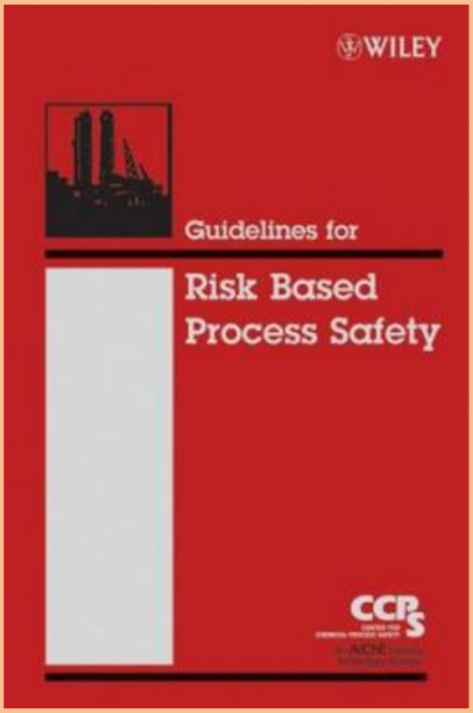
An AIChE Technology Alliance

CCPS

Center for Chemical Process Safety

Guidelines for Risk Based Process Safety

A summary of risk based process safety (RBPS) management approach as detailed in ***Guidelines for Risk Based Process Safety***



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Acronyms and Abbreviations

AIChE	American Institute of Chemical Engineers
CCPS	Center for Chemical Process Safety
EPA	U.S. Environmental Protection Agency
HIRA	hazard identification and risk analysis
ITPM	inspection, testing, and preventive maintenance
KSA	knowledge, skills, and ability
MOC	management of change
MSDS	material safety data sheet
OSHA	U.S. Occupational Safety and Health Administration
RBPS	risk-based process safety

1. INTRODUCTION

Process safety management is widely credited for reductions in major accident risk and improved process industry performance. Process safety practices and formal safety management systems have been in place in some companies for many years. Over the past 20 years, government mandates for formal process safety management systems in Europe, the U.S., and elsewhere have prompted widespread implementation of a management systems approach to process safety management.

However, after an initial surge of activity, process safety management activities appear to have stagnated within many organizations. Incident investigations continue to identify inadequate management system performance as a key contributor to the incident. And audits reveal a history of repeat findings indicating chronic problems whose symptoms are fixed again and again without effectively addressing the technical and cultural root causes.

While all of these issues may not have occurred in your company, they have all happened to some degree in other companies. Left unchecked, such issues can do more than cause stagnation; they can leave organizations susceptible to losing their focus on process safety, resulting in a serious decline in process safety performance or a loss of emphasis on achieving process safety excellence. This is one of the reasons the Center for Chemical Process Safety (CCPS) created the next generation process safety management framework – ***Risk Based Process Safety (RBPS)*****.**

1.1 Purpose of These Guidelines

The purpose of these *RBPS Guidelines* is to help organizations design and implement more effective process safety management systems. These *Guidelines* provide methods and ideas on how to (1) design a process safety management system, (2) correct a deficient process safety management system, or (3) improve process safety management practices. The RBPS approach recognizes that all hazards and risks in an operation or facility are not equal; consequently, apportioning resources in a manner that focuses effort on greater hazards and higher risks is appropriate. Using the same high-intensity practices to manage every hazard is an inefficient use of limited resources. A risk-based approach reduces the potential for assigning an undue amount of resources to managing lower-risk activities, thereby freeing up resources for tasks that address higher-risk activities.

These *Guidelines* offer two central strategies for how companies can succeed in applying their management system:

- ***Use RBPS criteria to design, correct, or improve process safety management system elements***. Review the work activities associated with each element and update them based on:
  (1) An understanding of the risks associated with the facilities and operations.
  (2) An understanding of the demand for process safety activities and the resources needed for these activities.
  (3) An understanding of how process safety activities are influenced by the process safety culture within the organization.
- ***Focus on process safety effectiveness as a function of performance and efficiency***. Use metrics to measure performance and efficiency so that finite resources can be applied in a prioritized manner

to the large number of competing process safety needs. Use management reviews to verify that the organization is doing the right things well in its journey toward process safety excellence.

1.2 Background

Causes of chemical process incidents can be grouped in one or more of the following categories:

- Technology failures
- Human failures
- Management system failures
- External circumstances and natural phenomena

For many years, companies focused their accident prevention efforts on improving the technology and human factors. In the mid-1980s, following a series of serious chemical accidents around the world, companies, industries, and governments began to identify management systems (or the lack thereof) as the underlying cause for these accidents. Companies were already adopting management systems approaches in regard to product quality, as evidenced by various Total Quality Management initiatives, with widely reported success. Companies developed policies, industry groups published standards, and governments issued regulations, all aimed at accelerating the adoption of a management systems approach to process safety. Thus, the initial, somewhat fragmented, hazard analysis and equipment integrity efforts were gradually incorporated into integrated management systems. The integrated approach remains a very useful way to focus and adopt accident prevention activities. More recently, inclusion of manufacturing excellence concepts has focused attention on seamless integration of efforts to sustain high levels of performance in manufacturing activities. Done well, manufacturing excellence deeply embeds process safety management practices into a single, well-balanced process for managing manufacturing operations.

1.3 Management Systems Concepts

In RBPS, the term **management system** means:

> ***A formally established and documented set of activities designed to produce specific results in a consistent manner on a sustainable basis.***

These activities must be defined in sufficient detail for workers to reliably perform the required tasks.

For process safety management, the CCPS initially compiled a set of important characteristics of a management system, which were published in the *Guidelines for Technical Management of Chemical Process Safety*. The CCPS gleaned those important characteristics from interactions with its member companies and traditional business process consulting firms that had significant experience in evaluating management systems. Those guidelines were the first generic set of principles to be compiled for use in designing and evaluating process safety management systems.

1.4 Application of *RBPS Guidelines*

In general, the RBPS management system is meant to address process safety issues in all operations involving the manufacture, use, or handling of hazardous substances or energy. Each company must

decide which physical areas and phases of the process life cycle should be subject to RBPS, using the risk-based thought process to decide the depth of detail to use in meeting process safety objectives.

2. OVERVIEW OF RISK BASED PROCESS SAFETY

2.1 Strategic Approaches to Process Safety Management

Over the years, the process industries have evolved several strategic approaches for chemical accident and loss prevention (Figure 1). At any given time, industries, companies, and facilities will not find themselves at the same point along this spectrum. In fact, different departments within a facility, different functions within a department, or the same departmental function at different times may choose to implement multiple strategies at the same time.

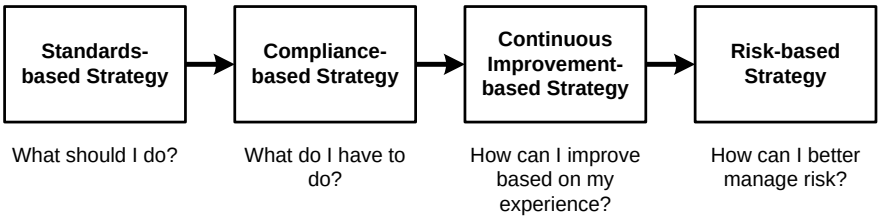

FIGURE 1. Evolution of Process Safety and Accident/Loss Prevention Strategies

Understanding the risk associated with an activity requires answering the following questions:

- What can go wrong?
- How bad could it be?
- How often might it happen?

Based upon the level of understanding of these answers, a company can decide what actions, if any, are needed to eliminate, reduce, or control existing risk.

2.2 Risk Based Process Safety Design and Improvement Criteria

The main objective of this RBPS approach is to help an organization build and operate a more effective process safety management system. These *Guidelines* describe how to design or improve each process safety activity so that the energy put into the activity is appropriate to meet the anticipated needs for that activity.

The RBPS strategic approach is founded on the principle that appropriate levels of detail and rigor in process safety practices are predicated on three factors:

- A sufficient understanding of the risk associated with the processes on which the process safety practices are focused.

- The level of demand for process safety work activity (e.g., the number of change requests that must be reviewed each month) compared to the resources that are available.
- The process safety culture within which the process safety practices will be implemented.

3. INTRODUCTION TO RBPS MANAGEMENT SYSTEM PILLARS (MAIN FOUNDATIONAL BLOCKS)

An RBPS management system incorporates four main accident prevention pillars (foundational blocks) (Figure 2).

