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Towards a Genuine Convergence of Process safety and Asset Management: An Integrative Framework with Composite Metrics

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This study examines the conceptual foundations, methodological approach, comparative analysis, and integration strategy of Asset Management (AM) and Risk-Based Process Safety Management (PSM). Asset Management, as defined by ISO 55000:2024, is the coordinated organizational activity aimed at deriving value from assets through balancing cost, risk, opportunity, and performance. It represents a managerial and cultural shift that extends beyond technical asset control to influence strategic decision-making and organizational objectives. In parallel, Risk-Based Process Safety, as structured by the CCPS, provides a formal and systematic framework to prevent major industrial accidents through proportional risk management, structured governance, and continuous improvement organized into four interdependent pillars. The research adopts a comparative methodological approach, combining documentary analysis with structured analytical mapping of normative frameworks, enabling systematic identification of similarities and differences between AM and PSM. The analysis demonstrates that both systems share core elements, including risk-based thinking, life-cycle orientation, governance structures, performance monitoring, and competence development. Mechanical integrity emerges as a key intersection point, treated explicitly within PSM and implicitly within ISO-based asset management standards. Despite these similarities, the systems differ in primary purpose and scope: PSM focuses on preventing high-consequence events and protecting people and the environment, whereas AM emphasizes sustainable value creation and economic optimization. The study proposes an integrated implementation strategy involving strategic alignment, harmonized requirements, unified governance, integrated critical processes, consolidated performance indicators, capability development, and joint continuous improvement. The findings conclude that structured integration enhances organizational robustness, strengthens asset reliability, reduces systemic risk, and supports sustainable operational, economic, and environmental performance in complex industrial environments.

Keywords: Process safety, asset management, ISO 55001, ISO 31000

1. Introduction

According to ISO 55000:2024 (ISO, 2024), Asset Management is the coordinated activity of an organization to derive value from assets. Achieving value typically involves balancing costs, risks, opportunities, and performance benefits. The term “activity” may also refer to the application of the elements of an asset management system. The word “activity” has a broad meaning and may include, for example, the approach, planning and plans, as well as their implementation.

According to Lafraia (2024), asset management is not the same as managing assets. Asset management is far more concerned with management itself than with technical actions performed on assets. When studying asset management, it should not be surprising that it does not address, in great technical detail, the administration of life cycle stages. The emphasis lies on managing the competencies that enable individuals to practice sound management.

As stated by Azevedo (2019), asset management is a managerial process that involves balancing costs, risks, opportunities, and performance benefits, and this balance may need to be considered across different time horizons. Asset management can only be effective when embedded in the context of achieving organizational objectives.

Asset management represents a cultural shift in corporate strategic planning by adding to the traditional focus on products and customers a perspective centered on assets and the value they are capable of generating for the business. Conceptually, it marks the beginning of a new era in corporate management, to be practiced by those seeking business excellence. Asset management is not limited to managing property; it extends beyond operational boundaries to influence business strategy.

Practicing asset management in accordance with the ISO 55K standards (ISO, 2024) means adopting an international framework to derive value from assets while achieving a balance among performance, associated costs, and related risks.
In turn, the Risk-Based Process Safety model was developed to enhance the effectiveness of management systems aimed at preventing major accidents in the process industries, structuring practices in proportion to the magnitude of hazards and levels of risk involved (CCPS, 2007).

The process safety approach recognizes that technological, human, managerial failures and external factors may contribute to catastrophic events, historically highlighting deficiencies in management systems. It therefore proposes a formal, documented, and sustainable system in which the level of detail and rigor is defined based on the understanding of risks, the demand for process safety activities, and the prevailing organizational culture. The model emphasizes resource prioritization, the use of performance and efficiency metrics, and periodic management reviews.

The structure of Risk-Based Process Safety is organized into four interdependent pillars, comprising twenty elements.

The first pillar addresses commitment to process safety, encompassing organizational culture, regulatory compliance, technical competence, workforce involvement, and stakeholder engagement.

The second pillar focuses on understanding hazards and risks, including process knowledge management and the systematic identification and analysis of risks throughout the facility life cycle.

The third pillar is dedicated to managing risk through operating procedures, safe work practices, asset integrity and reliability, contractor management, training and performance assurance, management of change, operational readiness, conduct of operations, and emergency management.

The fourth pillar emphasizes organizational learning through incident investigation, the use of metrics, auditing, and management review, thereby promoting continuous improvement. The model encourages integration with other corporate systems to reduce the frequency and severity of incidents and to sustain safe, environmental, and business performance over time (CCPS, 2007).

Process Safety likewise represents a cultural shift in operational management by integrating into the traditional focus on production and efficiency a perspective centered on incident prevention, protection of people, assets, and the environment, and business continuity through strategies that prevent and mitigate releases, dispersions, fires, and explosions.

