industry, it is required that a systematic process is used to identify all foreseeable major accidents. Recommended techniques include Hazard and Operability (HAZOP) studies, reviews of past accidents and incidents, industry checklists, or failure mode and effects analysis (FMEA).

For the risk assessment aspects, a Safety Report or Safety Case is frequently required and must demonstrate that major accident hazards have been systematically identified and that 'all necessary measures' have been taken to prevent such accidents and limit their consequences for people and the environment.

IEC 61508

IEC 61511

Where protection against major accidents is dependent on the action of an active shutdown system or human intervention, the risk assessment must consider whether the reliability of these measures ensures that risks remain As Low As Reasonably Practicable (ALARP). Such a risk assessment requires the severity and likelihood of the major accident scenario to be estimated, and the resultant risk compared with suitable risk criteria.

From the IEC 61508/61511 standard, the Safety Integrity Level (SIL) is fundamental in ensuring a safety related system satisfactorily performs the required safety functions under all stated conditions within a defined time period. It is an assessment of the risk reduction required to give a tolerable level of risk.

Inappropriate SIL determination can affect the safety integrity of the asset protection envelope and may in some cases place the asset integrity under threat. In addition to this, unnecessary spend in capital and operational budgets can be incurred.

In contrast, properly defined SIL levels allow for significant cost improvements to be achieved in both Greenfield and Brownfield operating environments. Asset operational safety integrity levels are maintained while the cost of ownership from ongoing testing and maintenance is optimized.

ABB Safety Services offer a set of proven techniques and methods to enable identification of hazards, assessment of risks, and determination of appropriate risk reduction strategies.

Hazard Identification

Hazard identification is important for identifying and eliminating or controlling plant hazards that could significantly harm people, the environment or the business itself. Effectively identifying hazards leads to safer processes with reduced operating costs, compliance with the legal requirements for risk assessment, and benefits from increased efficiency and profitability.

ABB Safety Services include a wide range of tools and techniques for hazard identification studies from early conceptual stages through ongoing operation. These include:

Inherent Safety Studies. Under the guidance of ABB, development chemists and engineers work to reduce or eliminate the inherent hazard potential of a plant, and reduce the need for extra risk reduction measures such as Safety Instrumented Systems. The methodology provides demonstration of a structured hierarchical approach, as required by international regulations.

Hazard Studies. The first stage is a checklist-based study at the beginning of process development to ensure that all the information related to safety, health and the environment is available to the project team. To avoid expensive future delays to the project, ABB's experienced staff also reviews what other studies are needed, and initiates contact with the regulatory bodies that may place restrictions on the project.

The second stage is a hazard based study of the preliminary process flow diagrams which aims to identify and eliminate significant hazards. If hazards cannot be eliminated, ABB will specify what safety measures are needed and carry out risk assessments to ensure risk is reduced to an acceptable level.

The final design stage hazard study is a HAZOP of the firm process design to identify significant deviations and ensure that appropriate measures have been built into the design.

SIL Determination

Safety Instrumented Systems are found on the vast majority of process industry manufacturing facilities to protect against hazards to personnel, the environment and plant equipment. A key requirement is to determine the criticality of all SIS's on the plant to identify systems that provide protection against major accident hazards. It is then important to assess the required reliability of critical systems to ensure that risks will be reduced to an acceptable level.

From the IEC 61508/61511 standards, the Safety Integrity Level is fundamental in ensuring a safety related system satisfactorily performs the required safety functions under all stated conditions within a defined time period. SIL assessment is the process of determining the required reliability for a SIS, taking account of the severity of the hazardous event and other independent layers of protection that are contributing to the overall risk reduction.

Inappropriate SIL determination can affect the safety integrity of the asset protection envelope and may in some cases place the asset integrity under threat. In addition to this, an overly conservative approach can result in unnecessary capital and operational spending. In contrast, properly defined SIL levels allow for significant cost improvements to be achieved in both Greenfield and Brownfield operating environments. Asset operational safety integrity levels are maintained while the cost of ownership from ongoing testing and maintenance is optimized.

ABB's SIL Determination package enables asset owners to become conversant with the relevance of SIL determination in the context of Functional Safety, and to then confidently determine the SIL level and configuration required to achieve these targets.

ABB's SIL Determination package consists of:

TRAC. TRAC is a PC based software tool used to assist safety, project, and maintenance engineers in determining the optimum design configuration and periodic test intervals for Safety Systems (Figure 3). It provides the engineer with a systematic and consistent approach to calculating required SIL and trip test interval for safety loops relating to safety, environmental, or asset loss.