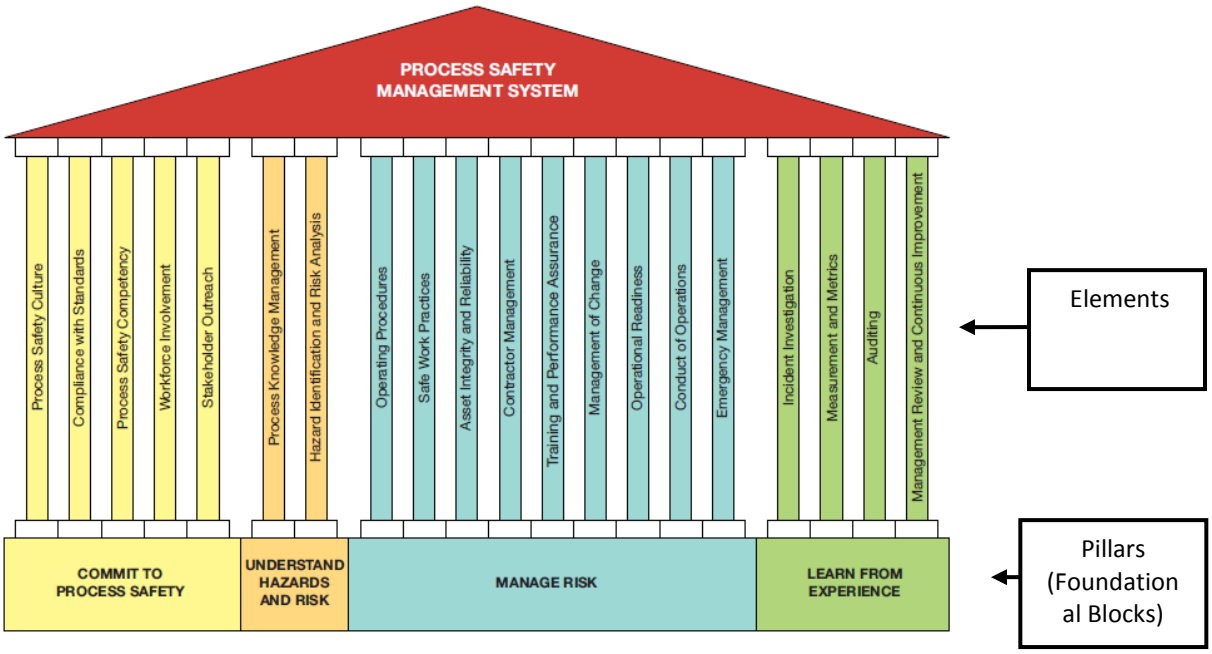

Figure 2: Pillars (Foundational Blocks) and associated Elements that constitute a sturdy RBPS Management System

- **1st Pillar (Foundational Block) -** Authentic ***commitment to process safety*** is the cornerstone of process safety excellence. Management commitment has no substitute. Organizations generally do not improve without strong leadership and solid commitment. The entire organization must make the same commitment. A workforce that is convinced that the organization fully supports safety as a core value will tend to do the right things, in the right ways, at the right times, even when no one is looking. This behavior should be consistently nurtured, and celebrated, throughout the organization. Once it is embedded in the company culture, this commitment to process safety can help sustain the focus on excellence in the more technical aspects of process safety.
- **2nd Pillar (Foundational Block)** - Organizations that ***understand hazards and risk*** are better able to allocate limited resources in the most effective manner. Industry experience has demonstrated that businesses using hazard and risk information to plan, develop, and deploy stable, lower-risk operations are much more likely to enjoy long term success.
- **3rd Pillar (Foundational Block) - Managing risk** focuses on three issues:
  (1) Prudently operating and maintaining processes that pose the risk.
  (2) Managing changes to those processes to ensure that the risk remains tolerable.
  (3) Preparing for, responding to, and managing incidents that do occur.

Managing risk helps a company or a facility deploy management systems that help sustain long-term, incident-free, and profitable operations.

- **4th Pillar (Foundational Block) - Learning from experience** involves monitoring, and acting on, internal and external sources of information. Despite a company's best efforts, operations do not always proceed as planned, so organizations must be ready to turn their mistakes – and those of others – into opportunities to improve process safety efforts. The most cost effective ways to learn from experience are to:
  (1) Apply best practices to make the most effective use of available resources.
  (2) Correct deficiencies exposed by internal incidents and near misses.
  (3) Apply lessons learned from other organizations.

  In addition to recognizing these opportunities to better manage risk, companies must also develop a culture and infrastructure that helps them remember the lessons and apply them in the future. Metrics can be used to provide timely feedback on the workings of RBPS management systems, and management review, a periodic honest self-evaluation, helps sustain existing performance and drive improvement in areas deemed important by management.

Focusing on these four foundational blocks should enable an organization to improve its process safety effectiveness, reduce the frequency and severity of incidents, and improve its long-term safety, environmental, and business performance. This risk-based approach helps avoid gaps, inconsistencies, and excess work, insufficient work, and rework that can lead to system failure. For process safety management to work most effectively, companies should integrate their RBPS practices with other management systems, such as those for product quality, equipment and human reliability, personnel health and safety, environmental protection, and security.

4. RBPS PILLAR (FOUNDATIONAL BLOCK) AND ELEMENTDEFINITIONS AND DESCRIPTIONS

The following pages include definitions and brief descriptions of the key principles of each of the twenty elements of RBPS.

4.1 PILLAR (FOUNDATIONAL BLOCK) - COMMIT TO PROCESS SAFETY

4.1.1 ELEMENT - PROCESS SAFETY CULTURE

Overview: Developing, sustaining, and enhancing the organization's process safety culture is one of five elements in the ***Commit to Process Safety*** **Pillar (Foundational Block)**. Process safety culture has been defined as, "the combination of group values and behaviors that determine the manner in which process safety is managed"[1]. More succinct definitions include, "How we do things around here," "What we expect here," and "How we behave when no one is watching." Investigations of catastrophic events, such as the Longford gas plant explosion and the Piper Alpha disaster, have identified common process safety culture weaknesses that are often factors in other serious incidents.

[1] Jones, David, "Turning the Titanic – Three Case Histories in Cultural Change," CCPS International Confeence and Workshop, Toronto, 2001.

The following key principles should be addressed when developing, evaluating, or improving any management system for the *process safety culture* element:

- **Maintain a Dependable Practice**

  Maintaining a dependable practice means ensuring that the practice is implemented consistently over time. With respect to the process safety culture element, the following four essential features will help achieve and maintain a sound process safety culture.
  - ***Establish process safety as a core value.***
  - ***Provide strong leadership***.
  - ***Establish and enforce high standards of performance***s.
  - ***Document the process safety culture emphasis and approach.***

- **Develop and Implement a Sound Culture**

  The attitudes and behaviors that an organization accepts as valid and subsequently incorporates into its culture are those that have been demonstrated to successfully deal with the challenges faced by the organization. The following essential features will help an organization manage its process safety challenges:
  - ***Maintain a sense of vulnerability***.
  - ***Empower individuals to successfully fulfill their safety responsibilities.***
  - ***Defer to expertise***.
  - ***Ensure open and effective communications.***
  - ***Establish a questioning/learning environment.***
  - ***Foster mutual trust.***
  - ***Provide timely response to process safety issues and concerns.***

- **Monitor and Guide the Culture**
  - ***Provide continuous monitoring of performance.***

4.1.2 ELEMENT - COMPLIANCE WITH STANDARDS

Overview: Identifying and addressing relevant process safety standards, codes, regulations, and laws over the life of a process are one of the five elements in the ***Commit to Process Safety*** **Pillar (Foundational Block)**. *Standards* is a system to identify, develop, acquire, evaluate, disseminate, and provide access to applicable standards, codes, regulations, and laws that affect process safety. The *standards* system addresses both internal and external standards; national and international codes and standards; and local, state, and federal regulations and laws. The system makes this information easily and quickly accessible to potential users. The *standards* system interacts in some fashion with every RBPS management system element. Knowledge of and conformance to *standards* helps a company (1) operate and maintain a safe facility, (2) consistently implement process safety practices, and (3) minimize legal liability. . The s*tandards* system also forms the basis for the standards of Responsible Care used in an audit program to determine management system conformance.

The following key principles should be addressed when developing, evaluating, or improving any system for the *standards* element:

- **Maintain a Dependable Practice**

  When a company identifies or defines an activity to be undertaken, that company likely wants the activity to be performed correctly and consistently over the life of the facility. The following essential features help ensure that process safety management activities are executed dependably across a facility involving a variety or people and situations:
  - ***Ensure consistent implementation of the standards system.***
  - ***Identify when standards compliance is needed.***
  - ***Involve competent personnel.***
  - ***Ensure that standards compliance practices remain effective.***

- **Conduct Compliance Work Activities**

  The actual work required to maintain compliance to standards, codes, regulations, and laws is conducted in the other RBPS elements. The *standards* system provides a communication mechanism for informing management and personnel about the company's obligations and compliance status. In addition, the *standards* element is the focal point for monitoring changes to obligations and the potential impact of those changes on the company.
  - ***Provide appropriate inputs to standards activities.***
  - ***Conduct compliance assurance activities.***
  - ***Determine compliance status periodically as required and provide a status report to management.***
  - ***Review the applicability of standards as new information or changes arise***.

- **Follow Through on Decisions, Actions, and Use of Compliance Results**

  The results of compliance status evaluations may dictate action by the company. If compliance is achieved, then no action is typically needed beyond possible notification of compliance to outside parties, as required. When compliance is not achieved, then management is informed, and the *standards* element participates in activities to regain compliance. The *standards* element is the archive for all compliance records.
  - ***Update compliance documents and reports as needed.***
  - ***Communicate conformance or submit compliance assurance records to the appropriate external entity.***
  - ***Maintain element work records.***

Want to learn more about compliance with standards? Check out **Practical Compliance with the EPA Risk Management Program**
http://www.aiche.org/ccps/publications/books/practical-compliance-epa-risk-management-program-ccps-concept-book

4.1.3 ELEMENT - PROCESS SAFETY COMPETENCY

Overview: Developing, sustaining, and enhancing the organization's process safety competency is one of five elements in the ***Commit to Process Safety*** **Pillar (Foundational Block)**. Developing and maintaining process safety competency encompasses three interrelated actions:

(1) continuously improving knowledge and competency, (2) ensuring that appropriate information is available to people who need it, and (3) consistently applying what has been learned.

