System and Best Practices to Manage the MOC Digital Transition Closed-Loop Model to Optimize Management of Change

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Management of Change (MOC) is one of the key elements in any modern model of a safety management system. Due to the dynamic nature of the oil and gas industry, frequent changes are essential to maintain facilities and optimize production. Changes come with associated risks that require effective management to ensure safe and effective execution. The MOC system includes identifying, reviewing and authorizing changes that are not replacement-in-kind to ensure any potential adverse impact is addressed. The system also involves documenting and communicating changes to affected employees. Failure of the MOC system has been considered as a major contributor to incidents in the industry. Both operational and organizational changes, if not managed well, can lead to major industrial incidents. For example, improper control of changes has been identified as a major contributor to the Flixborough disaster in 1974, and Texas City Refinery explosion in 2005. Improving the implementation of MOC requires a healthy system in place and adequate levels of competency. In addition, digitalizing the MOC system can enhance effectiveness of risk management when the integration and transition, from manual to digital practices, are managed effectively. The paper proposes a closed-loop model to systematically overcome challenges related to the implementation of the MOC process within the oil and gas industry, with provisions to ensure prioritised continuous improvement. Additionally, it discusses the digitalization challenges and focus areas to ensure effective deployment.

The failure of the MOC system can have different causes. The main cause is the failure to trigger the MOC process to manage applicable changes. This is still being identified as a contributory factory to major incidents in the industry. Other challenges include failure to implement adequate hazard identification and risk assessments, failure to revalidate control measures as part of temporary changes, and failure to update process safety information. A closed-loop model (between the technical authority and the auditing function) will systematically drive prioritised improvements with fit-for-purpose safety tools.

In addition, emerging technologies and digital solutions for MOC can enable better management of risks by minimizing human errors, improving efficiency, and simplifying the process implementation. Likewise, big data and advanced analytics can uncover invisible patterns and correlations. Like any other digitalization change, digitalizing the MOC process comes with its own challenges that could lead to unintentional results such as overwhelming the operator with unnecessary alarms/notifications, losing track of objectives due to the visibility of large volumes of data, missing the opportunity to drive effectiveness with unconventional Key Performance Indicators (KPIs), and losing the required technical expertise as a result of automation.

Keywords

Process Safety Management System (PSM), Management of Change (MOC), Risk Management, Risk Assessment, Process Safety Digital Transformation, Oil & Gas.

Management of Change Definition and Scope

Management of Change (MOC) is a process for evaluating and controlling modifications to facility design, operation, organization or activities, prior to implementation, to make certain that no new hazards are introduced and that the risk of existing hazards to employees, the public, or the environment is not unknowingly increased (CCPS, 2008). The process includes authorization of changes, risk assessment, documentation, communication. The MOC scope includes any change (e.g., operation, organization, software.) that is not a replacement-in-kind (RIK). RIK is defined as an item that meets the design specification of the item it is replacing, either identical replacement or any other alternative specifically provided for in the design specification, as long as the alternative does not in any way adversely affect the function or safety of the item or associated items (CCPS, 2008). Classification of changes vs. RIK can be a challenging and time-consuming task due to the dynamic nature of the oil and gas industry that requires frequent changes (e.g., as part of maintenance activities, operation optimization, upgrading projects), especially when this classification is made for each change. To overcome this challenge, a pre-identified list of typical identical changes can be identified with their associated implementation procedures. The list should be documented as part of the MOC process and communicated to all personnel.

Industrial Background

MOC has been identified as a significant contributor to major incidents in the industry, and its percentage contribution to incidents rate has not decreased over the last two decades (Han Siong P., 2017). The visible importance of MOC is cited back to the vapor cloud explosion incident in Flixborough, England, in March 1974. The explosion happened as a result of an uncontrolled change (i.e., due to a failed temporary bypass line around the fifth of a series of six cyclohexane reactors) leading to 28 fatalities and 89 injuries, including off-site injuries. Improper design of this change (i.e., large pipes with bellows) was identified as a key contributing factor to this incident (CCPS, 2007). In addition, the series explosions that occurred at the Texas City refinery in March 2005 is another example where MOC was identified as a key contributing factor. The incident resulted in 15 fatalities and 180 injuries. The investigation findings included improper siting of portable buildings, unassessed and unauthorized changes to operating procedures and ineffective management of organizational changes (CSB, 2007).

Modern frameworks for process safety management (PSM) systems have MOC as one element, underlining its importance. Table 1 below lists well-known PSM frameworks and the corresponding MOC element.