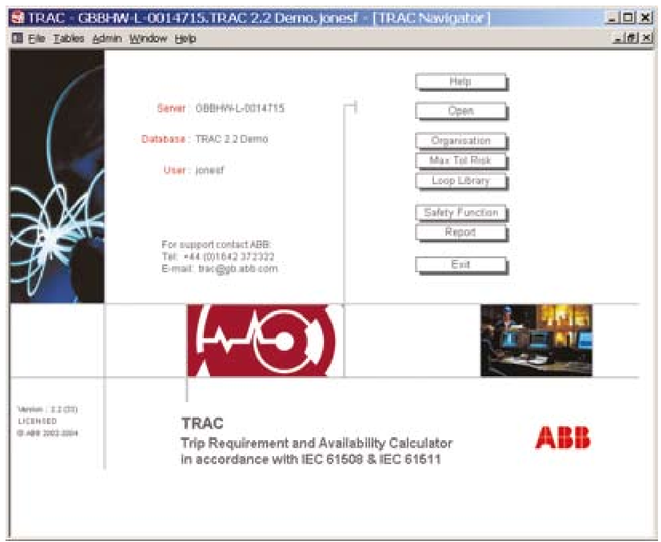

Figure 3. ABB's TRAC Software Tool is used to Calculate SIL Requirements and Trip Test Intervals

TRAC was developed in conjunction with BP and is used on many of their sites worldwide. Reliability and IEC risk graph methodologies underpin quantitative and qualitative techniques to calculate optimum values for trip testing interval set against the projected annualized cost. It has been designed with the remit to provide a means for optimization of trip testing intervals, relative to cost, and in accord with UK HSE regulatory framework.

TRAC offers both Risk Graph and Layer of Protection methodologies (from IEC 61511) to assess the SIL requirements (Figure 4).

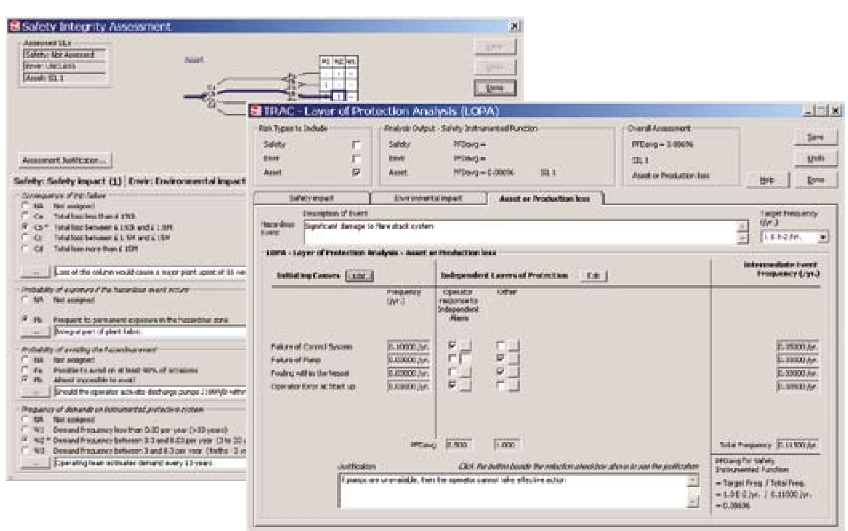

Figure 4. TRAC's Risk Graph and Layer of Protection Methodologies

TRAC then allows the safety loop to be configured from initiator through the logic solver to the actuator (Figure 5). The equipment failure rates are drawn from a database built into the software.

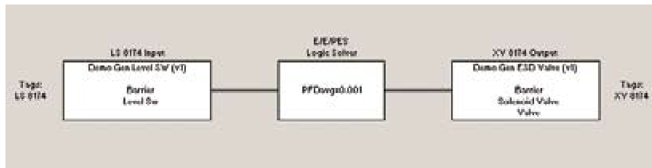

Figure 5. TRAC Configured Safety Loop

TRAC provides multiple solutions for testing of inputs and outputs within bands of the required maximum and minimum allowable probability of failure on demand. For each span of test intervals, a cost of testing is calculated from known annual testing costs. Results are displayed graphically and a comprehensive report is issued with fully traceable and archived decision processes (Figure 6).

Figure 6. Test Interval Decison Matrix

SIL Determination Training. This element of the package delivers tailored training in the concepts of risk assessment, hazard identification, SIL Determination and related aspects of IEC 61508/61511.

SIL Determination Engineering. In addition to the software product and training, ABB provides safety engineering expertise to equip clients with the skills and processes necessary for them to address their safety function and integrity issues. The phased delivery of this engineering content includes:

- Identifying suitable client risk criteria
- Installation & configuration of TRAC to meet client's risk criteria
- Coaching in initial SIL determination
- Coaching in the review of existing safety function design to meet the SIL targets

Safety System Implementation Portfolio

ABB safety systems offer complete TÜV certified SIS solutions through TÜV certified Safety Execution Centres complying with the IEC 61508 and IEC 61511 standards and covering, not only the 'logic solver,' but the entire safety loop, consisting of field instruments, controllers and I/O modules, and field actuators. Highly scalable, these safety solutions provide the flexibility to match specific safety functions with actual plant needs.