The following key principles should be addressed when developing, evaluating, or improving any management system for the *competency* element:

- **Maintain a Dependable Practice**

  Almost all companies profess to be learning organizations that aspire to a high degree of competency. However, those that are successful in this pursuit intentionally foster learning by establishing objectives and making plans to achieve the objectives. Normally, one or more of several conditions are necessary for an organization to invest in process safety competency: (1)a business case describes the expected benefits and the level of resources that must be invested to achieve those benefits, (2)the organization inherently values technology and places particular value on enhancing its process safety competency, (3)the organization believes that decisions should be based on knowledge that is supported by facts, and any significant improvement in the body of knowledge will lead to better decisions, thereby reducing risk and improving performance.
  - ***Establish objectives.***
  - ***Appoint a champion.***
  - ***Identify corollary benefits.***
  - ***Develop a learning plan.***
  - ***Promote a learning organization.***
  - ***Tolerates errors and mistakes, but learns from them.***

- **Execute Activities that Help Maintain and Enhance Process Safety Competency**

  Owners, budgets, plans, and objectives alone are normally insufficient to bring about positive change. These need to be transformed into actions that improve competency.
  - ***Appoint technology steward.***
  - ***Document knowledge.***
  - ***Ensure that information is accessible.***
  - ***Provide structure.***
  - ***Push knowledge to appropriate personnel.***
  - ***Apply knowledge.***
  - ***Update information.***
  - ***Promote person-to-person contact.***
  - ***Plan personnel transitions.***
  - ***Solicit knowledge from external sources.***

- **Evaluate and Share Results**

  Good management systems have a plan-do-check-act feature. In some cases, the steps are obvious and difficult to miss. If a facility undertakes a project to expand the output of a unit by 20%, the obvious “check” step, operate at the increased rate, will be integrated into the project. However, this model is often not applied to “softer” work activities that are part of

the *competency* element; an organization may continue to provide resources to an activity simply because it always has. Companies that periodically check the value derived from activities that are part of the *competency* element are more likely to maintain the vitality of these activities.

- ***Evaluate the utility of existing efforts.***
- ***Solicit needs from operating units.***

- **Adjust Plans**

  Periodically (e.g., annually) review the status of efforts to promote process safety competency. With one eye looking toward what is currently working well and the other focused on upcoming challenges, revise the plans to more closely align the activities with the perceived needs.

4.1.4 ELEMENT - WORKFORCE INVOLVEMENT

Overview: Promoting the active involvement of personnel at all levels of the organization is one of five elements in the ***Commit to Process Safety*** **Pillar (Foundational Block)**. Workers, at all levels and in all positions in an organization, should have roles and responsibilities for enhancing and ensuring the safety of the organization's operations. However, some workers may not be aware of all of their opportunities to contribute. Some organizations may not effectively tap into the full expertise of their workers or, worse, may even discourage workers who seek to contribute through what the organization views as a nontraditional role. *Workforce involvement* provides a system for enabling the active participation of company and contractor workers in the design, development, implementation, and continuous improvement of the RBPS management system.

The following key principles should be addressed when developing, evaluating, or improving any management system for the *workforce involvement* element:

- **Maintain a Dependable Practice**

  When a company identifies or defines an activity to be undertaken, that company likely wants the activity to be performed correctly and consistently over the life of the facility. For the *workforce involvement* practice to be executed dependably across a company or facility involving a variety of people and situations, the following essential features should be considered:

  - ***Ensure consistent implementation.***
  - ***Involve competent personnel*.**

- **Conduct Work Activities**

  - ***Provide appropriate inputs.***
  - ***Apply appropriate work processes and create element work products.***

- **Monitor the System for Effectiveness**

  - ***Ensure that the workforce involvement practices remain effective.***

- **Actively Promote the Workforce Involvement Program**
  - ***Stimulate workforce participation.***
  - ***Adopt new workforce participation opportunities.***
  - ***Publicize the success of the workforce involvement program*.**

4.1.5 ELEMENT - STAKEHOLDERS OUTREACH

Overview: Having good relationships with appropriate stakeholders over the life of a facility is one of the five elements in the ***Commit to Process Safety*** **Pillar (Foundational Block**.) Stakeholder outreach is a process for (1) seeking out individuals or organizations that can be or believe they can be affected by company operations and engaging them in a dialogue about process safety, (2) establishing a relationship with community organizations, other companies and professional groups, and local, state, and federal authorities, and (3) providing accurate information about the company and facility's products, processes, plans, hazards, and risks. This process ensures that management makes relevant process safety information available to a variety of organizations. This element also encourages the sharing of relevant information and lessons learned with similar facilities within the company and with other companies in the industry group. Finally, the *outreach* element promotes involvement of the facility in the local community and facilitates communication of information and facility activities that could affect the community.

The following key principles should be addressed when developing, evaluating, or improving any system for the *outreach* element:

- **Maintain a Dependable Practice**

  When a company identifies or defines an activity to be undertaken, that company likely wants the activity to be performed correctly and consistently over the life of that process and other similar processes. In order for *outreach* activities to be executed dependably across a company involving a variety or people and situations, the following essential features should be considered:
  - ***Ensure consistent implementation.***
  - ***Involve competent personnel.***
  - ***Keep practices effective.***

- **Identify Communication and Outreach Needs**

  Effective communication, outreach, and relationship building cannot happen unless key stakeholders are identified, specific audiences are targeted, perspectives are understood, company messages and themes are developed, and delivery venues are planned. The level of effort and rigor should be based upon risk and perceived stakeholder needs. A low need situation is exemplified by a facility with minimal potential offsite impacts that generally has a good relationship with neighbors. An example of a high need situation is a facility with a worst-case scenario that could affect people many miles away having a poor safety and environmental record. Companies/facilities should implement effective means of determining the level of need, and on that basis, identify the types of information and

messages that should be communicated for each stakeholder group. For an *outreach* system to address all potentially significant situations involving stakeholder needs and concerns, the following essential features should be considered:

- ***Identify relevant stakeholders***.
- ***Define appropriate scope.***

- **Follow Through on Commitments and Actions**

  If during an outreach/communication activity, a company representative commits to provide additional information, those promises should be tracked and diligently completed . The following essential features should be considered:

  - ***Follow-up commitments to stakeholders and receive feedback***.
  - ***Share stakeholder concerns with management.***
  - ***Document outreach encounters.***

4.2 PILLAR (FOUNDATIONAL BLOCK) - UNDERSTAND HAZARDS AND RISK

4.2.1 ELEMENT - PROCESS KNOWLEDGE MANAGEMENT

Overview: Developing, documenting, and maintaining process knowledge is one of two elements in the ***Understanding Hazards and Risk*** **Pillar (Foundational Block**.) The *knowledge* element primarily focuses on information that can easily be recorded in documents, such as (1) written technical documents and specifications, (2) engineering drawings and calculations, (3) specifications for design, fabrication, and installation of process equipment, and (4) other written documents such as material safety data sheets (MSDSs). The term *process knowledge* will be used to refer to this collection of information. The *knowledge* element involves work activities associated with compiling, cataloging, and making available a specific set of data that is normally recorded in paper or electronic format. However, *knowledge* implies understanding, not simply compiling data. In that respect, the *competency* element complements the *knowledge* element in that it helps ensure that users can properly interpret and understand the information that is collected as part of this element. The following key principles should be addressed when developing, evaluating, or improving any management system for the *knowledge* element:

- **Maintain a Dependable Practice**

  Accurate and complete process knowledge is required to thoroughly identify process hazards and analyze risk. The RBPS approach cannot be applied without an understanding of hazards and risk, which in turn depends on the *knowledge* element. Designing and building a modern, efficient, and safe process unit requires a significant investment. In addition to this initial investment, almost all units are modified over time to increase throughput and/or efficiency. The information required to design, construct, and optimize a unit represents a significant, and valuable, corporate asset. Because process knowledge provides the foundation for long-term viability and continued success of the business, a management system should be established to protect and promote the use of this information. Establishing a dependable practice to collect, maintain, and protect a company's process knowledge helps protect an important asset which simply makes good business sense. The management system should include the essential features listed below:

  - ***Ensure consistent implementation.***

- ***Define the scope.***
- ***Thoroughly document chemical reactivity and incompatibility hazards.***
- ***Assign responsibilities to competent personnel.***

- **Catalog Process Knowledge in a Manner that Facilitates Retrieval**

  Information that cannot be efficiently accessed becomes clutter. Too often, key data such as design bases, manufacturer's drawings/data reports, specifications, and other process knowledge are thrown away because the documents are not well organized or cataloged. A random mixture of current and out-of-date information in the same storage area is generally worse than clutter. In extreme cases, it is a trap set to catch an unsuspecting user of the out-of-date information.

