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Common Pitfalls in PSM Assessment - Case Studies and Lessons Learned

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Process Safety Management (PSM) is essential for mitigating risks in high-hazard industries, yet many organizations encounter challenges in implementation. DEKRA’s 7-workstream PSM model streamlines the CCPS 20-pillar framework, covering procedural, technical, and cultural areas. Case studies of the DEKRA PSM model highlight common pitfalls, such as relying on irrelevant KPIs, ineffective risk assessment frameworks, and weak leadership and cultural management. Pre-implementation KPIs often focus on lagging indicators like incident reports and regulations, which address past issues rather than preventing future risks. This approach overlooks leading indicators, such as near-miss reporting and hazard identification, which are crucial for anticipating potential risks. Improper risk assessment frameworks often miss hazard prioritization, leading to regulatory non-compliance and inconsistent safety performance This can lead to regulatory non-compliance and an inability to enhance safety over time, increasing the risk of operational failures and incidents Effective PSM requires strong leadership, and resource allocation, and open communication to build a proactive safety culture, with psychological safety enabling employees to report risks without fear, and ensuring continuous improvement and risk reduction. Organizations must take a holistic approach to PSM to overcome these challenges, aligning KPIs with continuous risk reassessment and avoiding reliance on completed PSM recommendations as the sole measure of success. The increasing complexity of the process industry calls for incorporating Artificial Intelligence (AI) and machine learning, for accurate risk prediction and system effectiveness of PSM systems.

* 1. Introduction

Process Safety Management (PSM) is a structured approach aimed at preventing accidents and managing the risks associated with complex industrial processes. Although numerous PSM frameworks are available, organizations frequently encounter obstacles in effectively assessing and implementing PSM systems. These challenges often stem from procedural inefficiencies, poorly designed risk assessment methodologies, and weak cultural support within the organization. Through an in-depth analysis of case studies where DEKRA's 7-workstream PSM model was applied, this article explores common pitfalls and provides actionable insights to help organizations strengthen their PSM frameworks.

* + 1. DEKRA’s Process Safety Management Model

To have and guide a systematic PSM, there are various frameworks such as:

* OSHA PSM standard outlined in 29 CFR 1910.119. This standard has 14 key elements aimed at controlling highly hazardous chemicals (U.S. Department of Labor, 1992).
* Seveso directive Safety Management system is similar to OSHA’s Process Safety Management system but is more extensive, as it also addresses environmental protection and public safety. The PSM system in SEVESO is built around 10 key elements aligned with European regulations and the specific requirements of the SEVESO Directive. ((Seveso), 2012)
* The Energy Institute PSM system is a comprehensive safety framework specifically designed for the energy sector, including oil, gas, and other energy-related industries. This framework consists of 20 key elements. (Energy Institute, 2010)
* The CCPS (Center for Chemical Process Safety) Model is a comprehensive model with 20 pillars, focusing on a range of safety aspects from risk analysis to emergency preparedness ((CCPS), 2007).

DEKRA’s model integrates these aiming for an efficient approach to PSM that prioritizes procedural, technical, and cultural factors. The model’s focus on simplification and actionable insights helps address common issues in PSM, particularly around assessment and implementation gaps (Table 1).

*Table 1: DEKRA’s 7-pillar framework*

|  |  |  |
| --- | --- | --- |
| # | Workstream | CCPS Elements |
| 1 | Competency | * Compliance with standards * Process knowledge management * Process safety competency * Training and Performance Assurance |
| 2 | Incident Response | * Stakeholder Outreach * Emergency Management * Incident Investigation |
| 3 | Risk Management | * Hazard Identification and Risk Analysis |
| 4 | Asset Integrity | * Asset Integrity and Reliability * Management of Change |
| 5 | Accountability | * Measurement and Metrics * Auditing * Management Review and Continuous Improvement |
| 6 | Operations | * Operating Procedure * Safe Work Practices * Operational Readiness * Contractor Management |
| 7 | Culture and Organization | * Process safety culture * Workforce Involvement * Conduct of Operations - Operational Discipline |

Building on the CCPS framework, DEKRA developed OPS (Organizational Process Safety) to be adaptable across various industries and to address the unique safety challenges organizations face. OPS introduces several enhancements, including a maturity model that measures the effectiveness of PSM practices. This model provides companies with an objective, precise, and repeatable way to assess their safety management maturity across a spectrum of six levels, from "Unaware" to "Excellence" (Table 2).

