Standardization and Methodologies issue for Automating Life Cycles of Experimental Facilities on collider

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Abstract

International standards play a crucial role in ensuring the success, safety, and efficiency of collider projects. These standards provide guidelines and frameworks for regulatory compliance, risk management, and quality assurance throughout the project lifecycle. By adhering to established standards, a collider project can optimize resource use, enhance safety protocols, and promote interoperability among various systems and stakeholders involved in the collider project. Moreover, standards facilitate continuous improvement and innovation, driving progress and sustainability in collider research and development.

I. Main Aim

I. Ensure safety, compliance, and efficiency in collider projects through the implementation of international standards.

II. Our overarching objective is to incorporate standardization throughout the life cycle phases inherent in the development of automation systems. Through the adoption of standardized methodologies, our aim is to markedly elevate the caliber and efficacy of forthcoming experimental configurations within the collider environment.

II. Introduction

In collider projects, the integration of international standards serves as a linchpin for ensuring regulatory adherence, bolstering safety protocols, and streamlining operational efficacy, while these standards provide a robust framework for collaboration and innovation, there exists a notable paradox within the scientific community: a reluctance to fully embrace standards alongside a ready acceptance of hardware and software solutions from industry, this discrepancy often results in compromised methodologies, leading to skewed results and hindered progress. Furthermore, the intersection of scientific innovation and industrial practices presents a fertile ground for enhancing collider projects, embracing industry-standard methodologies alongside hardware and software solutions can significantly augment compatibility, facilitate seamless data exchange, and expedite scientific breakthroughs, however, the absence of coherent methodologies undermines the potential benefits of such integration. This article endeavors to explore the nuanced dynamics surrounding the integration of international standards within collider projects, by elucidating the challenges, opportunities, and imperative for adopting standardized methodologies, this overview aims to catalyze a dialogue that fosters a harmonious synergy between scientific innovation and industry best practices, through this harmonization, collider projects can transcend existing limitations, realizing their full potential in advancing the frontiers of science and technology.

III. Theoretical Framework

I have separated the standards into different categories, so that you can have a more precise vision of the project, the categories are:

1. **Regulatory Compliance:** Standards in this category focus on ensuring compliance with regulatory requirements set by international organizations. They cover aspects such as energy management, information security, and building information modeling (BIM).

2. **Safety and Risk Management:** These standards address functional safety, machinery safety, and risk assessment principles to mitigate hazards and ensure the safety of personnel and equipment involved in a collider project.

3. **Construction and Engineering Standards:** Standards in this category provide guidelines for organizing and digitizing information about buildings and civil engineering works, including BIM, to streamline project management and improve collaboration among stakeholders.

4. **Automated Systems and Integration:** Standards related to automated systems and integration focus on human-machine interfaces, software lifecycle processes, statistical methods, and open systems application integration framework (OSAIF), ensuring seamless integration and interoperability of systems within a collider project.

5. **Machinery and Equipment Regulations:** These standards govern the design, construction, and operation of machinery and equipment, addressing safety-related parts of control systems, guards, and risk assessment principles to prevent accidents and ensure compliance with safety standards.

The standards are designed by different organizations, the main ones are:

A. **International Organization for Standardization:** ISO develops and publishes international standards across various industries, including energy management, information security, construction, engineering, and safety.

B. **International Electrotechnical Commission:** IEC is responsible for developing international standards for electrical, electronic, and related technologies.

C. **International Society of Automation:** ISA develops standards and technical resources for automation professionals worldwide.

IV. International Standards

The main standards that I chose for each category represent the critical points that the project should take into consideration for good planning to incorporate international standards.

1. Regulatory Compliance:

- ISO 50001 - Energy Management Systems: This standard provides guidelines for establishing, implementing, maintaining, and improving an energy management system, it helps organizations manage energy use effectively, reduce energy consumption, and improve energy performance, ultimately leading to cost savings and environmental sustainability.

- ISO 27001 - Information Security Management Systems: ISO 27001 specifies requirements for establishing, implementing, maintaining, and continually improving an information security management system, it helps organizations protect sensitive information, manage risks related to information security, and ensure the confidentiality, integrity, and availability of information assets.