  - ***Make information available and provide structure.***
  - ***Protect knowledge from inadvertent loss.***
  - ***Store calculations, design data, and similar information in central files.***
  - ***Document information in a user-friendly manner.***

- **Protect and Update Process Knowledge**
  - ***Control or limit access to out-of-date documents.***
  - ***Ensure accuracy.***
  - ***Protect against inadvertent change.***
  - ***Protect against physical (or electronic) removal or misfiling.***
  - ***Support efforts to properly manage change.***

❖ **Use Process Knowledge**

Process knowledge provides little value if it sits dormant in a file. This knowledge will be underused if any of the following conditions exist:

- ***Documents are not accessible.***
- ***Information cannot be readily located within documents.***
- ***Personnel have low confidence that the process knowledge is current and accurate.***
- ***Personnel are unaware of how to access process knowledge.***

The first three conditions were addressed in key principles discussed above. Companies make a substantial investment to generate, gather, and organize process knowledge. To make this investment pay dividends, personnel must be trained on what process knowledge is available, why it is important, how to access the knowledge, what to do if a change is made that could affect the information, how to update the information when an approved change is made, and the policy governing document control.

- ***Ensure awareness.***
- ***Ensure that process knowledge remains useful.***

To learn more about Process Knowledge Management, see the book, **Guidelines for Process Safety Documentation** http://www.aiche.org/ccps/publications/books/guidelines-process-safety-documentation

4.2.2 ELEMENT - HAZARD IDENTIFICATION AND RISK ANALYSIS

Overview: A thorough Hazard Identification and Risk Analysis, or *risk*, system is the core element in the ***Understanding Hazards and Risk*** **Pillar (Foundational Block**.) Hazard Identification and Risk Analysis (HIRA) is a collective term that encompasses all activities involved in identifying hazards and evaluating risk at facilities, throughout their life cycle, to make certain that risks to employees, the public, and/or the environment are consistently controlled within the organization's risk tolerance. These studies typically address three main risk questions to a level of detail commensurate with analysis objectives, life cycle stage, available information, and resources. The three main risk questions are:

- **Hazard** – What can go wrong?
- **Consequences** – How bad could it be?
- **Likelihood** – How often might it happen?

The following key principles should be addressed when developing, evaluating, or improving any management system for *risk*:

❖ Maintain a Dependable Practice

When a company identifies or defines an activity to be undertaken, that company likely wants the activity to be performed correctly and consistently over the life of that process and other similar processes. For the risk management system to be executed dependably across a facility involving a variety of people and situations, the following essential features should be considered:

- ***Document the intended risk management system.***
- ***Integrate HIRA activities into the life cycle of projects or processes.***
- ***Clearly define the analytical scope of HIRAs and assure adequate coverage.***
- ***Determine the physical scope of the risk system.***
- ***Involve competent personnel.***
- ***Make consistent risk judgments.***
- ***Verify that HIRA practices remain effective.***

❖ Assess Risks and Make Risk-based Decisions

Once hazards have been identified and associated risks have been analyzed, the acceptability of the risk must be judged. Some companies may judge a risk acceptable if the system conforms to a minimum standard, such as a regulation or code, while other companies may require that risks meet internal tolerable risk criteria or even be reduced as low as reasonably practicable. Some companies may judge the risk to be unacceptable under any circumstances and require that the process be relocated or abandoned unless an inherently safer alternative can be found.

- **Follow Through on the Assessment Results**

  Management should formally resolve each recommendation made by risk analysis teams, either by implementing the proposed change, implementing an alternative risk reduction measure, or by accepting the risk "as is" and documenting the rationale for rejecting the recommendation. Recommendations from early reviews may simply be incorporated into the next stage of design. But if the process is in operation, any corrective action must follow the *management of change* procedure. Sometimes action on a recommendation is deferred because it addresses a lower risk issue; nevertheless, these items should also be carefully tracked and resolved as soon as possible. To ensure that approved HIRA results are properly followed-up, the following essential features should be considered:

  - ***Communicate important results to management***.
  - ***Document the residual risk.***
  - ***Resolve recommendations and track completion of actions***.
  - ***Communicate results internally.***
  - ***Communicate results externally.***
  - ***Maintain risk assessment records.***

For more titles about Hazard Identification and Risk Assessment, see:

- **Guidelines for Hazards Evaluation Procedures**
  http://www.aiche.org/ccps/publications/books/guidelines-hazard-evaluation-procedures-3rd-edition
- **A Practical Approach to Hazard Identification for Operators and Maintenance Workers**
  http://www.aiche.org/ccps/publications/books/practical-approach-hazard-identification-operations-and-maintenance-workers
- **Layer of Protection Analysis: Simplified Process Risk Assessment**
  http://www.aiche.org/ccps/publications/books/layer-protection-analysis-simplified-process-risk-assessment

4.3 PILLAR (FOUNDATIONAL BLOCK) - MANAGE RISK

4.3.1 ELEMENT - OPERATING PROCEDURES

Overview: The RBPS element that ensures proper development, timely maintenance, and consistent use of operating procedures (*procedures*) is one of nine elements in ***Managing Risk* Pillar (Foundational Block).** Operating procedures are written instructions (including procedures that are stored electronically and printed on demand) that (1) list the steps for a given task and (2) describe the manner in which the steps are to be performed. Good procedures also describe the process, hazards, tools, protective equipment, and controls in sufficient detail that operators understand the hazards, can verify that controls are in place, and can confirm that the process responds in an expected manner. Procedures critical to the safe operation or maintenance of equipment should reference hazard review information (as appropriate) and include consequence of deviation warnings. Procedures should also provide instructions for troubleshooting when the system does not respond as expected. Procedures

should specify when an emergency shutdown should be executed and should also address special situations, such as temporary operation with a specific equipment item out of service. Operating procedures are normally used to control activities such as transitions between products, periodic cleaning of process equipment, preparing equipment for certain maintenance activities, and other activities routinely performed by operators. The scope of this element is limited to those operating procedures that describe the tasks required to safely start up, operate, and shut down processes, including emergency shutdown. Operating procedures complement *safe work* and *asset integrity* procedures, which are addressed later.

The following key principles should be addressed when developing, evaluating, or improving any management system for the *procedures* element:

❖ Maintain a Dependable Practice

Documented, current, and accurate operating procedures help ensure that each shift team operates the process in a consistent, safe manner. Procedures should be consistent throughout the organization. Written procedures also help ensure that the same person operates the process consistently from one day (or batch) to the next. Consistent operation, even if it happens to be less than optimal, will lead to consistent results. This enables process engineers and others charged with improving operations to identify opportunities for changes that will improve safety, product quality, yield, throughput, and so forth. Consistent operation will also help facilities determine the impact that changes have on these parameters.

- ***Establish management controls.***
- ***Control procedure format and content.***
- ***Control documents.***

❖ Identify What Operating Procedures Are Needed

The tasks that should be described in written procedures depend on the knowledge, skills, and abilities of qualified workers. Failure to provide the necessary procedures in adequate detail will lead to low human reliability. However, too many procedures, or procedures that contain extraneous information or too much detail, are difficult to use. Non-routine operating modes or abnormal conditions (e.g., troubleshooting) warrant particular attention because they often involve much greater risk than routine operations.

- ***Conduct a task analysis***.
- ***Determine what procedures are needed and their appropriate level of detail***.
- ***Address all operating modes, including non-routine and abnormal conditions***.

❖ Develop Procedures

Once the list of tasks is developed and reviewed, procedures are developed. Procedure development can be a complex activity, particularly if there is disagreement on how a task should be performed. However, identification of differences in how tasks are performed, and the process to resolve the differences and arrive at a single intended method, should improve overall operation of the facility and help reduce risk. Information must be presented in a consistent and useful format. Fully trained and experienced operators tend to use procedures primarily as reference documents on an infrequent basis, in other words, a procedure is not used as a step-by-step reference each time the task is performed.

Consistency allows operators to find information more quickly, which increases the likelihood that procedures will be followed. Clearly, exceptions to this practice exist; some detailed procedures for critical or high-risk operations are used daily, and detailed procedures are routinely used in highly regulated sectors, such as parts of the nuclear and pharmaceutical industries.

- ***Use an appropriate format.***
- ***Ensure that the procedures describe the expected system response, how to determine if a step or task has been done properly, and possible consequences associated with errors or omissions.***
- ***Address safe operating limits and consequences of deviation from safe operating limits.***
- ***Address limiting conditions for operation.***
- ***Provide clear, concise instructions.***
- ***Supplement procedures with checklists***.
- ***Make effective use of pictures and diagrams***.
- ***Develop written procedures to control temporary or non-routine operations.***
- ***Interlink related procedures.***
- ***Validate procedures and verify that actual practice conforms to intended practice***.

❖ Use the Procedures to Improve Human Performance

Procedures that are not followed are of little value. Tolerance or endorsement of working solely from memory or using alternatives to approved procedures can lead to highly unpredictable, and sometimes unsafe, operation. To promote their use, procedures should be available to the user at the time and location they are needed.