The Process Safety Maturity indicators described in Table 2 provide benchmarking of individual site performance against industry best-in-class. These metrics also allow for to definition of improvement areas and can be presented using a spider’s web graphic (Figure 1) to highlight strengths and weaknesses in an easily understood format. This output will be used in the debrief session(s) to facilitate discussion and debate around the direction and pace of improvement of PSM.



Figure 1 DEKRA PSM Performance Radar

*Table 2: Maturity Levels Definitions*

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Process safety Maturity | Avoidance- Driven | | Compliance- Driven | | Values- Driven | |
| Maturity Level | Oblivious | Embryonic | Basic | Advancing | Continuous Improvement | Process Safety Excellence |
| Short Description | No organized process safety activities | Responds to recognized process safety problems | Does minimum required by regulations | Meets regulatory requirements and has more rigorous internal standards in at least some aspects of process safety | Formal efforts to understand and move toward achieving best-in-class performance | Demonstrates best-in-class performance, with ongoing efforts at continuous improvement |
| Focus | Avoidance | Responding | Compliance | Managing | Learning | Anticipation and Resilience |
| Capability | No specific process safety expertise | Individuals with some process safety knowledge but no organized structure | Process Safety expertise and defined roles & responsibilities | Process Safety expertise and defined R&R with a widespread understanding of process safety requirements | Same as the “Advancing” level, plus active management involvement in process safety | Same as the “Continuous Improvement” level, plus active external networking and engagement of senior executives |
| Systems Characteristics | o process safety systems | Pockets of good practices | Process safety management systems exist and are documented | Auditing process & control loops work, PS actions are followed and implemented | Thorough PSM systems as well as efforts to reinforce the culture that supports process safety | Systems are mature and the culture required to make them efficient is embedded |
| Short Description | No organized process safety activities | Responds to recognized process safety problems | Does minimum required by regulations | Meets regulatory requirements and has more rigorous internal standards in at least some aspects of process safety | Formal efforts to understand and move toward achieving best-in-class performance | Demonstrates best-in-class performance, with ongoing efforts at continuous improvement |

* 1. Common Pitfalls in PSM Assessment

Despite the availability of robust frameworks, PSM assessments are often undermined by several recurring issues. Based on DEKRA’s experience, the most common pitfalls include ineffective selection of KPIs, inadequate risk assessment frameworks, and deficiencies in cultural and leadership practices. In the next paragraphs, these aspects will be analysed to illustrate the common pitfalls and describe the possible approaches to be adopted.

* + 1. Inefficient risk assessment

Risk assessments are one of the most important safety procedures for any industrial setting since they have a large role in ensuring safety by identifying major accident scenarios. Nevertheless, several long-standing problems limit their efficiency and accuracy.

Accurate and up-to-date Process Safety Information (PSI) is the first step in conducting a proper risk assessment. Yet, several organizations fail as they face the problem of cluttered documentation, poor data quality, and stale information. During some of DEKRA’s PSM audits, it has been found that the necessary data was stored in a personal folder or even in the email inbox, without saving it in the related work folder; therefore, these necessary documents were not available for all related functions. Centralizing PSI in a shared and regularly updated digital repository is fundamental to ensure the availability of documentation to all personnel and departments. By leveraging real-time operational data using AI tools, records would now be updated automatically and always consistent, making them more freely accessible.