2. Safety and Risk Management:

- IEC 61508 - Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems: This standard provides a framework for ensuring the safety of safety-related systems used in various industries, including collider projects, it covers principles for risk assessment, safety integrity level (SIL) determination, and safety lifecycle management processes.

- ISO 13849 - Safety of Machinery - Safety-Related Parts of Control Systems: ISO 13849 specifies requirements for the design and integration of safety-related parts of control systems used in machinery, it addresses risk assessment, safety performance level determination, and validation of safety functions to prevent or mitigate hazards associated with machinery operation.

- ISO 12100 - Safety of Machinery - General Principles for Design - Risk Assessment and Risk Reduction: ISO 12100 provides guidance on risk assessment and risk reduction principles for machinery design, it helps projects to identify and mitigate potential hazards associated with machinery, ensuring the safety of personnel and equipment.

3. Construction and Engineering Standards:

- ISO 19650 - Organization and Digitization of Information about Buildings and Civil Engineering Works (including BIM): ISO 19650 specifies requirements for managing information throughout the lifecycle of buildings and civil engineering works, including the application of Building Information Modeling, it helps streamline project management, improve collaboration, and optimize project outcomes.

4. Automation Systems and Integration:

- ISA 101 - Human-Machine Interfaces (HMIs) for Process Automation Systems: ISA 101 provides guidelines for designing effective human-machine interfaces (HMIs) for process automation systems, it covers principles for HMI layout, graphics, navigation, alarm management, and user interaction to improve operator control and monitoring.

- ISO 12207 - Software Life Cycle Processes: ISO 12207 specifies processes for managing software development life cycles, including requirements analysis, design, implementation, testing, deployment, and maintenance, it helps ensure the quality, reliability, and maintainability of software products throughout their lifecycle.

- ISO 15745 - Industrial Automation Systems and Integration - Open Systems Application Integration Framework (OSAIF): ISO 15745 provides a framework for integrating industrial automation systems using open standards, it helps facilitate seamless integration and interoperability among diverse automation technologies, systems, and components.

- ISO 22514 - Statistical methods in process management - Provides guidance on statistical methods for assessing and improving process capability and performance, it includes techniques for data collection, analysis, interpretation, and process optimization.

5. Machinery and Equipment Regulations:

- ISO 14120 - Safety of Machinery: ISO 14120 specifies requirements for the design and construction of guards used to protect personnel from hazards associated with machinery, it helps ensure that guards are designed, installed, and maintained effectively to prevent access to hazardous areas.

V. Applying Standards

In the intricate domain of collider research, the implementation of international standards within automated systems stands as a linchpin for advancing scientific endeavors, colliders represent the pinnacle of scientific exploration, where precision and reliability are paramount, within this context, the integration of international standards into automated systems becomes imperative for ensuring methodological rigor and operational excellence.

This chapter lays the groundwork for an examination of the methodologies and practices underpinning the application of international standards in collider projects, in conjunction with the annex section, particularly focusing on their integration with automated systems, through this exploration, we delve into the intricacies of standardization to enhance the efficiency, reliability, and reproducibility of collider experiments, thereby pushing the boundaries of scientific discovery ever further. To apply these standards to a collider project, we need to focus on several key areas:

Energy Management: Implement ISO 50001 to systematically manage energy use, reduce consumption, and improve efficiency in collider facilities, this involves establishing energy policies, conducting energy reviews, and implementing action plans for continuous improvement.

Information Security: Adhere to ISO 27001 to protect sensitive data and ensure the confidentiality, integrity, and availability of information assets related to collider operations, this involves conducting risk assessments, implementing controls, and regularly evaluating the effectiveness of the information security management system.

Functional Safety: Follow IEC 61508 to ensure the safety of electrical, electronic, and programmable systems used in collider experiments, this involves assessing risks, determining safety integrity levels, and implementing safety lifecycle management processes to prevent failures and malfunctions.

Building Information Management (BIM): Apply ISO 19650 to manage information throughout the lifecycle of collider facilities, including design, construction, and operation, this involves using BIM technologies to organize, share, and exchange information among stakeholders to optimize project outcomes.

Human-Machine Interfaces (HMIs): Utilize ISA 101 guidelines to design intuitive and user-friendly HMIs for controlling and monitoring collider equipment and processes, this involves considering layout, graphics, navigation, and alarm management to enhance operator performance and situational awareness.