- ***Use the procedures when training.***
- ***Hold the organization accountable for consistently following procedures.***
- ***Ensure that procedures are available.***

❖ Ensure that Procedures Are Maintained

Historically, some organizations treated written procedures as a reference manual. That is, the procedures were not expected to be 100% current or accurate, but they were useful in describing how the process operated and were sometimes useful in troubleshooting. This model has proven inadequate, both for ensuring process safety and for other aspects of effective operation. The accuracy, and hence effectiveness, of static procedures in a dynamic operating environment will decay rapidly with time. Therefore, ensuring that procedures are maintained and enforced is vital. If operating procedures are not being following consistently, deviations must be investigated and corrected.

- ***Manage changes.***
- ***Correct errors and omissions in a timely manner.***
- ***Periodically review all operating procedures.***

For more information on this subject see **Guidelines for Effective Operating and Maintenance Procedures** http://www.aiche.org/ccps/publications/books/guidelines-writing-effective-operating-and-maintenance-procedures

4.3.2 ELEMENT - SAFE WORK PRACTICES

Overview: The RBPS element safe work practices helps control hazards associated with maintenance and other non-routine work is one of nine elements in the ***Managing Risk*** **Pillar (Foundational Block)**. Procedures are generally divided into three categories. Operating procedures govern activities that generally involve producing a product. Maintenance procedures, generally involve testing, inspecting, calibrating, maintaining, or repairing equipment. Safe work procedures, which are often supplemented with permits (i.e., a checklist that includes an authorization step), fill the gap between the other two sets of procedures. Safe work practices help control hazards and manage risk associated with non-routine work.

The following key principles should be addressed when developing, evaluating, or improving any management system for the *safe work* element:

- **Maintain a Dependable Practice**

  A written policy should: (1) describe the scope of the *safe work* element, (2) identify which safe work procedures and permits govern specific non-routine work activities, and (3) define the roles and responsibilities for implementing activities associated with the *safe work* element, including who may authorize non-routine work or how this authority is delegated and controlled. The policy should also specify the physical scope of the *safe work* element (i.e., where certain requirements apply), and how the requirements change over the life cycle of a process. This policy should include a list of references to subordinate safe work procedures that control specific non-routine work activities.

  - ***Define the scope.***
  - ***Specify when in the facility's life cycle the safe work procedures apply.***
  - ***Ensure consistent implementation.***
  - ***Involve competent personnel.***

- **Effectively Control Non-Routine Work Activities**

  Effective management of risk associated with non-routine work requires robust systems, thorough training and awareness, a sound culture, and diligence.

  - ***Develop safe work procedures, permits, checklists, and other written standards.***
  - ***Train employees and contractors.***
  - ***Control access to particularly hazardous areas.***
  - ***Enforce the use of safe work procedures, permits, and other standards.***
  - ***Review completed permits.***

4.3.3 ELEMENT - ASSET INTEGRITY AND RELIABILITY

Overview: Asset integrity, the RBPS element that helps ensure that equipment is properly designed, installed in accordance with specifications, and remains fit for use until it is retired, is one of nine elements in the ***Managing Risk*** **Pillar (Foundational Block)**. The *asset integrity*

element is the systematic implementation of activities, such as inspections and tests necessary to ensure that important equipment will be suitable for its intended application throughout its life. Specifically, work activities related to this element focus on: (1) preventing a catastrophic release of a hazardous material or a sudden release of energy and (2) ensuring high availability (or dependability) of critical safety or utility systems that prevent or mitigate the effects of these types of events.

The following key principles should be addressed when developing, evaluating, or improving any management system for the *asset integrity* element:

- **Maintain a Dependable Practice**

  Organizations that decide to adopt a formal *asset integrity* program should develop written policies or procedures to guide the implementation and execution of the program. These documents should address the scope, roles and responsibilities, standards, and other aspects of the management system for this element.
  - ***Develop a written program description/policy***.
  - ***Determine the scope of the asset integrity element.***
  - ***Base design and inspection, testing and preventative maintenance (ITPM) tasks on standards.***
  - ***Involve competent personnel.***
  - ***Update practices based on new knowledge.***
  - ***Integrate the asset integrity element with other goals.***

- **Identify Equipment and Systems that Are Within the Scope of the Asset Integrity Program and Assign ITPM Tasks**

  The scope of the *asset integrity* element includes the physical equipment that provides containment and safety/utility systems that are designed to prevent or mitigate the effects of loss of containment or a sudden release of energy.
  - ***Identify equipment/systems for inclusion in the asset integrity element.***
  - ***Develop an ITPM.***
  - ***Update the ITPM plan when equipment conditions change.***

- **Develop and Maintain Knowledge, Skills, Procedures, and Tools**

  Successful execution of work activities for the *asset integrity* element depends on trained workers using the right tools and executing activities in accordance with written procedures. In this context, tools include both: (1) devices used to conduct inspections, tests, and repairs and (2) systems used to schedule ITPM tasks and store/analyze the large volume of data generated by these activities.
  - ***Develop procedures for inspection, test, repair, and other critical maintenance activities.***
  - ***Train employees and contractors.***
  - ***Ensure that inspectors hold appropriate certifications.***
  - ***Provide the right tools.***

❖ Ensure Continued Fitness for Purpose

Regardless of the procedures, tools, and other conditions, the ultimate measure of success for the *asset integrity* element is ensuring that equipment remains fit for its intended purpose, at least until its next scheduled inspection. In the case of safety systems, equipment needs to be available when needed, and capable of operating at a specified level of performance for a specified mission time. This performance is normally achieved via an integrated combination of ITPM tasks and quality assurance measures.

- ***Conduct initial inspections and tests as part of plant commissioning.***
- ***Conduct tests and inspections during operations***.
- ***Execute calibration, adjustment, preventive maintenance, and repair activities.***
- ***Plan, control, and execute maintenance activities.***
- ***Ensure the quality of repair parts and maintenance materials.***
- ***Ensure that overhauls, repairs, and tests do not undermine safety.***

❖ Address Equipment Failures and Deficiencies

Although the notion of taking action based on inspection and test data is intuitive, in practice this can become an issue. At some facilities, inspection files are full of unaddressed recommendations. Causes of this vary, including recommendations that lack specificity, unavailability of the downtime necessary to complete the repair work, insufficient funding in the maintenance budget, and/or lack of awareness of the need to carefully review inspection/test reports.

- ***Promptly address conditions that can lead to failure.***
- ***Review test and inspection reports.***
- ***Examine results to identify broader issues.***
- ***Investigate chronic failures using a structured methodology.***
- ***Plan maintenance and repair activities.***

❖ Analyze Data

The value of knowing the condition of a piece of equipment at a specific point in time is somewhat limited. The intent of the *asset integrity* element is to determine with a reasonable degree of certainty that the equipment: (1) is currently fit for service and (2) will continue to be fit for service, at least until the next scheduled inspection or test. Thus, data collection **and** analysis are generally needed.

- ***Collect and analyze data.***
- ***Adjust inspection frequencies and methods.***
- ***Conduct additional inspections or tests as needed.***
- ***Plan replacements or other corrective actions.***
- ***Archive data.***

For more information on this topic see

- Guidelines for Mechanical Integrity Systems
  http://www.aiche.org/ccps/publications/books/guidelines-mechanical-integrity-systems

- Guidelines for Improving Plant Reliability through Data Collection and Analysis
  http://www.aiche.org/ccps/publications/books/guidelines-mechanical-integrity-systems

4.3.4 ELEMENT - CONTRACTOR MANAGEMENT

Overview: Implementing practices to ensure that contract workers can perform their jobs safely, and that contracted services do not add to or increase facility operational risks, is one of nine elements in the ***Managing Risk*** **Pillar (Foundational Block)**. Industry often relies upon contractors for very specialized skills and, sometimes, to accomplish particularly hazardous tasks – often during periods of intense activity, such as maintenance turnarounds. Such considerations, coupled with the potential lack of familiarity that contractor personnel may have with facility hazards and operations, pose unique challenges for the safe utilization of contract services. *Contractor management* is a system of controls to ensure that contracted services support both safe facility operations and the company's process safety and personal safety performance goals. This element addresses the selection, acquisition, use, and monitoring of such contracted services.

The following key principles should be addressed when developing, evaluating, or improving any management system for the *contractor management* element:

- **Maintain a Dependable Practice**

  When a company identifies or defines an activity to be undertaken, that company likely wants the activity to be performed correctly and consistently over the life of the facility. In order for the *contractor management* practice to be executed dependably across a company or facility involving a variety of people and situations, the following essential features should be considered:

  - ***Ensure consistent implementation.***
  - ***Identify when contractor management is needed.***
  - ***Involve competent personnel.***
  - ***Ensure that practices remain effective.***

- **Conduct Element Work Activities**

  Appropriately ***select contractors.*** Many companies maintain a list of pre-screened contract firms as potential bidders for future contracts. Such a list (often maintained and managed by the purchasing function) can be based upon preliminary information supplied by potential contractors, and supplemented with a more detailed evaluation during the final qualification process. Contractors previously used by the company, whose past performance was satisfactory, could automatically be included on this list.

  Company requirements and expectations regarding contractor safety performance and safety program contents should be included in bid requests and made part of the final contract language. Expectations should be specific and explicit, going beyond general requirements such as compliance "with all applicable regulations". To avoid duplication of efforts, the company should clearly identify which safety responsibilities it will assume during the contract.