#	SAFETY MANAGEMENT FRAMEWORK	MANAGEMENT OF CHANGE ELEMENT
1	OSHA Process Safety Management (14 elements)	Element # 13
2	CCPS Risk Based Process Safety Management (20 elements)	Element # 13
3	EI High Level Framework for Process Safety Management (20 elements)	Element # 12

Table 1: MOC Element in PSM Frameworks

Typical MOC Challenges

There are various challenges in the implementation of the MOC process as it involves several activities interfaced with other Process Safety Management elements (e.g., hazard identification and risk assessment, Pre-Start-up Safety Reviews, Process Safety Information). According to the Center for Chemical Process Safety (CCPS), the MOC process includes maintaining a dependable practice, identifying potential change situations, evaluating possible impacts, authorizing the change and completing follow-up activities (CCPS, 2008). First, second, and third-party audits can identify site-specific challenges in the MOC implementation and drive effective improvements. The common challenge in the MOC implementation is the failure to trigger the process to manage applicable changes (i.e., leading to creeping changes that are accumulated uncontrolled changes that could lead to major incidents). This is still being identified as a contributory factor to major incidents, as demonstrated in Table 2.

	Incident	MOC Contribution
1	2001 Delaware City Refinery Explosion (1 killed, 8 injured, offsite environmental impact)	Failure to trigger MOC process for converting an atmospheric storage tank from fresh to spent acid service. (CSB, 2002)
2	2003 Hayes Lemmerz International Aluminium Dust Explosion (1 killed, 6 injured)	Failure to trigger MOC process for the new dust collector installed less than 50 feet from buildings/contractor trailers. The engineering control/approval process incorporated only an informal review of safety issues and applied only to capital projects. (CSB, 2005)
3	2005 Texas City Refinery Explosion (15 killed, 180 injured)	Failure to trigger the MOC process for the modification of start-up procedures. (CSB, 2005)
4	2014 DuPont La Porte Chemical Facility Toxic Release (4 killed)	Failure to trigger MOC process for using hot water to heat the piping of methyl mercaptan liquid, for piping alignment to nitrogen relief valves or for draining liquid from waste gas vent header (draining activity was not governed by a specific procedure). (CSB, 2019)

Table 2: Major Incidents in the Industry with "MOC not Triggered" as a Contributing Factor

There are other challenges related to MOC implementation including failure to implement adequate hazard identification and risk assessment, failure to revalidate control measures as part of temporary changes, and failure to update process safety information. All challenges can be addressed through a closed-loop model as discussed in the following section.

Proposed Closed-Loop Model to Overcome MOC Challenges

Responsive governance is necessary to systematically drive MOC improvements. A closed-loop performance model is proposed to bridge the gap between audit findings and the technical authority. As a result, fit-for-purpose requirements, guidelines, technical training and awareness publications can be developed to bridge the gaps. To synchronize these provisions and the implementation practices, the auditing function should conduct up-to-date deep-dive assessments focused on measuring the effectiveness of implementation. The proposed closed-loop model, outlined in Figure 2, links the auditing function with the technical authority responsible for establishing governing requirements.

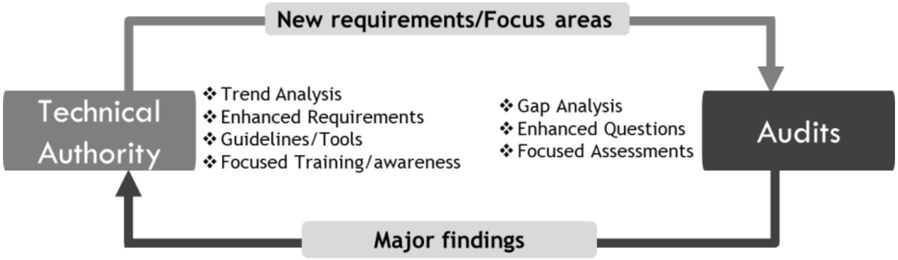

Figure 2: Proposed Closed-Loop Model to Drive Prioritised Improvements in the MOC System

Major findings from audits are provided to the technical authority to enable regular trend analyses and reveal common/repeated findings. Consequently, new requirements, and supplementary guidelines/tools should be introduced to bridge the identified gaps. Additionally, technical training and awareness material should be developed/updated to educate employees and equip them with the necessary knowledge to adequately implement the new requirements. The three-focus areas are summarized in Figure 3.