Software Development: Implement ISO 12207 to manage the software lifecycle processes involved in developing control systems and data analysis software for collider experiments, this involves requirements analysis, design, testing, deployment, and maintenance to ensure high-quality software products.

Process Optimization: Use ISO 22514 to apply statistical methods for analyzing collider processes, identifying areas for improvement, and optimizing performance, this involves data collection, analysis, and interpretation to reduce variation, enhance quality, and increase efficiency.

Safety of Machinery: Adhere to ISO 13849 and ISO 14120 to design and integrate safety-related control systems and guards for collider equipment, this involves assessing risks, determining safety performance levels, and implementing safety functions and protective measures to prevent accidents and injuries.

Industrial Automation Integration: Follow ISO 15745 to integrate industrial automation systems using open standards, facilitating communication and data exchange between different systems and components, this involves defining integration requirements, selecting technologies, implementing solutions, and monitoring performance to achieve greater efficiency and flexibility in collider operations.

In the annex you will find the *cycle of requirements and compliance justifications for each of the standards*.

VI. Conclusions

In conclusion, implementing international standards within a collider project offers numerous benefits that contribute to its success, efficiency, and safety. These standards provide structured frameworks and guidelines for various aspects of project management, engineering, safety, and information management. By adhering to these standards, organizations can achieve the following benefits:

1. Compliance and Safety: Standards ensure adherence to regulations, enhancing project safety and credibility.

2. Efficiency and Performance: Standardized processes optimize energy use, improve productivity, and reduce costs.

3. Interoperability and Integration: Standards facilitate seamless collaboration and data exchange among stakeholders.

4. Quality Assurance and Improvement: Standardized practices ensure quality, reliability, and continuous improvement throughout the project.

5. Risk Mitigation and Resilience: Standards provide systematic risk assessment and mitigation, enhancing project resilience.

6. Global Recognition: Adhering to standards enhances the project's reputation and market acceptance worldwide.

By embracing international standards, collider projects can achieve greater efficiency, safety, and success, benefiting both stakeholders and society as a whole.

VII. Annex

This section contains information regarding the normative applications of the different international standards, their requirements as well as the justification per section, so that considering it you can opt for the accreditation and certification of standards.

* Cycle of requirements and compliance justifications for each of the standards.

1. ISO 50001 - Energy Management Systems:

Step-by-Step General Requirements:

1.Establishing an energy policy.

2.Planning energy management actions.

3.Implementing energy management actions.

4.Monitoring and measurement of energy performance.

5.Reviewing the energy management system's performance.

6.Continual improvement of the energy management system.

Justification:

Establishing an energy policy: Provide a framework for setting energy-related goals and objectives, aligning with the project's sustainability and cost-effectiveness objectives.

Planning energy management actions: Identifies energy-saving opportunities, resource allocation, and strategies for optimizing energy use within the collider project, ensuring efficient operation.

Implementing energy management actions: Ensures the execution of planned energy-saving measures and initiatives, reducing energy consumption and associated costs.

Monitoring and measurement of energy performance: Enables the assessment of energy consumption patterns, identification of areas for improvement, and tracking progress towards energy-related goals, enhancing accountability and transparency.

Reviewing the energy management system's performance: Facilitates regular evaluation of the effectiveness of energy management efforts, identifying successes, challenges, and opportunities for refinement.

Continual improvement of the energy management system: Promotes a culture of continuous improvement, driving ongoing enhancements to energy efficiency, resource utilization, and environmental sustainability within the collider project.

2. ISO 27001 - Information Security Management Systems:

Step-by-Step General Requirements:

1.Context establishment.

2.Leadership commitment.

3.Planning.

4.Support.

5.Operation.

6.Performance evaluation.

7.Improvement.

Justification:

Context establishment: Identifies the scope, objectives, and external/internal factors relevant to information security within the collider project, laying the foundation for effective management.

Leadership commitment: Demonstrates organizational leadership's commitment to information security, fostering a culture of accountability, awareness, and responsibility among stakeholders.

Planning: Involves risk assessment, risk treatment, and the development of information security objectives and strategies tailored to the collider project's specific needs and requirements.

Support: Ensures adequate resources, competence, awareness, communication, and documentation to support the implementation and maintenance of information security measures.

