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# PROCESS SAFETY MANAGEMENT AND RELEVANCE TO THE CANADIAN WOOD PRESERVATION ASSOCIATION

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## Abstract

Process Safety Management is the application of management systems to identify, understand and control process hazards to prevent process-related losses. Process safety has evolved from traditional health and safety programs which focused on individual actions and technical solutions to improve workplace safety, into a comprehensive management system with the objective of eliminating all process-related incidents. Effective Process Safety Management systems can be integrated into existing policies, procedures, and activities for all personnel from operators to the chief executive officer. Chemical producers and engineering societies provide leadership and guidance to advance the Process Safety Management initiative, reduce the likelihood and consequences of accidents, and increase safety within our communities. Process Safety Management is a structured method of managing risk, and is applicable to all industries and activities that are susceptible to accidents or risks.

## Introduction

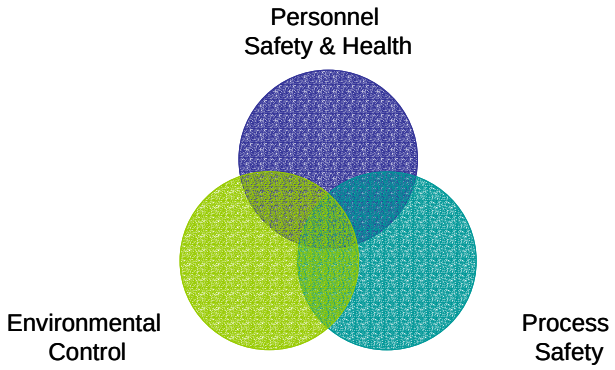
The Canadian Society for Chemical Engineering (CSChE) is the national technical association representing the chemical engineering profession and their interests in university education, government and industry. CSChE provides Process Safety Management leadership and guidance throughout the country to reduce the likelihood and consequences of accidents involving hazardous materials. The CSChE Process Safety Management division is aligned with the Canadian Chemical Producers Association (CCPA), which provides guidance to member companies and leads the Process Safety Management initiative for its partners to promote safer communities.

A number of major process-related incidents have occurred in the past 20-30 years that had significant impacts on surrounding communities. Several of these incidents, such as Flixborough, Bhopal, Chernobyl and Piper Alpha have become household names due to their impact and widespread effects, and have redefined the way the chemical industry approaches Process Safety Management. Initially, process safety was considered very technical in nature however, it was soon recognized that the mechanisms leading to major failures and the potential consequences of these incidents could not be prevented by technology alone. This re-examination of how major hazards are controlled led to a focus on management systems for process safety.

The Occupational Safety and Health Association (OSHA) defines a process as any activity involving hazardous chemicals including the use, storage, manufacturing, handling, or on-site movement of such chemicals. Process safety, as defined by the Centre for Chemical Process Safety (CCPS), is the operation of facilities that handle, use, process or store hazardous materials in a manner that is free from episodic or catastrophic incidents. Therefore, Process Safety Management is defined by CCPS as the application of management systems to identify, understand and control process hazards to prevent process-related injuries and incidents or losses. Process Safety Management is a comprehensive system that affects all areas of a facility operation and all disciplines.

CCPS has defined twelve elements which should be incorporated in a comprehensive Process Safety Management program. Components within each element are intended to be integrated into existing organizational policies and procedures, and overlap traditional personnel safety, health and environmental programs as shown in Figure 1 below. These elements should be considered in all facility processes from plant design, construction, startup, operation, maintenance, modification and decommissioning, and are applicable to wide range of situations, not just major chemical hazards.

**Figure 1:** Personnel Safety & Health, Environmental Control & Process Safety Management Overlap




*CCPS: Guidelines for Technical Management of Chemical Process Safety*

**Process Safety Management Elements**

The 12 elements of Process Safety Management defined by the CCPS are:

- Accountability
- Process Knowledge and Documentation
- Capital Project Review and Design
- Process Risk Management
- Management of Change
- Process and Equipment Integrity
- Human Factors
- Training and Performance
- Incident Investigation
- Standards, Codes and Regulations
- Audits and Corrective Action
- Process Safety Knowledge Enhancement

*Accountability*

Accountability is the obligation to justify and answer for one's actions as they relate to company values, goals and objectives and must be included in each element of the Process Safety Management system. Specific accountability components include continuity of operations, system and organization, quality processes, control of exceptions, utilization of alternative methods, management accessibility, communication, and company expectations.

Management accountability begins with clear, explicit, and specific statements of a company's goals and objectives. These goals must be communicated and understood throughout the organization, and supported by appropriate resources. Management commitment to achieving these goals must be demonstrated at all levels of the organization, and includes accessibility for providing support and guidance in decision making and resolving conflicts. The importance of process safety relative to other organizational objectives such as production and costs must be well defined and demonstrated.

*Process Knowledge and Documentation*

Capturing an organization's experience and wisdom, and documenting process knowledge, is fundamental to the long-term viability and success of a company, and is the foundation upon which many aspects of a process safety program are built. This element includes chemical and occupational health hazards, process definition and design criteria, process and equipment design, protective systems, operating procedures for normal and upset conditions, process risk management decisions, and documentation of company knowledge.