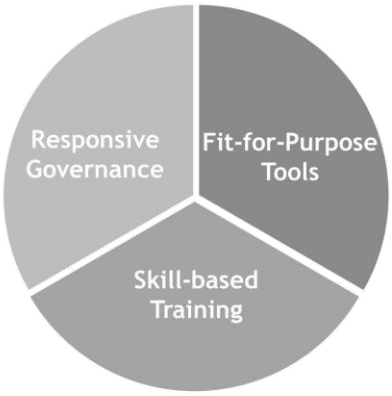

Figure 3: Technical Authority Focus Areas to Address Major/Repeated Audit Findings

For example, applying these focus areas to address the repeated finding of "Uncontrolled Changes" and to prevent pile up of "Creeping Changes," the technical authority can:

1- Enhance governing requirements with elevated accountability to identify and analyse uncontrolled changes as part of regular duties (e.g., inspections, annual first party audit, safety management committee meetings).

2- Develop a checklist-based tool to identify various types of uncontrolled changes with a focus on the most repeated uncontrolled changes.

3- Continuously improve knowledge and hands-on provisions in technical courses to educate frontline personnel on how to avoid uncontrolled changes and how to identify and address them.

New requirements developed by the technical authority, as a result of analysing the audit's findings, can be communicated to the auditors to measure the effectiveness of implementation. The auditing party will need to regularly conduct a gap analysis on the auditing tool (e.g. questionnaire, checklists, etc.) to enable fit-for-purpose deep-dive assessments. This will augment the audit function and help companies ensure that their Process Safety Management programs are working as intended.

Sustaining this closed-loop model can drive systematic and prioritised improvements consistently across facilities. Effective management of closed-loop performance (i.e., taking action based on the results of performance monitoring to generate updated plans and goals to drive business value and impact) will require a combination of management processes including a metrics framework and applications that support real-time access to operational data, coupled with technologies for collaboration and alerts to enable other applications or users to define, agree and monitor actions based on feedback (Gartner, 2021).

Digital Transformation: Process Safety Opportunity with Emerging Challenges

The rapid advance of digitalisation can simplify day-to-day functions and deliver business needs in a more reliable, sustainable, and safe way. Digital transformation in the oil and gas industry extend to Process Safety Management and can play a role in reducing human error, simplifying processes and minimizing risk exposure for personnel. Digital provisions include real-time analytics, inspection robotics, mobile connectivity, big data, cloud computing, and artificial intelligence (AI). Therefore, a digital MOC solution will optimize a closed-loop performance. Additionally, it will provide the following advantages:

- Enhance visibility of MOC to all personnel (including all levels of management) through cascading dashboards.

- Drive consistent implementation across facilities with a standardized approach of managing changes (will also facilitate benchmarking between facilities).
- Provide insights from real-time analytics to enable better and swift decision-making.
- Improve audits with the ability to conduct comprehensive analyses, compared with the traditional data collection/sampling method that is error-prone and time-consuming.
- Detect uncontrolled changes in real-time (requires integration with other processes and deployment of Wi-Fi/ connectivity capabilities).

Like any other digitalization change, digitalizing the MOC process comes with its own challenges that could lead to unintentional consequences, such as overwhelming the operator with abundance of unnecessary alarms/notifications, losing track of objectives due to the large volume of data, missing the opportunity to drive effectiveness with unconventional Key Performance Indicators (KPIs), and losing the required technical expertise as a result of automation.

Alarm Management

Automated processes usually come with alarm provisions that are essential to close the loop. Responsibility for acting on alarms in digitalization extend from the control room operator to other functionaries such as team leaders/members, engineering/maintenance personnel, management, etc. Therefore, it is vital to manage alarms to ensure personnel are not overloaded and/or distracted. Special attention should be given to field operators who might be equipped with hand-held devices and/or smart helmets that are connected to the digital MOC solution. A risk assessment will be necessary to identify and assess the alarms types/priorities, required response time, required actions, available manpower, etc. Accordingly, roles and responsibilities in internal processes should be updated to reflect any new provisions.

Noisy Data

Large volumes of data as a result of digitalization will enable Big Data analyses that can augment the decision-making process with new types of insights. The availability of large volumes of data could also create a situation of noisy data (i.e., a large amount of additional corrupt data, meaningless data, less relevant data, etc.). This situation can lead to wasted time and effort in understanding irrelevant information and trends. Therefore, identifying the required data points from the design stage and ensuring agility of the digital solution to modify data points are essential to produce meaningful results.