Operation: Addresses the implementation and execution of information security controls, processes, and procedures to safeguard critical assets, data, and systems against threats and vulnerabilities.

Performance evaluation: Involves monitoring, measurement, analysis, and evaluation of information security performance, compliance, incidents, and effectiveness of controls.

Improvement: Encourages proactive identification of opportunities for enhancing information security posture, addressing deficiencies, and continually adapting to emerging threats and challenges within the collider project.

3. IEC 61508 - Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems:

Step-by-Step General Requirements:

1.Initiation of the safety lifecycle.

2.Concept phase.

3.Implementation phase.

4.Operation and maintenance phase.

5.Modification phase.

6.Decommissioning phase.

Justification:

Initiation of the safety lifecycle: Marks the beginning of the safety lifecycle process, initiating hazard and risk assessment activities and defining safety requirements, ensuring a systematic approach to functional safety from the project's inception.

Concept phase: Involves the development of safety requirements, specifications, and architectural designs, ensuring that safety considerations are integrated into the early stages of system development, minimizing risks and ensuring compliance with safety objectives.

Implementation phase: Focuses on the implementation of safety measures, including hardware and software design, verification, and validation activities, ensuring that safety-critical systems meet specified requirements and standards, and are capable of performing safety functions reliably.

Operation and maintenance phase: Addresses the operational aspects of safety-related systems, including monitoring, maintenance, testing, and periodic inspection activities, ensuring ongoing reliability, availability, and integrity of safety functions throughout the project lifecycle.

Modification phase: Deals with modifications or updates to safety-related systems, including changes in hardware, software, or operational procedures, ensuring that modifications do not compromise the safety integrity level (SIL) or overall safety performance of the system.

Decommissioning phase: Involves the safe disposal or decommissioning of safety-related systems at the end of their lifecycle, ensuring that all safety-critical components are appropriately decommissioned, and residual risks are mitigated to prevent adverse consequences.

4. ISO 19650 - Organization and Digitization of Information about Buildings and Civil Engineering Works:

Step-by-Step General Requirements:

1.Establishing the information requirements.

2.Appointing a project information manager.

3.Implementing a common data environment (CDE).

4.Implementing information management processes.

5.Managing information through the project lifecycle.

6.Collaborative production of information.

7.Verification and validation of information.

8.Asset management and information handover.

Justification:

Establishing the information requirements: Defines the project's information needs, including BIM requirements, ensuring clarity and alignment among stakeholders regarding information exchange and management throughout the project lifecycle.

Appointing a project information manager: Designates responsibility for overseeing information management activities, including the establishment of roles, responsibilities, and processes for information exchange, coordination, and control.

Implementing a common data environment (CDE): Provides a centralized platform for storing, sharing, and managing project information, facilitating collaboration, version control, and access control among project participants.

Implementing information management processes: Defines procedures and workflows for creating, reviewing, approving, and updating project information, ensuring consistency, accuracy, and traceability throughout the project lifecycle.

Managing information through the project lifecycle: Ensures that relevant and up-to-date information is available to stakeholders at each stage of the project, supporting informed decision-making, risk management, and project delivery.

Collaborative production of information: Encourages collaborative working practices and information sharing among project participants, fostering transparency, efficiency, and innovation in project delivery.

Verification and validation of information: Involves quality assurance processes to verify the accuracy, completeness, and compliance of project information with specified requirements, ensuring the reliability and integrity of BIM data.

Asset management and information handover: Prepares for the transfer of project information to asset owners or operators upon project completion, ensuring that relevant information is organized, documented, and accessible for ongoing maintenance and operation activities.

5. ISA 101 - Human-Machine Interfaces (HMIs) for Process Automation Systems:

Step-by-Step General Requirements:

1.Defining HMI philosophy.

2.Developing HMI design requirements.

3.Creating HMI conceptual design.

4.Developing detailed HMI design.

5.Implementing HMI.

6.Verifying and validating HMI.

7.Operating and maintaining HMI.

Justification:

Defining HMI philosophy: Establishes the overarching principles and objectives guiding the design and implementation of HMIs, ensuring consistency, usability, and alignment with operational requirements and user needs.

Developing HMI design requirements: Specifies the functional and performance requirements of HMIs, including graphical elements, navigation, alarms, and interactivity, ensuring that HMIs meet operational, safety, and regulatory standards.