The implementation of process safety is not limited to the application of technical rules; it transcends operational controls and permeates strategic decisions, influencing planning, risk management, and resource allocation.

Practicing Risk-Based Process Safety in accordance with recognized international standards (CCPS, 2006; ISO, 2018) means adopting a structured approach to identify, assess, and control risks in industrial processes, ensuring the protection of people and assets, system reliability, and the balance among operational performance, costs, and risk exposure.

Despite the numerous similarities and potential synergies between the two management systems, the approach of treating them separately still persists, as if no substantial gains could be achieved through the integration of these important systems.

2. Research Method

The integration between Process Safety Management (PSM) and Asset Management (AM) is rigorously investigated through the comparative method, which is particularly well suited to the analysis of complex organizational structures. The comparative method consists of the systematic identification of similarities and differences among phenomena in order to understand patterns, relationships, and causal explanations (Gil, 2019; Lakatos and Marconi, 2021).

From a research design perspective, the study may be classified as exploratory-explanatory, combining documentary analysis with a comparative case study approach. The first stage involves constructing an analytical matrix based on the normative frameworks of PSM and AM, enabling the comparison of governance principles, risk management practices, organizational competencies, and continuous improvement mechanisms (ABNT, 2014; CCPS, 2007). This stage corresponds to systematic documentary analysis, as recommended by Gil (2019).

This methodological approach makes it possible to understand how the articulation between process risk management and asset life cycle management contributes to the reduction of systemic failures and to sustainable organizational performance.

3. Comparison Between Management Systems

Within the framework of risk-based process safety management, mechanical integrity is treated as a formal management system designed to ensure that equipment and systems containing hazardous substances or energy remain fit for service throughout their entire life cycle, thereby preventing large-scale accidental releases.

The proposed approach to mechanical integrity goes beyond isolated inspection and maintenance activities by structuring a systemic program that integrates policies, clearly defined responsibilities, compliance with technical standards, personnel qualification, document control, and continuous improvement. A mechanical integrity program within risk-based process safety management must encompass critical equipment such as pressure vessels, piping systems, storage tanks, relief devices, instrumentation systems, and utilities essential to operational safety.

Such a program relies on defined criteria for scope determination, development of inspection, testing, and preventive maintenance plans, as well as risk-based prioritization. It emphasizes quality assurance in the procurement of materials and spare parts, inspector certification, and traceability of executed activities. The systematic collection and analysis of inspection data are considered fundamental to assessing equipment condition, adjusting inspection intervals, and identifying degradation trends.

The effectiveness of mechanical integrity within a risk-based process safety management system depends on integration with other process safety elements, including management of change, operational readiness, and incident investigation. Organizational culture, leadership commitment, and the use of performance indicators are also decisive factors in sustaining asset reliability over time. By consolidating technical and managerial principles, this approach provides a structured basis for preventing failures caused by corrosion, fatigue, manufacturing defects, or inadequate maintenance, thereby contributing to the reduction of major accident risk and to the preservation of operational safety and reliability (CCPS, 2006).

From the perspective of asset management, as established in ISO 55000 (ISO, 2024a) and ISO 55001 (ISO, 2024b), the term “mechanical integrity” is not explicitly used. Nevertheless, the principles and requirements set forth in these standards systemically incorporate the technical and managerial foundations necessary to preserve the physical condition and functional performance of assets throughout their life cycle.

ISO 55000 (ISO, 2024a) defines asset management as the coordinated activity of an organization to realize value from assets, establishing that such value derives from balancing cost, risk, opportunity, and performance. By recognizing risk as the combination of the probability of failure and its consequences, the standard implicitly encompasses risks associated with physical degradation, corrosion, fatigue, structural failures, and other mechanisms typically addressed in mechanical integrity programs. Maintaining asset performance therefore presupposes systematic control of technical condition.

ISO 55001 (ISO, 2024b), in specifying requirements for an asset management system, reinforces this approach. In the planning clause, the organization is required to determine risks and opportunities that may affect the achievement of asset management objectives, including risks arising from physical failures. Similarly, in the operations clause, adequate operational planning and control are required, including the definition of performance criteria and the implementation of plans to ensure that assets fulfill their intended functions. These requirements support the need for inspections, testing, condition monitoring, and structured maintenance.

Additionally, the support and performance evaluation clauses of ISO 55001 (ISO, 2024b) require the maintenance of technical competence, control of documented information, and systematic monitoring of performance and reliability indicators. These elements are essential to ensure that assets remain fit for service and that their condition is continuously evaluated and improved.

Process Safety Management (PSM) and Asset Management (AM) are therefore complementary disciplines, although they differ in primary focus. Both operate within structured organizational systems, adopt a risk-based approach, and depend on governance, technical competence, and continuous improvement. However, they differ in strategic purpose, scope, and operational emphasis.