For System 800xA safety systems, process availability is improved while reducing risk to overall plant operation through the system's unique common high integrity environment for production control, safety supervision, and production monitoring. This common environment eliminates the duality of system operations and their associated lifecycle costs and leads to optimized project engineering, training, operations, maintenance, and spare parts. In addition, System 800xA's high integrity controller, AC 800M HI, provides the ability to combine safety loops with control applications without sacrificing safety integrity. The AC 800M HI, in combination with a diversified co-processor, performs diagnostics and monitoring of application execution and I/O scanning. For embedded safety and control applications, all functions/types in standard libraries are marked non-SIL and SIL to show their usability. Embedded safety measures prevent inadvertent degradation of safety applications (Figure 7).

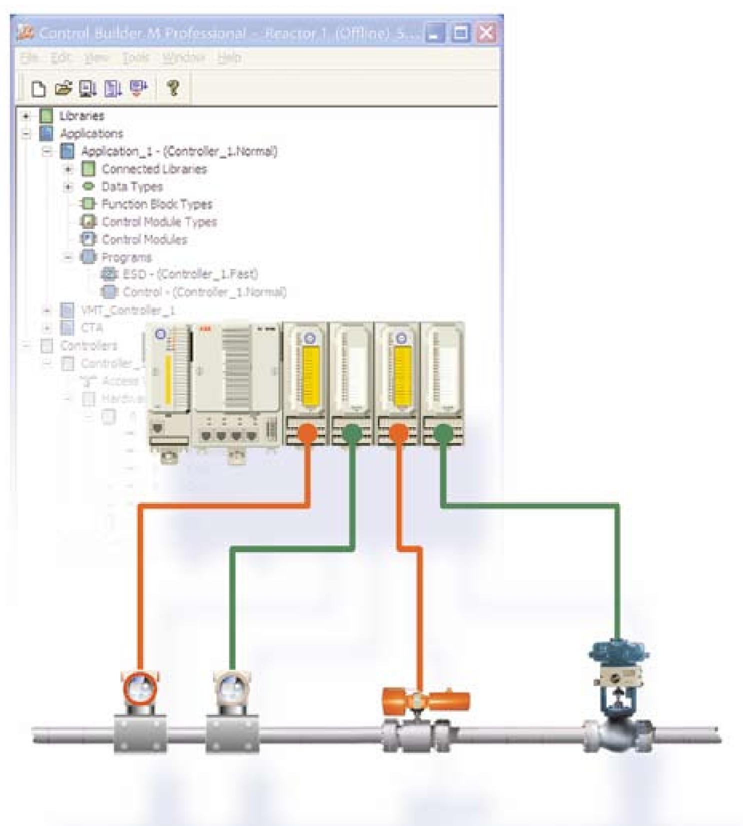

Figure 7. Certified firewalls isolate SIL and non-SIL applications from one another, enabling them to reside in the same controller and run concurrently.

System 800xA's object oriented engineering environment with SIL compliant function libraries efficiently supports the entire safety system lifecycle from planning, through design and library management, to commissioning and support. The engineering environment includes safeguards against non-SIL compliant configurations. Once identified as a safety application, the engineering system will automatically limit user configuration choices and will prevent download if SIL requirements are not met. The engineering environment includes a comprehensive set of application specific libraries that contain pre-configured Control Modules, Function Blocks, and graphic elements (Figure 8). ABB provides a wide range of field proven safety applications including Fire and Gas systems, Emergency and Process Shutdown (ESD and PSD), Interlock systems, Burner Management and Boiler Protection (BMS), Critical Control, High Integrity Pressure Protection Systems (HIPPS), and Pipeline Protection Systems (PPS). The integrated libraries and tools are complimented with an extensive range of stand-alone services and methodologies for determining safety requirements and maintaining the compliance for the complete lifecycle.

For more information regarding the 800xA Safety System Offering, please refer to the 800xA Safety Overview.

