2

RELATIONSHIP TO RISK BASED PROCESS SAFETY

The Center for Chemical Process Safety (CCPS) has published *Guidelines for Risk Based Process Safety* (RBPS), a comprehensive look at the next-generation process safety management (PSM) system.[8] These management of change (MOC) guidelines are intended to be consistent with the principles in that book.

2.1 BASIC CONCEPTS AND DEFINITIONS

This chapter reviews terminology necessary for understanding how MOC systems fit within the RBPS management system and how readers can use these guidelines to help achieve accident prevention, preparedness, and response goals.

2.1.1 Process Safety and Risk

Process safety deals with the prevention of catastrophic releases of chemicals or energy from systems handling hazardous substances that could affect workers, the community, the environment, or business continuity. Risk deals with the lack of certainty about the ability to be accident-free and is best described by the following basic risk questions concerning a process or operation:

- What can go wrong?
- How likely is it?
- What are the impacts?

Based on the level of understanding of answers to these three basic risk questions and knowledge of regulatory and other constraints, a company can determine how it can best manage change in order to manage risk. Early in the life cycle of a process (i.e., conceptual design), limited information typically exists to answer all three of these questions – normally only enough information exists to understand the hazards of the chemicals/process. Once a process moves into the detailed design stage or is put into operation at a site, more detailed answers to these three questions can be discovered.

Understanding of risk helps a company decide how to shape its PSM activities. Even in a highly regulated environment, process safety professionals have a wide range of options to choose from when deciding how much technical rigor to incorporate into the PSM activities at their facilities. Sometimes this flexibility is limited by regulatory constraints, which define a minimum standard of performance for process safety activities. In some cases, an industry consensus standard or internal company requirement may shape or limit the process safety professional's design or improvement options. The range of options may be further constrained by corporate policies, standards, or guidelines.

Understanding risk is the most important part of a foundation for determining the type, capability, and dependability of the MOC system a facility needs.

2.1.2 Management Systems

Causes of chemical process accidents fall into one or more of the following categories:

- Technology failures
- Human failures
- Management system failures
- External circumstances/natural disasters

For many years, companies focused their accident prevention efforts on addressing technology and human factors. Incidents continued to occur despite industry efforts. In the mid-1980s, following a series of serious chemical accidents around the world, companies, industries, and governments began to focus on management systems (or lack thereof) as the underlying cause of these accidents. As a result, a large effort was launched to find ways to accelerate the industry adoption of a management systems approach to solving process safety problems.

Management system approaches had already begun to take root in the area of product quality, as evidenced by the establishment of various Total Quality Management frameworks. Moreover, the evolution of integrating manufacturing excellence into the business model has helped focus attention on boosting PSM performance.

A management system is a framework for getting work done in a dependable way over a long time. In the U.S., the introduction of these approaches prompted companies to initiate somewhat fragmented hazard analysis and equipment integrity efforts. Eventually, companies realized that an integrated management systems approach might be useful in focusing future accident prevention activities.

Management systems need to address certain issues in order to be comprehensive and dependable. Table 2.1 lists important issues that should be addressed in any management system. A PSM system that focuses on work activities to prevent, prepare for, mitigate, or respond to accidental releases should also address these issues – either in each individual PSM element [e.g., roles and responsibilities in an MOC or process hazard analysis (PHA written program] or in a single PSM element (e.g., auditing issues are all contained in the auditing element).

Whether designing or reconfiguring individual elements or the entire PSM system, the items in Table 2.1 should be used to ensure that the management systems issues that are essential for success are being addressed.

Because of the breadth and complexity of the activities within their scope, PSM systems are typically broken down into a layered hierarchy. The most basic level within a PSM system is the element. *MOC is an element within the CCPS RBPS system structure.* A written program for MOC should address all of the components in Table 2.1.

TABLE 2.1. Important Issues to Address in a Process Safety Management System

- Purpose and scope
- Personnel roles and responsibilities
- Tasks and procedures
- Necessary input information
- Anticipated results and work products
- Personnel qualifications and training
- Activity triggers, desired schedule, and deadlines
- Resources and tools needed
- Continuous improvement
- Management review
- Auditing

2.1.3 Life Cycles of Processes and Management Systems

Physical processes have life cycles consisting of several stages: conceptual design, research and development, detailed engineering design, procurement, construction, startup, normal operation, maintenance and turnarounds, and decommissioning. The names, numbers, and sequence of life-cycle stages vary across industries and companies; no commonly accepted set of descriptors exists. *MOC is an important activity in each life-cycle stage.* For simplicity, in this book CCPS chooses to use the following definitions for life-cycle stages:

- Process development
- Detailed design
- Construction and startup
- Operating lifetime
- Extended shutdowns
- Decommissioning

Like physical processes, management systems also experience life-cycle stages, even if a company does not explicitly recognize such stages. Thus, management systems should also be carefully designed, built, started up, operated, maintained, and eventually shut down or decommissioned.