  - ***Establish expectations, roles, and responsibilities for safety program implementation and performance.***

- ***Ensure that contractor personnel are properly trained.***
- ***Fulfill company responsibilities with respect to safety***

❖ **Monitor the Contractor Management System for Effectiveness**

- ***Audit the contractor selection process.***
- ***Monitor and evaluate contractor safety performance.***

For more information on contractor management see **Contractor and Client Relations to Assure Process Safety** http://www.aiche.org/ccps/publications/books/contractor-and-client-relations-assure-process-safety

4.3.5 ELEMENT - TRAINING AND PERFORMANCE ASSURANCE

Overview: Training workers and assuring their reliable performance of critical tasks is one of nine elements in the ***Managing Risk*** **Pillar (Foundational Block**.) Training is practical instruction in job and task requirements and methods. It may be provided in a classroom or workplace, and its objective is to enable workers to meet some minimum initial performance standards, to maintain their proficiency, or to qualify them for promotion to a more demanding position. Performance assurance is the means by which workers demonstrate that they have understood the training and can apply it in practical situations. Performance assurance is an ongoing process to ensure that workers meet performance standards and to identify where additional training is required.

The following key principles should be addressed when developing, evaluating, or improving any management system for the *training* element:

❖ **Maintain a Dependable Practice**

A documented training program is fundamental to achieving reliable worker performance. The jobs and tasks that workers are expected to perform must be identified, workers must be selected and trained, and their performance must be monitored on an ongoing basis. The management system must be designed to accomplish those objectives consistently over the life of the process.

- ***Define roles and responsibilities***.
- ***Validate program effectiveness***.
- ***Control documents.***

❖ **Identify What Training Is Needed**

Training is needed when a gap exists between a worker's or job applicant's current knowledge, skills, and abilities (KSAs) and those required for successful performance of the job. Performance testing is a common way to discover those gaps and identify training needs.

- ***Conduct a job/task analysis***.
- ***Determine minimum requirements (or essential elements) for job candidates***.
- ***Determine what training is needed.***
- ***Group training into logical programs.***
- ***Manage changes.***

❖ Provide Effective Training

Training may be delivered by a variety of means in various venues, but the objective is always the same – help workers to be successful in their jobs. Success means that the worker can accomplish the required task to a specified standard of performance.

- ***Develop or procure training materials.***
- ***Consider timing.***
- ***Interweave related topics.***
- ***Ensure that training is available***

❖ Monitor Worker Performance

Performance assurance requires that workers do more than restate the correct answers to a few questions on a written quiz. The only meaningful criterion for measuring training effectiveness is whether workers can successfully perform their jobs. Written quizzes, field observations, quality audits, and so forth are simply tools that management can use to gauge current worker performance. Poor performance might be the result of inadequate training, or it might result from other factors such as substance abuse, illness, or physical decline. The performance assurance system should be designed to detect unacceptable performance, regardless of cause, so that appropriate corrective actions can be implemented.

- ***Qualify workers initially.***
- ***Test workers periodically.***
- ***Review all qualification requirements periodically.***

4.3.6 ELEMENT - MANAGEMENT OF CHANGE

Overview: Managing changes to processes over the life of a facility is one of nine elements in the ***Managing Risk*** **Pillar (Foundational Block).** The *MOC* element helps ensure that changes to a process do not inadvertently introduce new hazards or unknowingly increase risk of existing hazards. The *MOC* element includes a review and authorization process for evaluating proposed adjustments to facility design, operations, organization, or activities prior to implementation to make certain that no unforeseen new hazards are introduced and that the risk of existing hazards to employees, the public, and/or the environment is not unknowingly increased. It also includes steps to help ensure that potentially affected personnel are notified of the change and that pertinent documents, such as procedures, process safety knowledge, and other key information, are kept up–to-date.

The following key principles should be addressed when developing, evaluating, or improving any system for the *MOC* element:

❖ Maintain a Dependable Practice

When a company identifies or defines an activity to be undertaken, that company likely wants the activity to be performed correctly and consistently over the life of the facility. To dependably execute an *MOC* system across a facility involving a variety or people and situations, the following essential features should be incorporated:

- ***Establish consistent implementation.***
- ***Involve competent personnel.***

- ***Keep MOC practices effective.***

❖ Identify Potential Change Situations

Modifications cannot be evaluated until they are identified. Facilities should implement effective means to identify the types of modifications that are anticipated for the facility/activity 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 increases the risk associated with an existing hazard. For 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 appropriate expertise and tools.***

❖ Decide Whether to Allow the Change

Once a change has been reviewed and its risks evaluated, management can then decide whether to: (1) approve the change for implementation as requested, (2) require amendment to the change request or implementation process, or (3) deny the change request. For 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 (*asset integrity*, *procedures*, *safe work*, etc.) by facility staff or contractors involved in design, engineering, or construction. Prior to the startup of the change (exposure of personnel to the modified situation, which could introduce new hazards or increase risk), the *MOC* procedure or reviewers/authorizers may require that drawings and procedures be updated, affected personnel be trained, required risk control measures be implemented, and so forth. Action items are occasionally deferred until after startup, for example, the installation of heat tracing on bypass piping commissioned in summertime. Such deferred items should be carefully tracked to completion. For facilities to ensure that approved MOCs are properly concluded, the following essential features should be considered:

- ***Update records.***
- ***Communicate changes to personnel***.

- ***Enact risk control measures.***
- ***Maintain MOC records.***

Interested in more information on Management of Change? See

- Guidelines for the Management of Change for Process Safety http://www.aiche.org/ccps/publications/books/guidelines-management-change-process-safety
- Guidelines for Managing Process Safety Risks During Organizational Change http://www.aiche.org/ccps/resources/publications/books/guidelines-managing-process-safety-risks-during-organizational-change

4.3.7 ELEMENT - OPERATIONAL READLINESS

Overview: Ensuring the safe startup of processes over the life of a facility is one of nine elements in the ***Managing Risk*** **Pillar (Foundational Block**.) The *readiness* element ensures that shut down processes are verified to be in a safe condition for re-start. This element addresses startups from all types of shut down conditions and considers the length of time the process was in the shutdown condition. Some processes may be shut down only briefly, while others may have undergone a lengthy maintenance/modification outage, or they may even have been mothballed for an extended period. Other processes may have been shut down for administrative reasons, such as a lack of product demand; for reasons unrelated to production at all; or as a precautionary measure, for example, because of an approaching hurricane. In addition to the shutdown duration, this element considers the type of work that may have been conducted on the process (e.g., possibly involving line-breaking) during the shutdown period to help focus the *readiness* review prior to startup. The *readiness* element in these *Guidelines* is defined more broadly than the OSHA process safety management pre-startup safety review element in that it specifically addresses startup from all shutdown conditions – not only those resulting from new or changed processes.

The following key principles should be addressed when developing, evaluating, or improving any system for the *readiness* element:

- **Maintain a Dependable Practice**

  A written program that documents the intentions of the *readiness* element is key to the long-term success of *readiness* activities. Defining roles and responsibilities, where and when *readiness* activities should be carried out, the technical issues that should be addressed, and the necessary technical expertise of personnel is critical to having an effective *readiness* system. Records should be maintained concerning *readiness* activities so that performance and efficiency can be periodically evaluated.

  - ***Ensure consistent implementation.***
  - ***Determine types of and triggers for the readiness practice.***
  - ***Determine the scope of readiness reviews.***
  - ***Involve competent personnel.***
  - ***Ensure that readiness practices remain effective.***

❖ Conduct Appropriate Readiness Reviews as Needed

Quality *readiness* reviews depend upon accurate input information and sufficient personnel expertise and resources. The review process should be thorough, yet flexible enough to be appropriate for simply restart situations as well as more complex startups of new processes. Appropriate tools should be used, and records should be created to document the results of each review.

- ***Provide appropriate inputs.***
- ***Involve appropriate resources and personnel.***
- ***Apply an appropriate work process.***
- ***Perform element work in a diligent manner.***
- ***Create element work products.***

❖ Make Startup Decisions Based upon Readiness Results

The results of each *readiness* review should drive action – either deciding that the startup may safely proceed or establishing conditions that must be met prior to startup. The *readiness* results and startup information should be broadly communicated to all potentially affected personnel.

- ***Consider important issues affecting the startup.***
- ***Communicate decisions and actions from the readiness review.***

❖ Follow Through on Decisions, Actions, and Use of Readiness Results

Readiness reviews may establish conditions that must be met prior to startup; completion of these conditions should be tracked and documented. Modifications to process safety knowledge and records should be completed.

- ***Enact risk control measures.***
- ***Update process safety knowledge and records.***
- ***Maintain element work records.***

For more information see **Guidelines for Performing Effective Pre-Startup Safety Reviews**
http://www.aiche.org/ccps/publications/books/guidelines-performing-effective-pre-startup-safety-reviews

4.3.8 ELEMENT - CONDUCT OF OERATIONS

Overview: Developing and sustaining high standards in the conduct of operations is one of nine elements in the ***Managing Risk*** **Pillar (Foundational Block**.) Conduct of operations (*operations*) is the execution of operational and management tasks in a deliberate and structured manner. It is also sometimes called “operational discipline” or “formality of operations”, and it is closely tied to an organization’s culture. Conduct of operations institutionalizes the pursuit of excellence in the performance of every task and minimizes variations in performance. Workers at every level are expected to perform their duties with alertness, due thought, full knowledge, sound judgment, and a proper sense of pride and accountability.