Maintaining process knowledge, and making this information available within a company, is important for recalling rationale for key design decisions, providing a basis for how and why a process should be operated in a specific way, ensuring a baseline for evaluation of process changes, and incorporating lessons learned into future projects and efforts. Operating procedures must be readily accessible and current and cover startup, shutdown, emergency shutdown, and safe restart in addition to normal operating conditions. Potential scenarios due to unintentional or intentional misuse of materials or processes should also be considered.

*Capital Project Review and Design*

Capital project design reviews typically apply to the construction of new plants, but may also involve modifications or alterations to existing facilities. Design reviews provide the greatest opportunity to impact process hazards, minimize the overall risk, and influence factors that may extend outside of the company. A number of components must be considered in Process Safety Management for project design reviews. These include the development of procedures for standard operation, start-up, shutdowns and emergencies, hazard reviews, location and siting, plot plans, process design and review procedures, and project management controls.

Project reviews can be used to ensure an adequate balance between competing objectives of production and cost versus risk management initiatives at each stage of the project. Risk mitigation techniques may be evaluated and selected from a cost-benefit analysis basis. Inherently safer designs can be utilized and incorporated at the project review stage with minimal costs versus future retrofits. Inherently safe design includes:

- Minimizing quantities of hazardous substances.
- Substituting or replacing materials with less hazardous substances.
- Moderating hazardous conditions by using less hazardous forms of a substance, or minimizing the impact of release of a hazardous material or energy.
- Simplifying process and facility designs by eliminating unnecessary complexity and reducing the impact of operating errors.

*Process Risk Management*

Process risk management is a systematic method of identifying hazards within a facility, evaluating those hazards in terms of probability and consequence, and identifying mitigation measures for controlling potential losses associated with such occurrences. Numerous techniques are available in the process safety industry for stepwise assessment of hazards and risks depending on the type of process, equipment or procedure undergoing the review such as what if scenario or checklist studies, hazard and operability (HAZOP) studies, layers of protection analysis (LOPA), loss of containment, and failure modes and effects analysis (FMEA). Identification of process hazards, and understanding the impacts or risks associated with these hazards, is a critical step in ensuring successful process risk management. The effectiveness of this process depends on the expertise of the multidisciplinary risk management team involved and their ability to identify all process hazards. Threats and hazards not identified cannot be addressed, and may not be controlled.

Each organization must determine what constitutes an acceptable level of risk in terms of likelihood of occurrence and impact from an environmental, employee, public, economic or production perspective. Risk ranking matrices are often developed to outline acceptable levels of risk from a company perspective based on hazard severity and probability in each of these areas. These may be qualitative in nature, based on judgment and experience, or quantitative based on statistical modeling techniques. All hazards identified during the stepwise assessment can then be evaluated in terms of the overall risk to ensure they satisfy established company standards.

*Management of Change*

Management of change in relation to Process Safety Management is a method of ensuring all changes that could affect the safe operation of a facility are reviewed and documented prior to their implementation to minimize the overall risk. Although it is widely recognized that new facilities and major plant modifications require process hazard analysis reviews to ensure safe operation, even small changes to existing facilities can have catastrophic consequences. It is essential to define and understand what is meant by change, recognize and identify such changes when they occur, and ensure triggers or flags for appropriate review of these changes. Change management is a critical Process Safety Management element and includes changes in process technology, changes to existing facilities, organization changes, variance procedures for deviations from normal practices, and must include both permanent and temporary modifications.

Process changes are typically made to maintain plant operation, compensate for equipment shutdowns, experiment with yield or quality improvement, change production rates, or for the start-up, shutdown or addition of new process equipment. Management of Change should consider the unique circumstances associated with each of these situations. Careful consideration should be given to potential implications from equipment modifications or changes, other than exact replacements in kind. Changes in personnel and organizational responsibilities can impact Process Safety Management, especially the loss of experienced staff when historical knowledge and lessons learned are not fully documented. Variance procedures ensure that deviations from normal practice do not create unacceptable risks, and require an explanation and reason for the deviation, assessment of potential safety, health and environmental implications, the duration of the variation, and control measures to be taken to minimize the risks associated with the deviation. Management of temporary changes must have the same controls as permanent changes, and the maximum acceptable time limit must be defined to avoid these changes becoming permanent modifications.

*Process and Equipment Integrity*

Equipment used to handle or process hazardous materials must be designed, built, installed, and maintained in an acceptable condition to control the risk of failure, material release, or other incidents. Components of process and equipment integrity include reliability engineering, materials of construction, fabrication and inspection procedures, installation procedures, preventative maintenance, inspection and testing of process, hardware and systems, maintenance procedures, alarm and instrument management, and demolition procedures.