2.1.4 Responses to Management System Problems

As PSM systems operate, they occasionally become defective, less effective, or fall into disuse. Facility management will typically diagnose and control the performance of its PSM system using a variety of means and sources of information. One typical approach is the use of an audit, whereby independent personnel evaluate the PSM activities to determine whether the PSM system is adequate and is being implemented in a dependable fashion. These audits can be resource-intensive and are typically performed at one- to three-year intervals. In between these audits, management is increasingly using metrics to monitor the PSM system on a more real-time basis.

PSM systems or elements that are found to be nonconforming (typically via PSM audits) − or even worse, chronically deficient − require correction. Companies that are fortunate enough to have PSM systems that run relatively problem-free still search for ways to improve their systems. *MOC is typically a very active management practice. Many companies focus a lot of attention on auditing and improving MOC systems.*

To help structure the discussion of PSM (or MOC) improvement, the following terms are defined below: performance, efficiency, effectiveness, and improvement.

Performance is reflected by the success with which the PSM/MOC work products from a specific PSM/MOC activity meet the company-defined standard for quality, thoroughness, and timeliness. PSM/MOC performance can be measured by outcome-oriented event indicators (e.g., incident rates) or process-related leading indicators (e.g., rate of improperly performed MOC activities).

On a company level, event indicators may be sufficient to provide an idea of where the company is going with respect to process safety; however, their power to discriminate and diagnose is limited. But on a site or process level, these statistics are not enough to help a company determine how close to the edge it is and where improvements need to be made. On the local level, PSM/MOC element leading indicators are one of the few ways that show promise in helping companies monitor the risk-health of their facilities.

Efficiency is reflected by the amount of resources used to create the desired PSM work product. Typically, resources are expressed in monetary terms or in terms of time spent in creating the work product. An adequate work product that costs less to make than it did last year is said to have been created more efficiently.

Effectiveness, therefore, is defined as the functional combination of performance and efficiency:

Effectiveness = function of [Performance & Efficiency]

To improve PSM/MOC effectiveness, a company can attempt one or more of the following:

- Achieve better results with no increase in costs
- Reduce costs while maintaining the same level of performance
- Improve performance and increase efficiency at the same time

Improvement efforts can address performance issues, efficiency issues, or both. Continuous improvement implies that the improvement activity is accomplished on a more regular, rather than episodic, basis. Thus, continuous improvement in PSM/MOC effectiveness must embody (1) regular, consistent activities and (2) tangible, positive changes in performance, efficiency, or both.

The following sections describe the RBPS system and the MOC system hierarchy.

2.2 OVERVIEW OF THE RBPS SYSTEM

An RBPS system addresses four accident operation pillars: (1) committing to process safety, (2) understanding hazards and evaluating risk, (3) managing risk, and (4) learning from experience. To manage risk, facilities focus on three aspects:

- Disciplined operation and maintenance of processes that pose residual risk and their associated protective systems
- Controlling changes to those processes and protective systems to avoid inadvertent risk increases
- Preparing for, responding to, and managing incidents that do occur

Efforts to control change-induced risk revolve around two RBPS elements: management of change and operational readiness. This section covers the attributes of an effective MOC system.

2.2.1 Risk Based Process Safety Management System Approach

RBPS is founded on the principle that appropriate levels of detail and rigor in process safety practices should be premised on the following three factors:

- Current understanding of the risk of the processes on which the process safety practices are focused
- Level of demand for the process safety activity (e.g., the number of changes that need review per month) and the sustainable resources available to support implementation over the life of the facility
- Existing company culture within which the process safety practices will be implemented

In this risk-based, layered approach, the right level of practices can be designed and implemented in a way that (1) optimizes PSM performance, efficiency, and effectiveness and (2) avoids gaps, inconsistencies, overwork, underwork, and associated process safety risks and economic risks.

Process safety professionals may have a wide range of options to choose from when deciding how much technical rigor to incorporate into their company/facility PSM activities. Sometimes this flexibility is limited by regulatory constraints, which define a minimum standard for pursuit of the process safety activity. In some cases, an industry consensus standard or internal company requirement may shape or limit a company’s MOC system design/improvement options.