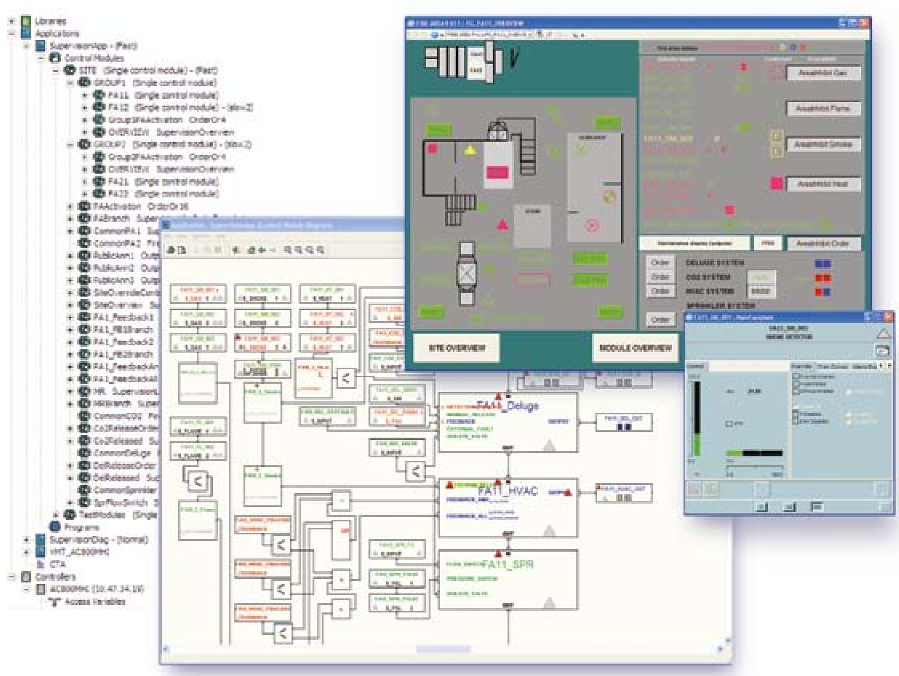

Figure 8. System 800xA's Fire and Gas Library includes a Complete Range of High-level Control Modules, Alarm Management, and Operational Templates and Strategies.

Maintaining Safety Performance Portfolio

Operating and maintaining the asset is not an insignificant activity and spans the majority of the asset life. The need to minimize operating expenditures (OPEX) is paramount. Over the life of the asset, the underlying process may well be modified, safety systems upgraded and replaced, and safety cases resubmitted for regulatory approval. Many assets have been operating long before the ratification of standards. However, the changing regulatory regime coupled with the need to drive down the cost of ownership determines the requirement for a number of asset safety health checks and benchmarking regimes. The Maintaining Safety Performance portfolio accomplishes this and provides validated software to enable management of trip and alarm systems.

TRAMS

TRAMS is a fully validated, professionally developed, interlock/trip and alarm management, scheduling and reporting system (Figure 9). It is a PC based software package developed by ABB for the management, scheduling, reporting and data storage of technical specifications, for plant trip and alarm safety or product critical systems.

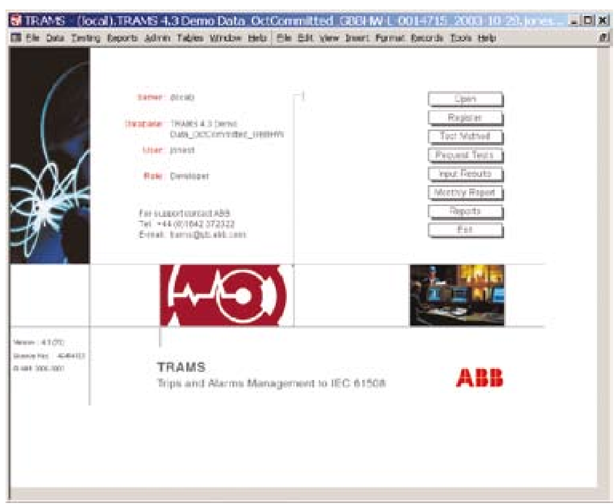

Figure 9. TRAMS is ABB's Trip and Alarm Management System

TRAMS draws together into one system all the data, including, where appropriate, specification (reasons, etc.), design data and test methods required to manage trips and alarms successfully (Figure 10).

TRAMS schedules tests to be performed on a monthly basis. Individual test results are recorded equally effectively. It has additional functionality to deal with overdue, shutdown, and ad hoc testing (Figure 10).

TRAMS provides monthly reports on the status of testing, drawing attention to items which require action. There are eight sub reports each month covering different aspects (Figure 10).