Together with the accurate and up-to-date PSI, it is fundamental to conduct the risk assessment properly (e.g., HAZOP study) since, if not well-focused, it will directly affect the outcome of risk assessment. Some of the key aspects of performing a high-quality risk assessment are:

* A good (and independent) chairman: leaders should be properly trained and competent in both technical and management aspects, to properly stimulate the discussion among the team and critically evaluate the resulting hazardous scenarios.
* Proper timing for the assessment: too early or too late risk assessment will lead to a loss of the cost benefits of this risk assessment; early stage risk assessment (e.g., when P&IDs are not yet detailed with operating process information) will make the exercise less impactful leading to the necessity to repeat the assessment later, while too late risk assessment could impact on the economic aspect of the project in case of required modifications. In general, proper scheduling of the project is fundamental to obtaining high-efficiency risk assessment with the minimum economic impact.
* Risk assessment team knowledge: people involved in risk assessments usually have no training to be able to participate. This can lead to identifying or overlooking hazards and failure to offer workable solutions. Reflecting, organizations need to ensure they have adequate targeted training programs in place. One of the best ways to practice is by running simulated Risk assessment sessions.
* Risk Matrix: not calibrated risk matrix can lead to misinterpretations or poor prioritization since the analysis may be too general, not considering unique aspects of a project, or lacking enough granularity to differentiate between extreme scenarios with low versus high severity risks. It is recommended to adopt an internationally recognized and agreed risk matrix to ensure adequate risk acceptability criteria (Reducing risk, Protecting People, 2001).
* Recommendations: risk assessments frequently lead to recommendations that everyone knows are impractical, such as No accountability for risk mitigation and No follow-up method for implementation tracking or effectiveness verification. Recommendations should be SMART (Specific, Measurable, Achievable, Relevant, and Time-bound); also leveraging a Dynamic Risk Register makes it possible to track recommendations continuously by assigning responsibility and sending automatic reminders for overdue actions.

Furthermore, risk assessment outcomes often lead to complex and long-term improvement plans which, in turn, lead to the need for continuous updating of the risk assessment results. Moreover, due to the increasing complexity of the industrial plants, it is more and more difficult to evaluate the effectiveness of implemented recommendations in reducing the risk level and to track the very high number of modifications that could be present in a facility (very often, MOC procedures are not sufficient or incomplete). In this regard, it is more and more important to understand and evaluate the benefits coming from the implementation of AI in risk assessment techniques and management systems: AI streamlines conventional risk management approaches by providing solutions that accelerate, optimize, and modernize the system. DEKRA developed AI-based tools, called Digital PHA and Dynamic Risk Registers (DRR), that can help in having a continuously updated risk assessment; these tools can support the organizations not just in mitigating the existing risks but also in preparing them for any new challenge that may arise in the near or long term.

* + 1. Cultural and Leadership Deficiencies

Culture within an organization reflects its shared beliefs, norms, and assumptions, and leadership plays a critical role in shaping and sustaining it. In organizations that prioritize safety, leadership is at the forefront because it drives culture. When leadership and cultural issues arise, they often lead to systemic problems that compromise safety, hinder operational efficiency, and lower employee morale. Supporting employees on the front lines isn’t just about training—it’s about creating an environment where culture, leadership, and systems work together seamlessly. To truly enable people to work safely, they must be at the center of the safety strategy, but this also requires aligning other elements like processes and communication. Poor management—characterized by unclear roles, lack of accountability, and rigid hierarchies—blocks collaboration and prevents important safety issues from being addressed. Employees often stay silent about hazards when they fear retaliation or get bogged down by excessive bureaucracy. Safety-focused organizations go beyond compliance. Meeting regulatory requirements is just the starting point, not the goal. A culture driven by compliance alone risks neglecting proactive safety efforts, which are critical for reducing risks and fostering engagement. Employees who feel undervalued or unsupported are less likely to follow safety protocols, report hazards, or contribute to improvements. This disengagement weakens the organization’s ability to maintain a safe environment.