In either case, these requirements may be written in a prescriptive form or in a performance-based fashion. Prescriptive requirements state precisely how the process safety activity is to be conducted and what the activity is to produce. Performance-based requirements are more flexible because they specify only what is to be accomplished and leave the method for generating the desired results up to the company/facility or the process safety professional in charge of the activity.

A main focus of the RBPS approach is to help process safety professionals build and operate more effective PSM systems by providing guidance on how to design or improve a specific process safety activity so that the energy put into the activity is sufficient to meet the anticipated needs for that activity. In this way, limited company resources can be focused elsewhere to generate improved safety and economic performance.

Higher-risk situations usually require a more formal and thorough implementation of an MOC protocol (e.g., a detailed written program that specifies exactly how changes are identified, reviewed, and managed). Companies having lower-risk situations may appropriately decide to manage changes in a less rigorous fashion (e.g., a general policy about managing changes implemented by trained key employees using informal practices).

Facilities that experience high demand for managing changes may need greater specificity in the MOC procedure and greater allocation of personnel resources to fulfill the defined roles and responsibilities. Lower-demand situations allow facilities to operate an MOC protocol with greater flexibility.

Facilities with sound safety cultures generally have MOC procedures that are more performance based, allowing trained employees to use good judgment when managing changes in an agile system. Facilities with an evolving or uncertain safety culture generally require more prescriptive MOC procedures, more frequent training, and stronger command and control management system features to ensure disciplined MOC implementation.

2.2.2 Risk Based Process Safety Elements

Table 2.2 lists the elements in the CCPS RBPS model.[8]

2.2.3 RBPS System Design Hierarchy

The level of rigor that any particular company or facility applies to establishing or improving an MOC system should be based on the RBPS criteria: perceived hazard/risk, demand for resources, and culture. The following sections provide an overview of MOC practices that are in use in industry today. Increasingly greater detail is provided as one goes deeper into the MOC element structure given in the RBPS guidelines book (summarized in Appendix B of this guideline), which is organized as follows:

- ***Element*** (e.g., management of change)
- ***Key Principle*** (e.g., identify potential change situations)
- ***Essential Feature*** (e.g., all sources of change are managed)
- ***Possible Work Activity*** (e.g., develop a list of areas to which MOC applies)
- ***Implementation Options*** (e.g., an MOC coverage list is maintained and communicated)

TABLE 2.2. CCPS Risk Based Process Safety Elements

Commit to Process Safety
1. Process Safety Culture
2. Compliance with Standards
3. Process Safety Competency
4. Workforce Involvement
5. Stakeholder Outreach
Understand Hazards and Evaluate Risk
6. Process Knowledge Management
7. Hazard Identification and Risk Analysis
Manage Risk
8. Operating Procedures
9. Training and Performance
10. Safe Work Practices
11. Asset Integrity and Reliability
12. Contractor Management
13. Management of Change
14. Operational Readiness
15. Conduct of Operations
16. Emergency Management
Learn from Experience
17. Incident Investigation
18. Measurement and Metrics
19. Auditing
20. Management Review and Continuous Improvement

The following section discusses only the MOC key principles and essential features. Additional details about possible work activities are provided in Chapter 15 of the *RBPS Guidelines* and in Appendix B of this book.

2.2.4 Key Principles and Essential Features of MOC Systems

A company should address the following MOC key principles:

- Maintain a dependable MOC practice
- Identify potential change situations
- Evaluate possible impacts
- Decide whether to allow the change
- Complete follow-up activities

Section 2.1 of this guideline defines the generic requirements of a management system (roles and responsibilities, scope, task procedures, etc.).

Readers should keep these requirements in mind as they seek to implement a comprehensive MOC system in a risk-appropriate fashion. Some facilities may decide to implement an MOC system at the key principle level of rigor. Other facilities may decide that greater rigor is required, and they explicitly implement the essential features for each key principle by identifying effective work activities to accomplish each essential feature in the MOC system. Following is a brief description of each of the MOC key principles and a list of the essential features that support each key principle.