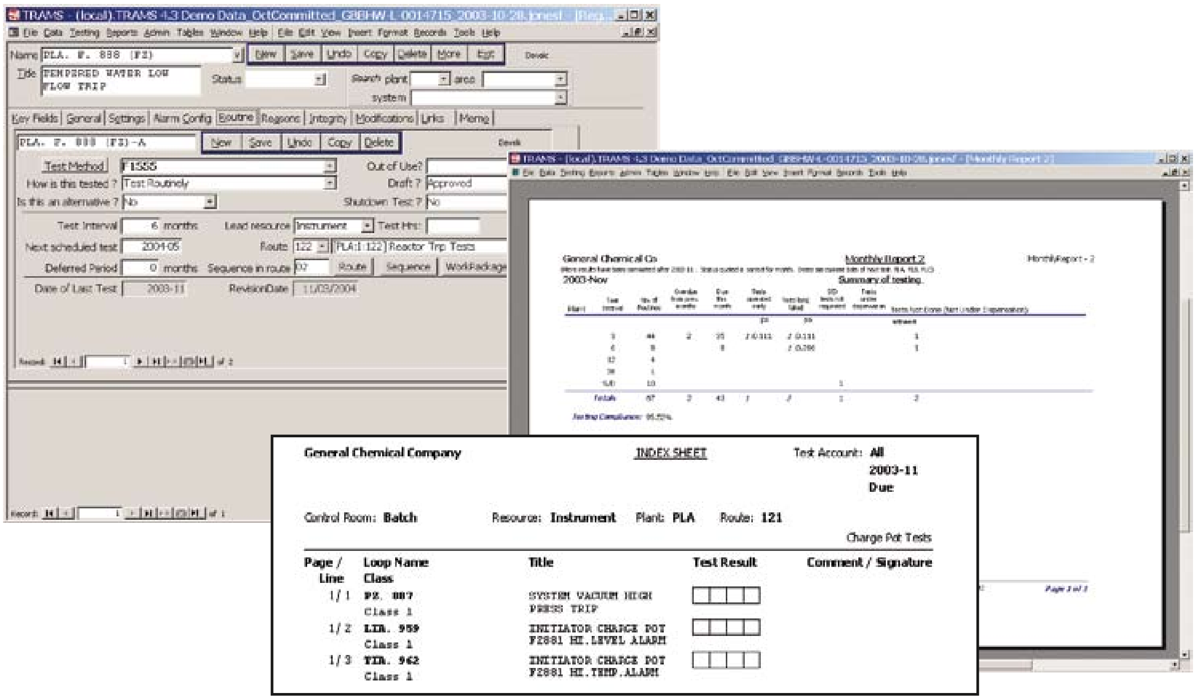

Figure 10. Examples of TRAM Register-Routine, Monthly Schedules, and Monthly Reports

TRAMS produces, on demand, reports on history of testing for selected time period/ plant/area or specific loop etc.

Key features of the system include:

- Draws together all relevant data in a customised, user friendly database
- Demonstrates the selection of appropriate safety integrity levels (SIL)
- Aids the reduction of maintenance costs by proof testing at optimum intervals
- Provides consistent proof testing using written test methods and specified set point tolerances
- Provides exceptionally fast and efficient reporting of proof test results
- Produces accurate reports on the status and results of proof testing
- Processes trip and alarm reporting data for easy review of safety system performance
- Identifies safety function items, which have poor availability and require improvement
- Windows based software with easy to understand menu and help displays
- A cost effective alternative to larger mainframe maintenance packages

Installed Systems Review

Historically, the way in which safety instrumented systems have been applied has varied across industry. A recent collaborative research project, led by ABB, has helped to define a set of indicators of what it is reasonable and practical to expect of installed systems. The areas of particular interest were the difficulty of comparison of older systems against the standard, and practical steps that can be taken towards compliance.

Benchmarking with Installed Sytems Review (ISR) allows owners and operators of older systems to know exactly where they stand in relation to current accepted good practice, and provides a clear direction for actions required to become compliant. ABB's ISR method compares the system against accepted norms, to allow a focussed approach to improvements, and highlights which areas for change should be addressed as priorities (Figure 11). The ISR is a structured approach that makes use of existing site functional safety management systems, and previous risk assessments.