Common elements include a risk-based approach, requiring systematic identification, analysis, and treatment of risks. Process safety focuses on catastrophic event risks, such as large releases of hazardous substances or energy, whereas asset management addresses risks affecting value, performance, and sustainability. Both disciplines adopt a systemic life-cycle perspective—from design through decommissioning—and rely on formal processes, controlled documentation, and organizational integration. Asset integrity and reliability are essential in both contexts: in PSM, integrity prevents major accidents; in AM, it ensures performance, availability, and value generation. Both also require active leadership, clearly defined responsibilities, technical competence, and performance indicators.

Key differences lie in strategic purpose, conceptual scope, metrics, and organizational emphasis. PSM primarily seeks to prevent high-consequence accidents and protect people, the environment, and facilities, whereas AM aims to maximize organizational value through balancing cost, risk, opportunity, and performance. PSM concentrates on industrial processes involving hazardous substances or significant energy, while AM applies to any class of assets—physical, financial, informational, or intangible. PSM metrics emphasize incident rates, barrier effectiveness, and reliability of critical safety systems, whereas AM metrics include economic and operational indicators such as availability, life-cycle cost, and return on investment. Finally, PSM is strongly oriented toward regulatory compliance and safety barrier management, whereas AM emphasizes corporate governance and sustainable value creation.

4. The integration of the systems

Process Safety may be understood as a specialized discipline focused on the prevention of high-severity events, whereas Asset Management constitutes a broader managerial system oriented toward the generation of organizational value. The intersection between the two occurs primarily in the management of technical risks, asset integrity, and the need for evidence-based decision-making. When integrated, they simultaneously reinforce operational safety and sustainable performance.

From an analytical perspective, Process Safety Management (PSM) concentrates on the integrity of safety barriers and the reliability of critical systems, while Asset Management (AM) expands the scope to include economic performance, operational availability, and strategic sustainability. Their convergence lies in the management of technical risks, the physical integrity of assets, and data-driven decision-making. In systemic terms, PSM may be regarded as a specialized subsystem within the broader AM framework when addressing high-risk industrial assets.

An integrated implementation should be structured through coordinated stages:

a) Strategic alignment – Define a single corporate policy that recognizes process safety as an essential component of value generation. Integrate safety and asset performance objectives into strategic planning.

b) Mapping and harmonization of requirements – Conduct a comparative analysis of the requirements of both systems, identifying overlaps (risk management, competence, integrity, management of change) and eliminating documentary redundancies.

c) Unified governance – Establish a clear organizational structure with integrated roles and responsibilities. Create a multidisciplinary committee to oversee decisions involving risk, reliability, and asset investment.

d) Integration of critical processes – Align risk management, management of change, operational readiness, and incident investigation procedures with maintenance planning, condition monitoring, and performance evaluation processes.

e) Single performance indicator system – Develop an integrated dashboard including safety metrics (barrier indicators, near misses) and asset performance metrics (availability, life-cycle cost).

f) Culture and capability development – Promote technical and managerial training that links asset reliability to accident prevention and value generation.

g) Integrated continuous improvement – Conduct combined audits and periodic management reviews to ensure consistency among safety, performance, and sustainability objectives.

This strategy reduces organizational silos, avoids duplication, and simultaneously strengthens operational protection and sustainable value creation.

5. Conclusion

The comparative analysis between Process Safety Management (PSM) and Asset Management (AM) demonstrates that, although they have distinct conceptual origins and specific strategic purposes, both converge on essential foundations: a risk-based approach, systemic perspective, life-cycle orientation, structured governance, organizational competence, and continuous improvement. Process Safety focuses on the prevention of high-severity events and the preservation of critical safety barriers, whereas Asset Management is directed toward the sustainable generation of value through balancing cost, risk, opportunity, and performance.

The integration of these systems does not constitute a mere overlap of requirements, but rather an opportunity for mutual reinforcement. The physical and functional integrity of assets, a central element of process safety, is likewise an indispensable condition for the performance and reliability required by asset management. Similarly, the strategic governance and decision-making discipline inherent in asset management enhance the effectiveness of process safety practices, providing them with greater economic and organizational coherence.

An integrated implementation strategy demonstrates that it is feasible to harmonize policies, processes, performance indicators, and governance structures, thereby reducing redundancies and eliminating functional silos. By aligning safety objectives with performance and value targets, the organization begins to treat accident prevention not as an isolated cost, but as an intrinsic component of operational and reputational sustainability.

It can therefore be concluded that the structured integration of PSM and AM promotes greater organizational robustness, strengthens asset reliability, reduces the likelihood of systemic failures, and sustains economic, environmental, and social outcomes over time. In complex, high-risk industrial environments, this convergence represents not merely a sound managerial practice, but a strategic requirement for excellence and long-term organizational continuity.

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