Behavioural Key Performance Indicators

Monitoring performance through KPIs will be improved in the digital era. For example, the availability of a wide range of data and the ability to easily develop and monitor behavioural KPIs will provide value added insights. Ensuring the agility of the digital solution to enable users to customize KPIs is an essential feature to drive continuous improvement (i.e., the ability to promptly adapt to changes that are needed either as a result of lessons learned or to achieve future strategic objectives). The ability to drill down into the KPIs' components by defining the building blocks will set the foundation for machine learning.

In addition, the enhanced ability to develop and monitor behavioural KPIs will provide more insights that will drive the behavioural change and bridge the gap between employees' training/qualifications and the organization's objectives. Such KPIs will be useful to manage human resources and address human factors as demonstrated through the examples in Table 3.

	Behavioural KPIs	Expected Insights
1	Frequency of MOCs	Drop or fall may indicate the MOC system is not being used effectively (e.g., due to qualifications of new involved personnel).
2	Percentage of MOCs authorized at the correct level	High percentage indicates adequate level of leadership engagement in the MOC system.
3	Average time to complete MOC activities	Increasing time to complete activities may indicate overloaded personnel and the need for more resources.
4	Frequency of change of reviewers	High frequency may indicate a habit of delegating technical review tasks to less experienced employees.
5	Number of escalated tasks	High frequency may indicate limited resources to effectively complete MOCs on time.

Table 3: Examples of Behavioural KPIs Facilitated by Digital Capabilities vs. Expected Insights

Integration and Legacy Data

Comprehensive integration of business processes is essential to facilitate automation and share data across applications. The digital MOC solution should have the capability to transfer and receive data from all business processes rather than developing a standalone MOC provision as part of different projects because MOC controls a wide range of changes including those in processes, maintenance/inspection, organizational, spare parts, etc. Digitalization of MOC processes as part of different projects can lead to duplication of process, unnecessary costs (e.g., purchasing and maintaining the additional solutions), and manual transfer of data to implement other processes (e.g., an MOC needed to close a HAZOP recommendation will need to be transferred from the MOC digital solution to the asset management solution where HAZOP is being implemented). To overcome this challenge, the MOC digital solution should be integrated with existing and new business process (e.g., by Robotic Process Automation).

In addition, legacy data (e.g., closed MOCs, open MOCs in the existing system) should be part of the digitalization scope to facilitate tracking, implementation, and incident investigation post-digitalization. Additionally, this will alleviate the burden on frontline personnel in navigating more than one system.

Operating Procedures

The digital disruption will change the way businesses operate. For example, automation will eliminate some job functions, while advanced analytics will require prompt decision making when certain thresholds are reached, connectivity/mobility will introduce new tasks as part of operators' daily rounds, etc. As a result, a review of the operating procedures should be part of the digitalization project to synchronize both the expectations and the new digital provisions.

Technical Expertise

Automating routine/repetitive tasks will increase efficiency and reduce human errors. However, this will entail modifying job functions (e.g., removing/de-manning, reskilling, upskilling). A comprehensive skills assessment should be part of the digitalization project to ensure the job-function modification process will not eliminate critical technical expertise. Knowledge and experience in process safety management in the oil and gas industry is fundamental to manage the risk to acceptable levels. In addition, such expertise is required to ensure sustainable advancement of digital solutions while meeting the intent of process safety management.

Conclusion

Changes are inevitable in the oil and gas industry, and they are essential to maintain and improve operations. Despite the MOC process having been established in the industry for a few decades, uncontrolled changes continue to contribute to major incidents. Additionally, the provisions of auditing and regular reviews have not bridged this gap. This paper proposes a closed-loop model between the auditing function and the technical authority to enable prioritised improvements in the MOC process. The model will systematically link identified focus areas (by audits) with the technical authority to produce fit-for-purpose safety tools on a sustainable basis (i.e., requirements, guidelines, training). Consequently, the safety tools will feed the auditing function to update their auditing protocols to drive effective implementation of MOC requirements across facilities.

Digital Transformation projects are envisioned to optimize closed-loop performance, with the swift and sustainable ability to identify gaps in a more comprehensive way, and closing them. Additionally, artificial intelligence capabilities will enable the identification of vast types of uncontrolled changes before they even occur. Digitalizing the MOC process comes with its own challenges that could lead to unintentional results (e.g., losing track of objectives due to a large volume of data, losing the required technical expertise as a result of automation, etc.). Adequate design reviews by process safety experts is essential to ensure the digital deliverables will function as intended and also to identify and address any unintended consequences.

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