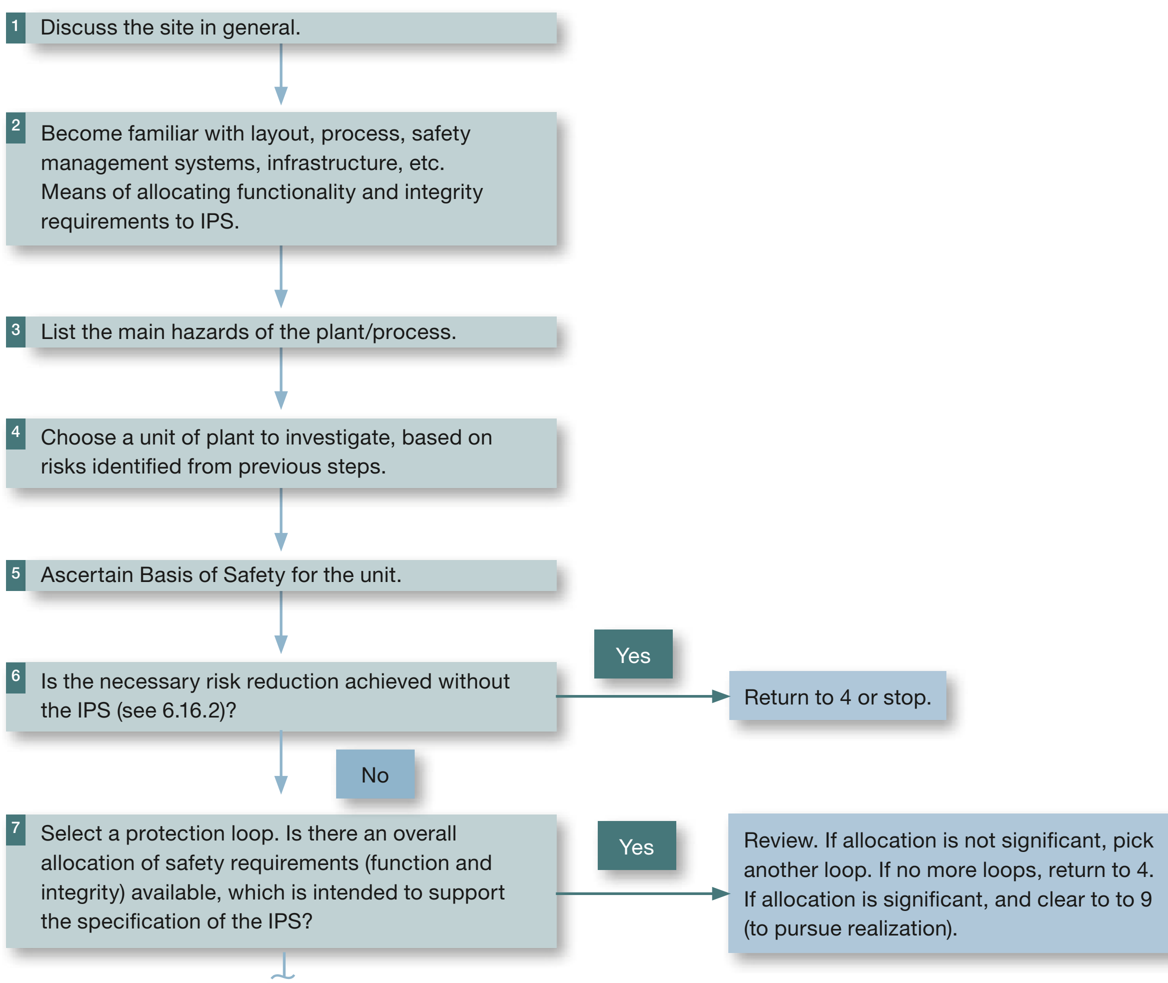

Figure 11. Sample ISR Methodology

A short site review program is planned in advance. In this way, evidence can be collated and site personnel time can be optimized. The ISR approach starts with an assessment of SIL requirements, followed by comparison of arrangements with industry consensus practical steps. This is done to yield a report specifying any necessary improvements.

Brief descriptions of what would be considered practicable for each of these clauses has been identified and graded according to SIL requirements.

Proof Test Benchmarking

Operators of hazardous plant need to take steps to ensure that they have in place suitable proof testing regimes to ensure that the required SIL of each safety instrumented function is maintained during operation and maintenance and to operate and maintain the SIS so that the designed functional safety is maintained. Proof Testing regimes form an integral part of the asset owners (functional) safety management system.

ABB's experts have worked with industry and regulatory bodies through research, analysis of industry good practice and relevance of standards into the practices of proof testing, to develop a methodology and comprehensive set of 'Guiding principles for the proof testing of SIS's in the process industry.' These guiding principles therefore provide independent guidance on proof testing issues which are of interest and concern to industry.

This feature of ABB's Safety Services supports users with a methodology designed to provide them with a benchmark for their proof-testing regime. This benchmark profiles attributes including:

- Management
- Design
- Testing
- Records
- Competency

These key attributes relate to a number of 'principles of proof testing' (PPT) and in-turn each PPT has a number of influencing factors.

These principles are:

IEC 61508

IEC 61511

- Proof testing practices
- Content of proof testing procedures
- Format of proof testing procedures
- Planning and scheduling
- Proof test records
- Competence
- Awareness of hazard and risk
- Management of change

The method enables cross comparison of proof test regimes to enable users to identify areas of weakness, implement improvement programs, and measure and demonstrate improvements in proof testing regimes.

Strengths and weaknesses in proof testing regimes can be analysed and improvement programs initiated.