Reliability engineering is the process of evaluating the length of time a system and its components can be safety operated before they should be taken out of service for maintenance or replacement. Vessel and piping specifications should be developed to ensure appropriate materials are used, and supplemented by systems that verify incoming materials meet design specifications. Fabrication and quality assurance programs must also ensure that equipment is built according to design specifications and meets all applicable codes and standards. Preventative maintenance programs must identify equipment and instrumentation that are critical to the safe facility operation, determine tests or inspections required to verify their condition, establish maintenance procedures and required inspection frequencies, ensure discipline in performing inspections and maintenance at the scheduled intervals, and document analysis of the results. Instruments and alarms deemed critical to the safe operation of a facility should be included in the preventative maintenance program, and changes to routine settings should be reviewed and approved as part of an effective Management of Change.

*Human Factors*

Human errors can play a significant role in process safety incidents. The likelihood of human errors should be acknowledged and anticipated in a facility design, and altered to prevent its occurrence or minimize its impact as much as practically possible. Improving ergonomics and simplifying the physical interface between operators and the equipment or process will significantly enhance process safety. An appropriate balance between administrative controls such as standard operating procedures versus hardware controls such as alarms and interlocks to control process hazards must be obtained. Increased automation can simplify the operator/equipment interface, but may increase process complexity and required maintenance frequencies. However, reliance on operator intervention in an emergency situation may not be adequate to ensure safe and suitable response. Human error assessments to determine human reliability and performance concerns can be used to determine if specific design changes or procedural controls are required.

*Training and Performance*

Defining job descriptions and responsibilities, determining appropriate hiring qualifications, and assessing training requirements are an essential part of a Process Safety Management program. A systematic approach should be developed to assess required skills and knowledge for all employees and contractors, and should play a major role in determining hiring qualifications. Specific training programs should be selected and developed to meet these requirements, including appropriate instructor programs. Performance measuring and monitoring can be used to assess the suitability and effectiveness of training programs and the instructors. Documentation of training programs may be required from a regulatory perspective, but also facilitates verification of training provided and its effectiveness. Ongoing performance and refresher training is then required to maintain knowledge and ensure changes in regulations, equipment, procedures and processes are recognized and understood.

*Incident Investigation*

Incidents are unplanned events with undesirable consequences including fires, explosions, releases of toxic or hazardous substances, injury, death, or any adverse human, environmental, or property effects. Incident investigation is a management system to identify the contributing factors and root causes of incidents, and ensure appropriate steps are taken to prevent recurrence. Each incident should be investigated to determine its cause, evaluate potential consequences, and determine how future incidents can be avoided.

It is important to learn from major incidents, but also potential incidents and near miss situations which could have reasonably resulted in an accident. It is essential that incident follow-up and resolution occur promptly following an incident, and the investigation must involve competent and knowledgeable people to be effective. Third party participation should be sought where beneficial for specific knowledge or objectivity. All incidents, including near misses, should be reported. Major, serious, and near miss incidents with the potential for major or serious consequences should be investigated and root causes identified, with follow-up actions determined to prevent another occurrence. Communicating incident investigations throughout the organization, to other facilities within the company, and to similar organizations helps others benefit from the lessons learned and advances the Process Safety Management initiative.

*Standards, Codes and Regulations*

Internal company standards, codes and regulations are designed to communicate acceptable practices and ensure a common approach to process safety within the organization. Internal standards allow the incorporation of company knowledge, experience, history and lessons learned into future process designs and operation. Such standards also ensure consistency in safe facility design, operation and maintenance. Internal standards often complement or incorporate external codes and design practices. Many external regulations and standards apply to the layout, design and operation of facilities, protection of equipment, employees and public. Responsibility for maintaining current codes, standards and regulations must also be established. Once a list of appropriate standards is developed, they need to be readily accessible, disseminated, understood and maintained to ensure their effectiveness.

*Audits and Corrective Action*

Audits are periodic assessments conducted to verify compliance with regulatory requirements, facility procedures, internal standards, guidelines, and best practices. Objectives of management system audits, compliance reviews and process safety audits are to improve the overall process safety performance, document compliance with established requirements, increase process safety awareness, improve the process risk management system, and develop a basis for optimizing process safety. Both internal and external audits can be used depending upon available expertise and the desire for an independent review. Corrective action planning and follow-up is essential to evaluate the effectiveness of action taken and ensure a successful audit process.

*Process Safety Knowledge Enhancement*

Process safety is a dynamic field, with continuous advances in technology and industrial best practices. Enhancement of process safety knowledge supports not only safety programs, but can provide a competitive advantage through increased productivity, improved quality and efficiency of operation. Technology and safety knowledge is constantly changing, and safety regulations continue to become more stringent. By designing for continuous improvement, a system of proactively seeking new process knowledge ensures one remains current with changing technology and industry practice. Access to relevant information through a Process Safety Management reference library can be an effective tool.

## Conclusion

Process Safety Management is a structured and disciplined approach to improving equipment reliability, process performance, and reducing the level of risk associated with various processes. While originally developed for the chemical industry, it can be applied to all industries and processes where hazardous materials are used, manufactured, stored, transported or handled. The twelve elements and components of Process Safety Management defined by the Centre for Chemical Process Safety (CCPS) are effective guidelines to be used in the development and enhancement of process safety programs in your organizations. We all benefit as professionals, employees and community citizens by improving the operation and safety of our facilities.

## References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