The following key principles should be addressed when developing, evaluating, or improving any management system for conduct of operations:

❖ Maintain a Dependable Practice

A documented *operations* program is fundamental to maintaining reliable worker performance. The procedures governing worker activities and interactions must be documented, workers must be trained, and their performance must be monitored on an ongoing basis. The management system must be designed to accomplish those objectives and to consistently provide positive feedback for desired behaviors over the life of the process. A good organization and effective administration establishes the framework for the *operations* activities to build upon.

- ***Define roles and responsibilities.***
- ***Establish standards for performance.***
- ***Validate program effectiveness.***

❖ Control Operations Activities

The control of operations activities is the heart of the *operations* element. The management system must establish clear expectations for every operations activity – from following procedures to controlling access. In particular, reliable communication between workers, shifts, and work groups helps to ensure that all operations activities are safely planned and controlled.

- ***Follow written procedures.***
- ***Follow safe work practices.***
- ***Use qualified workers.***
- ***Assign adequate resources.***
- ***Formalize communications between workers.***
- ***Formalize communications between shifts.***
- ***Formalize communications between work groups.***
- ***Adhere to safe operating limits and limiting conditions for operation***.
- ***Control access and occupancy***.

❖ Control the Status of Systems and Equipment

Maintaining a keen awareness of the status of process systems and equipment at all times enables operators to perform their duties reliably. Thus, the human-machine interface should be designed and maintained in a manner that facilitates the collection of information. In addition, the administrative system should make it clear who is in control of the equipment at any given time and responsible for maintaining safe conditions.

- ***Formalize equipment/asset ownership and access protocols.***
- ***Monitor equipment status.***
- ***Maintain good housekeeping***.
- ***Maintain labeling***.
- ***Maintain lighting***.
- ***Maintain instruments and tools***.

❖ **Develop Required Skills/Behaviors**

The focus of the *operations* element is on maintaining reliable operations activities. Obviously, developing and maintaining a workforce with the necessary knowledge, skills, and abilities is central to achieving this objective. In addition, the process safety culture must continually reinforce desired behaviors, such as a questioning attitude and attention to detail.

- ***Emphasize observation and attention to detail.***
- ***Promote a questioning/learning attitude.***
- ***Train workers to recognize hazards.***
- ***Train workers to self-check and peer-check***.
- ***Establish standards of conduct.***

❖ **Monitor Organizational Performance**

Long-term excellence in performance cannot be achieved with fear and intimidation. The workers must perceive real rewards flowing from their achievements, and the intangible satisfactions, such as peer recognition, supervisor recognition, and team victory, are often more important than pure financial rewards. Thus, the objective of monitoring organizational performance is primarily to provide a gauge of progress and achievement, not to provide an excuse for punishment. Poor performance must be analyzed so that appropriate corrective actions can be implemented; however, poor performance is more often an indication of management system weaknesses than of worker failings.

- ***Maintain accountability***.
- ***Strive to continuously improve.***
- ***Maintain fitness for duty.***
- ***Conduct field inspections***.
- ***Correct deviations immediately.***

For more information see **Conduct of Operations and Operational Discipline: For Improving Process Safety in Industry** http://www.aiche.org/ccps/publications/books/conduct-operations-and-operational-discipline-improving-process-safety

4.3.9 ELEMENT - EMERGENCY MANAGEMENT

Overview: Developing appropriate emergency management and response capabilities is one of nine elements in the ***Managing Risk*** **Pillar (Foundational Block**.) Emergency management includes: (1) planning for possible emergencies, (2) providing resources to execute the plan, (3) practicing and continuously improving the plan, (4) training or informing employees, contractors, neighbors, and local authorities on what to do, how they will be notified, and how to report an emergency, and (5) effectively communicating with stakeholders in the event an incident does occur.

The following key principles should be addressed when developing, evaluating, or improving any management system for the *emergency* element:

❖ Maintain a Dependable Practice

An incident triggers emergency management activities. People will do (or intentionally decide to not do) something in an emergency, even if it is wrong. Planning for emergencies greatly increases the likelihood that people will do the right things. However, plans must be tested regularly and rigorously because emergency response activities seem to be more prone to erosion from lack of attention than any other RBPS element. For example, verifying that an effective evacuation plan is in place, or that the plan is understood, is very difficult unless the plan is periodically tested and updated. Because emergency response activities are infrequent, and facilities normally don't get a second chance to address systemic weaknesses, maintaining a dependable practice for this element is critical.

Most facilities in the process industries do not lack for emergency plans. More likely, the facility will have large volume of documents dealing with incidents ranging from a major spill that threatens the environment to a security breach to a large release that could form a toxic vapor cloud. The challenge is not developing more plans; rather it is in ensuring that plans that already exist: (1) cover the range of credible scenarios and (2) are likely to work if needed.

- ***Develop a written program.***
- ***Designate an owner and define roles and responsibilities.***
- ***Define the scope of the program.***
- ***Involve competent personnel***.

❖ Prepare for Emergencies

By definition, emergencies provide little to no warning lead time. There is little chance or opportunity to develop, update, or revise plans. Responders are faced with choosing a course of action based on a range of preplanned response options or derivatives of those options. The response options are typically limited by personnel, their training, equipment, communication protocols, and external support. In general, providing each of these resources has a cost. Planners often have to make a risk-based decision, balancing the potential need with the cost of obtaining and maintaining these resources.

- ***Identify accident scenarios based on hazards.***
- ***Assess credible accident scenarios.***
- ***Select planning scenarios.***
- ***Plan defensive response actions.***
- ***Plan offensive response.***
- ***Develop written emergency response plan.***
- ***Provide physical facilities and equipment.***
- ***Maintain/test facilities and equipment.***
- ***Determine when unit operator response is appropriate***.
- ***Train Emergency Response Team (ERT) members.***
- ***Plan communications***.
- ***Inform and train all personnel.***
- ***Periodically review emergency response plans.***

❖ **Periodically Test the Adequacy of Plans and Level of Preparedness**

If emergency communications are inadequate, the only indications of a possible problem may be a drill or an emergency response activity that exposes this weakness.

- ***Conduct emergency evacuation and emergency response drills.***
- ***Conduct tabletop exercises***.
- ***Practice crisis communication.***
- ***Critique exercises, drills, and actual responses.***
- ***Conduct assessments and audits.***
- ***Address findings and recommendations.***

Interested in more information, see **Guidelines for Technical Planning for On-Site Emergencies** http://www.aiche.org/ccps/publications/books/conduct-operations-and-operational-discipline-improving-process-safety

4.4 PILLAR (FOUNDATIONAL BLOCK) - LEARN FROM EXPERIENCE

4.4.1 ELEMENT - INCIDENT INVESTIGATION

Overview: Developing, sustaining, and enhancing the organization's incident investigation competency is one of four elements in the ***Learning From Experience*** **Pillar (Foundational Block).** Incident investigation is a process for reporting, tracking, and investigating incidents that includes: (1) a formal process for investigating incidents, including staffing, performing, documenting, and tracking investigations of process safety incidents and (2) the trending of incident and incident investigation data to identify recurring incidents. This process also manages the resolution and documentation of recommendations generated by the investigations.

The following key principles should be addressed when developing, evaluating, or improving any management system for the *incidents* element:

❖ **Maintain a Dependable Incident Reporting and Investigation Practice**

Implement the program consistently across the company. Investigations are a responsibility that is typically shared across many personnel in the company. In order to achieve consistency, investigators need a defined process and clear expectations. In addition, because most investigation personnel only perform investigations on an occasional basis, they typically need the guidance provided by a policy or procedure and/or element expert. The more detailed the guidance provided to the teams through the program documentation and through an element expert, the greater the level of consistency that will be achieved. Providing a champion and coordinator for the program will enhance consistency. The champion, usually an upper level manager within the company, helps to set management expectations for the investigation. The coordinator supports the team; helps to overcome routine obstacles encountered by the team, such as obtaining supplies, coordinating logistics, and processing reports; and provides continuity from one investigation to the next.

- ***Define an appropriate scope for the incident investigation element.***
- ***Involve competent personnel.***

- ***Monitor incident investigation practices for effectiveness***.

❖ Identify Potential Incidents for Investigation

Monitor all sources of potential incidents. In order to investigate an incident, it must first be identified. While some incidents are obvious, others, particularly near misses, may go unnoticed. Several methods can be used to identify incidents, including verbal reports from personnel and reviews of documents, such as logs, work orders, emergency response activations, and data trends. Careful review of these data sources allows near misses and incident precursors to be identified.

- ***Ensure that all incidents are reported.***
- ***Initiate investigations promptly.***

❖ Use Appropriate Techniques to Investigate Incidents

Collect appropriate data during the investigation. Performing an investigation without collecting all of the required data often results in the identification of incorrect causes and the development of ineffective recommendations. Developing a list of the types of data typically available and/or required for an analysis will help the team to efficiently collect all of the data it needs. Listing the data collected in the investigation report also helps reviewers understand the depth of the analysis.