Creating HMI conceptual design: Involves the development of conceptual layouts and prototypes for HMIs, considering factors such as process visualization, information hierarchy, and user workflows, facilitating stakeholder feedback and validation.

Developing detailed HMI design: Refines the conceptual design into detailed specifications and layouts for HMIs, incorporating feedback from stakeholders, usability testing, and best practices in human factors engineering, ensuring intuitive and efficient user interfaces.

Implementing HMI: Involves the deployment and configuration of HMIs within process automation systems, including software installation, hardware integration, and system integration, ensuring seamless interaction between operators and control systems.

Verifying and validating HMI: Conducts testing and validation activities to verify the functionality, performance, and reliability of HMIs, including functional testing, usability testing, and validation against design requirements and operational scenarios.

Operating and maintaining HMI: Addresses the ongoing operation, monitoring, and maintenance of HMIs throughout their lifecycle, including software updates, alarm management, and user training, ensuring continued usability, reliability, and effectiveness in supporting operational activities.

6. ISO 12207 - Software Life Cycle Processes:

Step-by-Step General Requirements:

1.Initiation.

2.Planning.

3.Implementation.

4.Assessment.

5.Deployment.

6.Maintenance.

7.Configuration management.

8.Quality assurance.

Justification:

Initiation: Defines the scope, objectives, and constraints of software development projects, laying the groundwork for effective planning and execution.

Planning: Establishes project plans, schedules, resources, and budgets, ensuring that software development activities are organized and aligned with stakeholder needs and expectations.

Implementation: Involves the creation, coding, and testing of software components, ensuring that they meet specified requirements and quality standards.

Assessment: Evaluates software products and processes to identify defects, assess risks, and verify compliance with requirements and standards.

Deployment: Involves the installation, configuration, and deployment of software products in operational environments, ensuring smooth transition and minimal disruption to users.

Maintenance: Addresses ongoing support, updates, and enhancements to software products, ensuring their continued functionality, security, and performance.

Configuration management: Manages changes to software products and associated documentation, ensuring version control, traceability, and consistency throughout the software life cycle.

Quality assurance: Implements processes and techniques to ensure that software products meet defined quality standards and customer expectations, minimizing defects and improving overall reliability and customer satisfaction.

7. ISO 22514 - Statistical Methods in Process Management - Capability and Performance:

Step-by-Step General Requirements:

1.Defining process characteristics.

2.Selecting statistical methods.

3.Planning data collection.

4.Conducting data collection.

5.Analyzing data.

6.Interpreting results.

7.Implementing improvement actions.

Justification:

Defining process characteristics: Identifies key parameters and variables relevant to the process under study, ensuring clarity and alignment on what aspects of the process will be measured and analyzed.

Selecting statistical methods: Determines appropriate statistical techniques and tools for analyzing process data, ensuring that the chosen methods are suitable for the characteristics of the data and the objectives of the analysis.

Planning data collection: Establishes procedures and protocols for collecting data, including sampling methods, measurement techniques, and data recording formats, ensuring the reliability and consistency of data collected for analysis.

Conducting data collection: Executes the data collection plan, ensuring adherence to established protocols and minimizing sources of bias or error in the data.

Analyzing data: Applies statistical methods to analyze collected data, identifying patterns, trends, and relationships that provide insights into process capability and performance.

Interpreting results: Draws conclusions from the data analysis, evaluating process performance against defined targets or benchmarks, and identifying areas for improvement or optimization.

Implementing improvement actions: Develops and implements corrective or preventive actions based on the findings of the data analysis, aiming to enhance process capability, efficiency, and reliability.

8. ISO 15745 - Industrial Automation Systems and Integration:

Step-by-Step General Requirements:

1.Identifying integration requirements.

2.Defining integration architecture.

3.Selecting integration technologies.

4.Implementing integration solutions.

5.Testing integration solutions.

6.Deploying integration solutions.

7.Monitoring and optimizing integration performance.

Justification:

Identifying integration requirements: Determines the functional and technical requirements for integrating automation systems, ensuring that integration solutions meet the needs of the collider project and its stakeholders.

Defining integration architecture: Specifies the overall structure, interfaces, and interactions of integrated systems, providing a blueprint for designing and implementing integration solutions.