Today's high hazard industries faces many challenges and issues, these include:

- Achieving continuous improvement on aging assets
- Changes in design intent due to modifications
- Need to demonstrate that systems are fit for purpose
- Backdrop of rising standards and stakeholder expectation

Process Hazards Review

Process Hazard Review (PHR) is a team based hazard identification and risk assessment methodology used to achieve continuous safety improvement for ongoing process operations (Figure 12). It has a good track record in identifying key issues and it is much quicker than comparable techniques such as HAZOP, thereby minimizing both the costs for review and the time required for busy operations staff. It has been widely used in the Process Industry and is accepted by the regulatory authorities.

PHR is often used on existing plants where hazard studies have not been carried out or where they have become out of date. It is an effective method for identifying the main hazardous events and the critical risk reduction measures, including SIS's. PHR provides the opportunity to identify and assess shortcomings in the risk reduction measures, and to make recommendations for improvements.

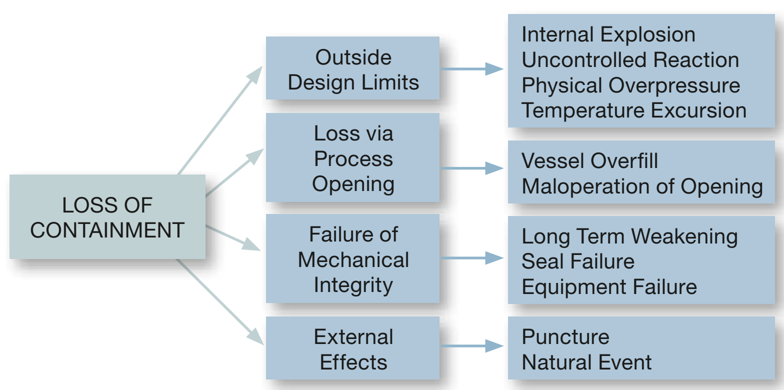

Figure 12. PHR Guidewords

ABB's well proven, structured and risk based approach provides a detailed risk assessment and prioritized improvement plan that is defendable with senior management and the regulatory authorities. Staff attending the review enjoy ongoing benefits as they gain an improved understanding of their operation's process related hazards.

PHR can help maintain a license to operate and prevent major accidents, which can harm people, the environment, and the business. With a thorough understanding of the risks and a knowledge that all reasonably practicable steps have been taken, it also provides peace of mind.

Functional Safety Management Portfolio

For those organizations that operate globally, the demands of the international market create challenges to formally demonstrate their safety management capabilities due to differing regulatory regimes, mutual recognition, and profit versus safety balance. Safety standards, notably IEC 61508 and IEC 61511, draw attention to a relatively new concept, the management of functional safety and the requirements to establish appropriate functional safety management systems. These systems frequently underpin an organizations safety management system.

Functional Safety Management systems review and implementation

However, for organizations that are developing functional safety management systems, this is not an overnight activity. Has the organization defined its functional safety strategy, what are drivers behind the development of the system; regulatory pressure, to demonstrate due diligence, reduce the effort and cost involved in regulatory review and inspections, lower insurance premiums, gain market advantage, or reduce external audits and assessments? How does the benchmark standards (IEC61508 & IEC 61511) help in understanding the concepts and terminology, what are the boundaries of the system, is third party certification required, are there pitfalls to implementation?

The Functional Safety Management Review is designed to assist any organization involved in the safety lifecycle to benchmark their functional safety management system and competency scheme against the requirements of IEC 61508/61511 (Figure 13).

By using checklists aligned to the relevant phases and clauses of the standards, evidence gathering and interviews, a 'gap analysis' report is compiled and used as a basis for development of an improvement program. ABB work with the client in implementing a 'road map to compliance.' This includes the provision of validated generic compliant procedures.

The benefits of such an approach include:

- Actively promote their functional safety management systems capability as compliant with 'good practice' international safety standards
- Reduce the need (and subsequent cost) of assessment by second parties (customers)
- Streamline contractual negotiations with clients
- Limit exposure to contract and corporate liability
- Demonstrate due diligence
- Meet both local and international regulations
- Remove barriers to 'route to market'