- ***Interface with the emergency management element.***
- ***Use effective data collection methods.***
- ***Use appropriate techniques for data analysis.***
- ***Investigate causes to an appropriate depth to uncover "root" causes.***
- ***Demand technical rigor in the investigation process.***
- ***Provide investigation personnel with appropriate expertise and tools.***
- ***Develop effective recommendations***.

❖ Document Incident Investigation Results

Prepare incident investigation reports. A basic outline or report template can be provided to the investigation teams to provide report consistency across different investigations. However, teams will have to adapt the outline to the specifics of the current investigation. One approach that reduces the amount of time required to generate the report is to use the results of the analysis techniques as the core of the report. For example, a logic tree, such as a cause and effect tree, or a time-based cause and effect chart, such as a causal factor chart, that was used to analyze the data provides a wealth of information regarding the incident. Its inclusion in the report can significantly reduce the incident description and cause discussions in the report.

- ***Provide clear linking between causes and recommendations.***

❖ Follow Through on Results of Investigations

- ***Resolve recommendations.***
- ***Communicate findings internally.***
- ***Communicate findings externally.***
- ***Maintain incident investigation records***.

- **Trend Data to Identify Repeat Incidents that Warrant Investigation**

  The only way to see "common-thread" links of incident data is through trending of the data. Trending of data from multiple facilitates looks across investigations performed by a variety of personnel to identify common underlying threads between the incidents. Trending is particularly useful in identifying lower consequence incidents that have a medium to high frequency of occurrence. These incidents usually do not justify an analysis based on the consequences of a single occurrence. However, they collectively represent a significant risk to the company that warrants additional investigation.

  - ***Log all reported incidents.***
  - ***Analyze incident trends.***

For more information on Incident Investigation see

- **Guidelines for Incident Investigation, 2nd Ed.**
  http://www.aiche.org/ccps/publications/books/guidelines-investigating-chemical-process-incidents-2nd-edition
- **Incidents that Define Process Safety**
  http://www.aiche.org/ccps/publications/books/incidents-define-process-safety

4.4.2 ELEMENT - MEASURMENTS AND METRICS

Overview: Identifying and using relevant process safety metrics over the life of a process is one of four elements in the ***Learning from Experience*** **Pillar (Foundational Block**.) The *metrics* element establishes performance and efficiency indicators to monitor the near-real-time effectiveness of the RBPS management system and its constituent elements and work activities. This element addresses which indicators to consider, how often to collect data, and what to do with the information to help ensure responsive, effective RBPS management system operation. A combination of leading and lagging indicators is often the best way to provide a complete picture of process safety effectiveness. Outcome oriented lagging indicators, such as incident rates, are generally not sensitive enough to be useful for continuous improvement of process safety management systems because incidents occur too infrequently. Measuring process safety management performance requires the use of leading indicators, such as rate of improperly performed line breaking activities. The following key principles should be addressed when developing, evaluating, or improving any system for the *metrics* element:

- **Maintain a Dependable Practice**

  A written program that documents the intentions of the *metrics* element is key to long-term success and continuous improvement. Defining roles and responsibilities, which *metrics* data should be collected and how often, and the necessary technical expertise of personnel is critical to having an effective *metrics* system. Records should be maintained concerning *metrics* activities so that performance and efficiency can be periodically evaluated.

  - ***Establish consistent implementation.***
  - ***Determine triggers for metrics collection and reporting.***
  - ***Ensure that the scope of the metrics is appropriate.***

- ***Involve competent personnel.***
- ***Keep metrics practices effective.***

❖ **Conduct Metrics Acquisition**

Too many metrics can overwhelm an organization and too few will not provide sufficient real-time monitoring of RBPS system effectiveness. Facilities should define the appropriate number, scope, and refresh rate of metrics. Using a practical format and selecting the best media for users is as important as the technical content of the metrics.

- ***Implement appropriate element metrics.***
- ***Collect and refresh metrics.***
- ***Summarize and communicate metrics in a useful format.***

❖ **Use Metrics to Make Element Corrective Action Decisions**

Metrics should drive correction or improvement; otherwise they are a waste of resources. Facilities may need to gain experience with monitoring certain *metrics* to learn what variance in the metrics mean and when action is indicated.

- ***Use the metrics element to improve RBPS elements.***

For more information on Metrics see

❖ **Guidelines for Process Safety Metrics**
http://www.aiche.org/ccps/publications/books/guidelines-process-safety-metrics

❖ **Process Safety Leading Indicators Survey (Free** download includes **Process Safety Leading and Lagging Metrics)**
http://www.aiche.org/sites/default/files/docs/pages/8404_leading.web_v2.pdf

4.4.3 ELEMENT - AUDITING

Overview: Critical evaluation of the RBPS management system is one of four elements in the ***Learning from Experience*** **Pillar (Foundational Block).** The *audits* element is intended to evaluate whether management systems are performing as intended. It complements other RBPS control and monitoring activities in elements such as *management review*, *metrics*, and inspection work activities that are part of the *asset integrity* and *conduct of operations* elements. The *audits* element comprises a system for scheduling, staffing, effectively performing, and documenting periodic evaluations of all RBPS elements, as well as providing systems for managing the resolution of findings and corrective actions generated by the audits. The following key principles should be addressed when developing, evaluating, or improving any management system for the *audits* element:

❖ **Maintain a Dependable Practice**

When a company identifies or defines an activity to be undertaken, that company likely wants the activity to be performed correctly and consistently over the life of the facility. The *audits* element should be documented to an appropriate level of detail in a procedure or a written program addressing the general management system aspects previously.

- ***Ensure consistent implementation.***
- ***Identify when audits are needed.***

❖ **Conduct Element Work Activities**

Note: This narrative assumes that a 2nd or 3rd party audit team is conducting an audit of the full RBPS management system. Many of these same activities would be required for a 1st party audit; however, some of the logistical issues and preparatory tasks would be simpler, or nonexistent, for a team self-auditing its own facility.

- ***Prepare for the audit.***
- ***Determine the audit scope and schedule.***
- ***Assemble the team.***
- ***Assign responsibilities.***
- ***Gather advanced information.***
- ***Plan onsite activities.***
- ***Conduct the audit.***
- ***Document the audit***.
- ***Address audit findings and recommendations.***

❖ **Use Audits to Enhance RBPS Effectiveness**

- ***Monitor RBPS maturation over time for each facility.***
- ***Share best practices.***

For more information on Auditing see **Guidelines for Auditing Process Safety Management Systems** http://www.aiche.org/ccps/publications/books/guidelines-auditing-process-safety-management-systems-2nd-edition

4.4.4 ELEMENT - MANAGEMENT REVIEW AND CONTINUOUS IMPROVEMENT

Overview: Routinely reviewing the organization's process safety systems to spur continuous improvement is one of four elements in the ***Learning from Experience*** **Pillar (Foundational Block)**. Management review is the routine evaluation of whether management systems are performing as intended and producing the desired results as efficiently as possible. It is the ongoing "due diligence" review by management that fills the gap between day-to-day work activities and periodic formal audits. Management review is similar to a doctor giving a routine physical examination – even when no overt signs of illness are present, life-threatening conditions may be developing that are best addressed proactively. Management reviews have many of the characteristics of a 1st party audit as described previously. They require a similar system for scheduling, staffing, and effectively evaluating all RBPS elements, and a system should be in place for implementing any resulting plans for improvement or corrective action and verifying their effectiveness.

The following key principles should be addressed when developing, evaluating, or improving any system for the *management review* element:

❖ Maintain a Dependable Practice

Documenting the *management review* program is the first step in maintaining a dependable practice. The procedures governing management reviews must be established, reviewers should be trained, and their effectiveness should be periodically verified. The management system should be designed to detect current or incipient weaknesses in RBPS elements so they can be corrected before a serious breakdown occurs.

- ***Define roles and responsibilities.***
- ***Establish standards for performance.***
- ***Validate program effectiveness.***

❖ Conduct Review Activities

Once a *management review* system is in place, the reviews must be reliably performed. Reviews should be scheduled based on: (1) the perceived risk of a breakdown in each element and (2) the consequences of that failure. Information must be gathered and summarized so the review can proceed efficiently, but the review process must be flexible enough to probe areas of perceived weakness with field verifications, as necessary. Any corrective actions deemed necessary by the review team should be implemented as swiftly as possible.

- ***Prepare for the review.***
- ***Determine the review scope.***
- ***Schedule the review.***
- ***Gather information.***
- ***Prepare a presentation.***
- ***Conduct the review.***
- ***Document the review.***
- ***Address review findings/recommendations.***

❖ Monitor Organizational Performance

A safety management system can be seriously deficient, yet appear satisfactory by superficial measures – the paperwork appears to be in place and no serious incidents have been recorded. Complacency replaces a sense of vulnerability, and the execution of program tasks becomes perfunctory. The purpose of management reviews is to monitor the organizational performance of other RBPS elements, but the *management review* element can itself fall victim to the same complacency when upper management attention is directed elsewhere. Thus, the objective of monitoring review performance is primarily to provide a gauge of its effectiveness in identifying program weaknesses.

- ***Strive to continuously improve.***
- ***Conduct field inspections.***