Selecting integration technologies: Evaluates and selects appropriate technologies and standards for implementing integration solutions, ensuring compatibility, interoperability, and scalability.

Implementing integration solutions: Develops and deploys integration solutions based on the defined architecture and selected technologies, ensuring that systems can communicate and exchange data effectively.

Testing integration solutions: Conducts testing and validation activities to verify the functionality, performance, and reliability of integration solutions, ensuring seamless interoperability and data exchange between systems.

Deploying integration solutions: Installs and configures integration solutions in operational environments, ensuring smooth integration into existing systems and processes.

Monitoring and optimizing integration performance: Establishes monitoring and performance measurement mechanisms to track integration performance, identify bottlenecks or issues, and optimize integration processes for efficiency and effectiveness.

9. ISO 13849 - Safety of Machinery - Safety-Related Parts of Control Systems:

Step-by-Step General Requirements:

1.Risk assessment.

2.Determining safety performance level (PL).

3.Designing safety-related parts of control systems.

4.Verifying safety-related parts of control systems.

5.Validating safety-related parts of control systems.

Justification:

Risk assessment: Identifies and evaluates potential hazards associated with machinery and determines the necessary safety measures to mitigate risks, ensuring the safety of personnel and equipment involved in the collider.

Determining safety performance level (PL): Classifies safety functions based on their required performance level, considering factors such as severity of potential injury, frequency of exposure, and possibility of avoiding the hazard, ensuring that safety-related control systems meet specified safety requirements.

Designing safety-related parts of control systems: Develops safety-related components and systems to achieve the required safety performance level, incorporating measures such as redundant safety features, fail-safe mechanisms, and reliable monitoring systems.

Verifying safety-related parts of control systems: Conducts testing and analysis to verify that safety-related components and systems meet design requirements and performance specifications, ensuring their reliability and effectiveness in safeguarding against hazards.

Validating safety-related parts of control systems: Confirms through testing and validation that safety-related components and systems perform as intended under actual operating conditions, ensuring their reliability and integrity in real-world scenarios.

10. ISO 14120 - Safety of Machinery:

Step-by-Step General Requirements:

1.Identifying hazards requiring guarding.

2.Designing guards.

3.Selecting guard materials.

4.Installing guards.

5.Maintaining guards.

Justification:

Identifying hazards requiring guarding: Identifies potential hazards associated with machinery and equipment within the collider project and determines the need for guards to protect personnel from injury or harm.

Designing guards: Develops guard designs that effectively prevent access to hazardous areas while allowing necessary visibility and access for operation and maintenance activities, ensuring both safety and operational functionality.

Selecting guard materials: Chooses appropriate materials for constructing guards based on factors such as durability, strength, and resistance to environmental conditions, ensuring the effectiveness and longevity of the guarding system.

Installing guards: Ensures proper installation of guards according to design specifications and regulatory requirements, preventing bypass or tampering and ensuring the integrity of the guarding system.

Maintaining guards: Establishes procedures for inspecting, repairing, and replacing guards as needed to maintain their effectiveness over time, ensuring ongoing protection against hazards throughout the lifecycle of the collider project.

11. ISO 12100 - Safety of Machinery - General Principles for Design - Risk Assessment and Risk Reduction:

Step-by-Step General Requirements:

1.Identifying hazards.

2.Estimating risk.

3.Evaluating risk.

4.Eliminating or reducing risk.

5.Evaluating residual risk.

Justification:

Identifying hazards: Identifies potential hazards associated with machinery and equipment within the collider project, including mechanical, electrical, chemical, and ergonomic hazards.

Estimating risk: Determines the likelihood and severity of harm resulting from identified hazards, considering factors such as exposure, frequency, and consequences of hazardous events.

Evaluating risk: Assesses the level of risk posed by identified hazards, comparing estimated risk levels against established criteria or tolerances to prioritize risk reduction efforts.

Eliminating or reducing risk: Implements measures to eliminate or mitigate identified hazards, including engineering controls, administrative controls, and personal protective equipment (PPE), reducing the likelihood and severity of harm to personnel.

Evaluating residual risk: Assesses the remaining risk after risk reduction measures have been implemented, ensuring that residual risks are at an acceptable level and providing a basis for ongoing risk management and improvement efforts.