Maintain a Dependable MOC Practice

If a PSM activity is important enough to have been identified as something that should be done, then it is likely that the company/facility will want the activity to be performed in a fashion that is consistent over the life of the facility. In order for an MOC practice that applies to a variety of people and situations to be executed dependably throughout a facility, the following essential features should be considered:

- Establish consistent implementation
- Involve competent personnel
- Keep MOC practices effective

Identify Potential Change Situations

Modifications cannot be evaluated unless they are known. Companies/ facilities should implement effective means of identifying the types of modifications that are anticipated and the sources/initiators of these modifications. In order for an MOC system to address all potentially significant change situations, the following essential features should be considered:

- Define the scope of the MOC system
- Manage all sources of change

Evaluate Possible Impacts

Once potential change situations are identified, they can be evaluated using an appropriate level of scrutiny to determine whether the change introduces a new hazard or exacerbates the risk of an existing one. In order for companies/ facilities to adopt and implement appropriate review protocols for relevant change types, the following essential features should be considered:

- Provide appropriate input information to manage changes
- Apply appropriate technical rigor for the MOC review process
- Ensure that MOC reviewers have the appropriate expertise and tools

Decide Whether to Allow the Change

Once a change has been reviewed and the hazard/risk evaluated, management can decide whether to (1) approve the change for implementation as requested and thus accept any associated risk, (2) require amendment to the change request or the implementation process, (3) require that a more rigorous hazard evaluation be conducted, or (4) deny the change request. In order for companies/facilities to adopt and implement appropriate MOC approval protocols, the following essential features should be considered:

- Authorize changes
- Ensure that change authorizers address important issues

Complete Follow-up Activities

Once a change is authorized, it is released for implementation. Typically, the execution of a change is performed via work practices under other RBPS elements (e.g., mechanical integrity, operating procedures, safe work practices) by facility personnel or contractors involved in design, engineering, construction, operation, or maintenance. Prior to startup of the change (i.e., exposure of personnel to the modified situation, which could create new hazards or increase risk), certain activities may be required by the MOC procedure or the reviewers/authorizers (e.g., update process drawings, train affected personnel, implement required risk control measures).

Sometimes action items may be deferred until after startup; these items should be minimized and carefully tracked to completion to avoid potential failure to implement them. In order for companies/facilities to ensure that approved changes are properly followed up on, the following essential features should be considered:

- Update records
- Communicate changes to personnel
- Enact risk control measures
- Maintain MOC records

Chapters 3 and 4 of this book provide insights into how to design and develop an MOC system containing work activities to address each of the key principles and essential features mentioned above. Chapter 5 addresses how to diagnose and correct a seriously defective MOC system. Chapter 6 addresses how to improve the effectiveness of an existing, mature MOC system.

Note: The possible work activities, implementation options, and effectiveness improvement ideas found in the RBPS guidelines book and in the MOC system design tool described in Appendix B of this book may not be appropriate for every situation. Management should evaluate its own circumstances and determine the extent to which these activities are appropriate.

2.2.5 Interaction among MOC and Other RBPS Elements

The MOC system interacts with many other PSM elements because it is the day-to-day risk “watchdog.” Many elements provide inputs to the MOC system, and the MOC system provides work products or action item requirements that will be executed by other RBPS elements as a result of authorized change requests. Table 2.3 lists the interactions that the MOC system typically has with other RBPS elements.

In addition, the MOC element may interact with other non-PSM management systems. For example, some companies may use their PSM MOC system as a way to manage changes unrelated to process safety issues (e.g., security, environmental, quality). In addition, depending upon the life-cycle stage at which changes are managed, the MOC system may interact with other systems or activities, such as project management, budgeting, and product development.

TABLE 2.3. MOC Inputs and Outputs

RBPS Element	Inputs to MOC from the Element	Outputs from MOC to the Element
Process Knowledge Management	• Chemical/process hazard information • Drawings • Equipment specifications • Safe operating limits • Safety system definitions	• Updates to all relevant process safety information, knowledge, and records
Hazard Identification and Risk Analysis	• Indication of process/activity risk • Risk tolerance criteria • Safety systems • Recommendations needing to be managed as changes	• Results of MOC hazard evaluation
Training and Performance	• Job qualifications • Staffing (number, composition, and required competencies)	• Information on changes to inform or train potentially affected contractor personnel • Changes to all process safety knowledge and documentation
Operating Procedures	• Operating procedures	• Changes needed to affected operating procedures
Asset Integrity and Reliability	• Maintenance procedures • ITPM frequencies • Personnel qualifications	• Updates to affected maintenance procedures, frequencies, and personnel
Safe Work Practices	• Safe work practice procedures • Criteria for applying procedures	• Updates needed to affected procedures, application criteria, and personnel
Operational Readiness	• Items discovered during a PSSR that require change to the process prior to start-up	• Change situations requiring PSSR • Results of MOC hazard evaluation • Risk control measures mandated by MOC review process
Contractor Management	• Qualification requirements • Training requirements	• Information on change to inform or train potentially affected contractor personnel • Changes to all process safety knowledge and documentation • Change implementation timing