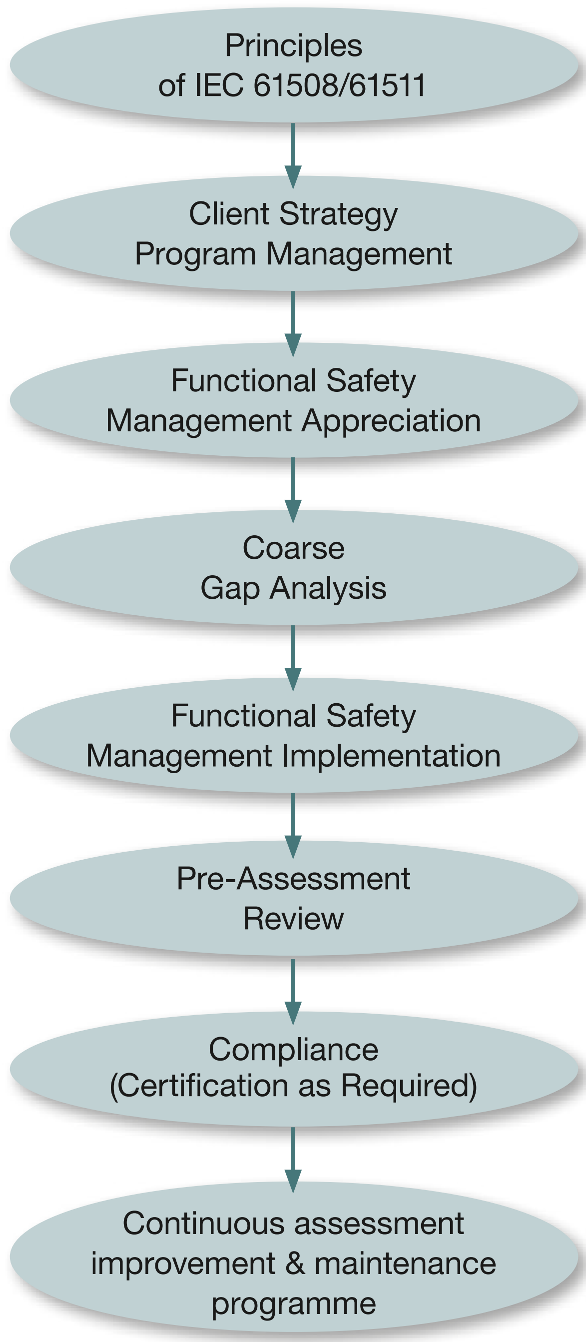

Figure 13. Functional Safety Management - Roadmap to Compliance

Independent safety project verification service

During safety project execution it is necessary to provide independent verification of safety project deliverables such as design documentation. This verification ensures a rigorous approach to safety system design and implementation reducing the likelihood of systematic errors. This verification activity supports a claim of systematic capability.

ABB offers a safety project verification service covering key safety lifecycle deliverables using a well defined and proven verification process based on the requirements of IEC 61508 and IEC 61511. ABB personnel work within the client's design and implementation team. The role may extend to other organisations working on behalf of the client and responsible for specific project deliverables. This together with a high level of individual competency ensures that any issues relating to functional safety are identified early in the safety lifecycle, leading to a reduction in potential rework and providing higher confidence to the client and other third parties.

Independent Functional Safety Assessment service

Functional Safety Assessment is a relatively new concept in functional safety. It is an investigation based on evidence to judge the functional safety achieved by one or more E/E/PES safety-related systems. It is now being demanded by many clients and third party organisations (regulatory authorities and certification bodies) as a key deliverable in the demonstration of the achievement of functional safety.

ABB offers a functional safety assessment service which is truly independent from the client's management and technical organisation and activities and meeting the independence requirements stated within IEC 61508 Part 1 clause 8.2.14. The ABB functional safety assessment methodology uses checklists developed directly from IEC 61508. This assessment process is tailored to the specific phases of the safety lifecycle being implemented by the client. The results of the assessment process are clearly provided in a report that is easily understood by different project engineering disciplines such as C&I engineers, Quality engineers and project management so facilitating an effective corrective action programme.

Client and other third parties are increasingly demanding that functional safety assessments are implemented by independent and competent organisations such as ABB.

SIL Achievement

Successful demonstration that the target SIL for a safety instrumented function has been achieved is reliant on many aspects of the overall safety lifecycle, such as Hazard and Risk Assessment, SIL Determination, Safety Requirements Allocation, and Realisation – phases 1 to 9 of the IEC 61508 safety lifecycle. The evidence required in order to demonstrate that a safety instrumented system function meets its target SIL (i.e. the SIL Achievement exercise) is far more than a quantitative exercise, based solely on target failure measure. Architectural constraints and Systematic capability must also be taken into account.

SIL Achievement is a demonstration that for each Safety Instrumented Function, the target SIL, as derived from SIL Determination, has been met in accordance with the requirements of IEC61508.

As part of our safety systems integration and engineering services we perform SIL Achievement using proven methodologies and provide comprehensive reports. Only when a safety instrumented function meets the criteria set by IEC 61508 in terms of architectural constraint, target failure measure and systematic capability, 'can the target SIL be said to be achieved.

Figure 14. SIL Achievement Collage

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