Delays in risk assessments or safety planning can lead to significant problems. For example, conducting a safety assessment after purchasing equipment often results in costly retrofits and compromises safety. A culture of blame only makes matters worse, discouraging openness, hiding mistakes, and preventing learning from past incidents. Without understanding the root causes, organizations are bound to repeat errors. Knowledge is another critical factor. When leaders or employees lack the skills to identify and manage risks, small issues can escalate into major crises. Specialized knowledge, whether it’s technical, safety-related, or human-focused, is essential for making informed decisions that protect both people and productivity. Research highlights that leadership commitment and safety culture are fundamental for effective Process Safety Management (PSM). A study on industrial corporations emphasizes that leadership must actively support safety initiatives by fostering an open communication culture, investing in employee training, and integrating safety into decision-making processes. By utilizing self-evaluation checklists and quantitative tools like the Relative Efficiency Indicator, organizations can assess and improve their PSM effectiveness (Markowski et al., 2021). A proactive approach to safety requires strategic planning. Without a clear plan, organizations waste resources reacting to problems instead of preventing them. Anticipating risks early and integrating safety into every step of a project leads to better outcomes and avoids costly last-minute fixes. Safety must be a core value embedded in every decision and process. Everyone in the organization, from leaders to employees, should be empowered to recognize hazards, assess risks, and take effective action. Instead of focusing solely on avoiding accidents, efforts should shift to reducing exposure to risks and addressing the conditions that lead to incidents before they occur. When employees feel safe to speak up about risks, near misses, or concerns without fear of punishment, organizations can learn and improve. Building a culture that values collaboration, trust, and continuous learning unites teams under a shared commitment to safety. With strong leadership and the right systems in place, organizations can create a workplace where safety isn’t just a priority—it’s a way of life.

* + 1. Ineffective Key Performance Indicators (KPIs)

KPIs in PSM can measure, monitor, and improve safety performance effectively. KPIs should ideally provide clear insights into safety conditions and help drive the right behaviors. However, organizations frequently encounter issues with their KPIs, which can undermine safety efforts in several ways, since they rely heavily on lagging indicators, which measure incidents that have already occurred, such as injury rates or incident counts.

Traditional safety metrics, which focus on historical data, predominantly rely on what are known as lagging indicators. These indicators provide retrospective insights into past events and performance but offer limited predictive value for future safety outcomes. Common examples of lagging indicators in industrial settings include recordable injuries, lost time incidents (LTIs), days without accidents, and mean time between failures. While these metrics are critical for compliance and post-event analysis—organizations are often legally required to track and report them—they do not proactively address potential hazards or risks. Consequently, relying solely on lagging indicators can be likened to navigating a vehicle by only looking in the rearview mirror: it provides no foresight into future dangers or risks. In contrast, leading indicators are proactive measures that provide foresight by identifying potential issues before they result in negative outcomes, such as accidents or injuries. Among the most vital leading indicators in the context of safety management is the concept of exposure. Exposure measures the degree to which an organization or its workforce is vulnerable to potential hazards. This concept can be analogized to the idea of an individual being exposed to a disease: just as exposure to pathogenic agents increases the likelihood of contracting the disease, exposure to workplace hazards heightens the risk of an accident or injury. By monitoring exposure levels, organizations gain insight into the conditions that could lead to an incident, even before one occurs. Several major safety investigations highlight the importance of focusing on exposure and not just historical incident data. The Baker Report, which analysed the 2005 BP Texas City refinery explosion (Baker, 2007), illustrated the dangers of focusing on a single safety metric, such as the OSHA recordable injury rate. The overemphasis on reducing this lagging indicator led to a false sense of safety, masking underlying systemic issues in the organization’s safety culture and operational procedures. This single-minded approach failed to address the organization's broader, more complex safety dynamics. Similarly, the investigation into the Deepwater Horizon (BP national Commission, 2011) oil spill uncovered a similar trend, where the company’s safety practices were dominated by a focus on lagging indicators, with insufficient attention paid to the real-time safety conditions and the actual state of exposure in high-risk activities. In both cases, the organizations did not fully appreciate that to build a truly effective safety culture, the focus must shift from simply tracking outcomes (like injuries) to actively managing and mitigating risk factors before they result in harm. For safety efforts to be truly transformative and impactful, they must move away from merely reacting to accidents and towards reducing exposure to hazards. The goal should not be simply to avoid incidents (which are the consequences of unsafe conditions) but to reduce the very conditions that enable these incidents to occur in the first place. In other words, the key to improving safety performance is not only in examining past incidents but also in proactively identifying and reducing the factors that increase vulnerability to future risks.

* 1. Conclusions and Lessons Learned

From the different case studies analysed, to truly understand both the quality and completeness of PSM activities, any evaluation must consider three categories: Procedural, Technical, and Cultural aspects. These are broadly outlined as follows:

* Technical aspects refer to the quality of the activity that occurs. It is important to assess the quality of the hazard analysis to ascertain how well the PHA identified hazards and mitigation measures, whether the mitigation measures are appropriate to the identified hazards, and whether those measures were implemented. Moreover, the Management of Change (MOC) process has revealed critical gaps, particularly in addressing even minor modifications (see 2.1);
* Cultural aspects refer to how well the organizational culture supports the reliable and consistent use of PSM systems and the engagement of employees at all levels in process safety. Both of these things are critical to achieving the desired results and need to be evaluated thoroughly in PSM audits (see 2.2);
* Procedural aspects refer to the examination of the procedures that have been established for their adequacy and using sampling to ascertain the extent to which they are reliably followed. This is where many process safety management audits and assessments stop (see 2.3).

From the analysis of the three common pitfalls reported in this paper and from DEKRA PSM experience, it is known that poor management on these three highlighted topics could have a huge impact on the safety level of a company. Nevertheless, by having proper and comprehensive PSM (including the 7 DEKRA’s pillars) it is possible to define and issue applicable guidelines to be adopted according to the company characterization and prevent serious incidents, so the result can be to have SMART recommendations and a robust culture to enhance safety levels at all levels of the organization (Table 3). Moreover, adopting AI could lead to tremendous improvements in terms of predictive analysis in real-time (e.g., using Dynamic Risk Register – DRR).

Table 3: Common pitfalls and suggested actions

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| --- | --- |
| Common Pitfalls | Suggested Actions |
| Technical | Develop a comprehensive methodology that not only facilitates the integration of changes but also ensures the necessary updates to critical documentation in response to modifications. This approach is essential for maintaining accuracy and consistency in documentation, thereby supporting operational safety and efficiency |
| Cultural | Conduct surveys within all the shareholders (from the management to the operators), creating promoting campaigns and ensuring specific trainings for the personnel, promoting a virtuous circle in which Safety is considered a benefit instead of a cost/compliance to be fulfilled |
| Procedural | The drafting of procedures must aim at their effectiveness, always including safety aspects.  The relation between the procedures issuing process and their implementation should be strengthened, ensuring to exploit their potential as a practical tool that enhances both operational efficiency and plant safety. |

Nomenclature

AI – Artificial Intelligence

CCPS – Center for Chemical Process Safety

DRR – Dynamic Risk Register

HazId – Hazard Identification analysis

HazOp – Hazard and Operability analysis

KPIs – Key Performance Indicators

LTIs – Lost Time Incidents

MOC – Management Of Change

OPS – Organizational Process Safety

OSHA – Occupational Safety and Health Administration

P&ID – Piping and Instrumentation Diagram

PHA – Process Hazard Analysis

PSI – Process Safety Information

PSM – Process Safety Management

SIL – Safety Integrity Level

SMART – Specific, Measurable, Achievable, Relevant and Time-bound

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