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IMPLEMENTATION OF PROCESS SAFETY MANAGEMENT (PSM) IN CAPITAL PROJECTS

**Charles Soczek
Principal Consultant
DuPont Sustainable Solutions
Wilmington, DE**

INTRODUCTION

There are three types of changes that occur in high-hazard processes that address PSM-related issues: 1) facility and technology changes in existing operating units, 2) small projects, and 3) major projects.

Facility and technology changes are managed with the PSM management of change process. They are relatively low-cost changes and modifications to existing facilities that are charged to operating cost, investment cost, or a blend of the two. These changes require minimal design. However, PSM requires consideration for a Process Hazards Review, changes in process documentation and operating procedures, the need for a Pre-startup Safety Review, and possibly other PSM elements depending on the change. These changes are implemented through the plant work order system.

Small projects are for higher cost changes, generally to existing facilities that are charged as capital investment. They require design, frequently completed with a local engineering group. Because they are completed on sites with an existing PSM program, not all the PSM elements are required tasks for the project team. Below are the elements that should be addressed:

- Developing of and storing process safety information
- Completing the PHAs, including impact on the site facility siting study
- Developing the operating and maintenance procedures as necessary
- Provide training as necessary to operators and mechanics
- Implementing a quality assurance process for equipment procurement and installation
- Developing or updating:
 - Mechanical integrity inspection and test program
 - Audit program
 - Emergency planning and response program as necessary
- Implementing Contractor Safety for Construction Safety
- Pre-startup safety review

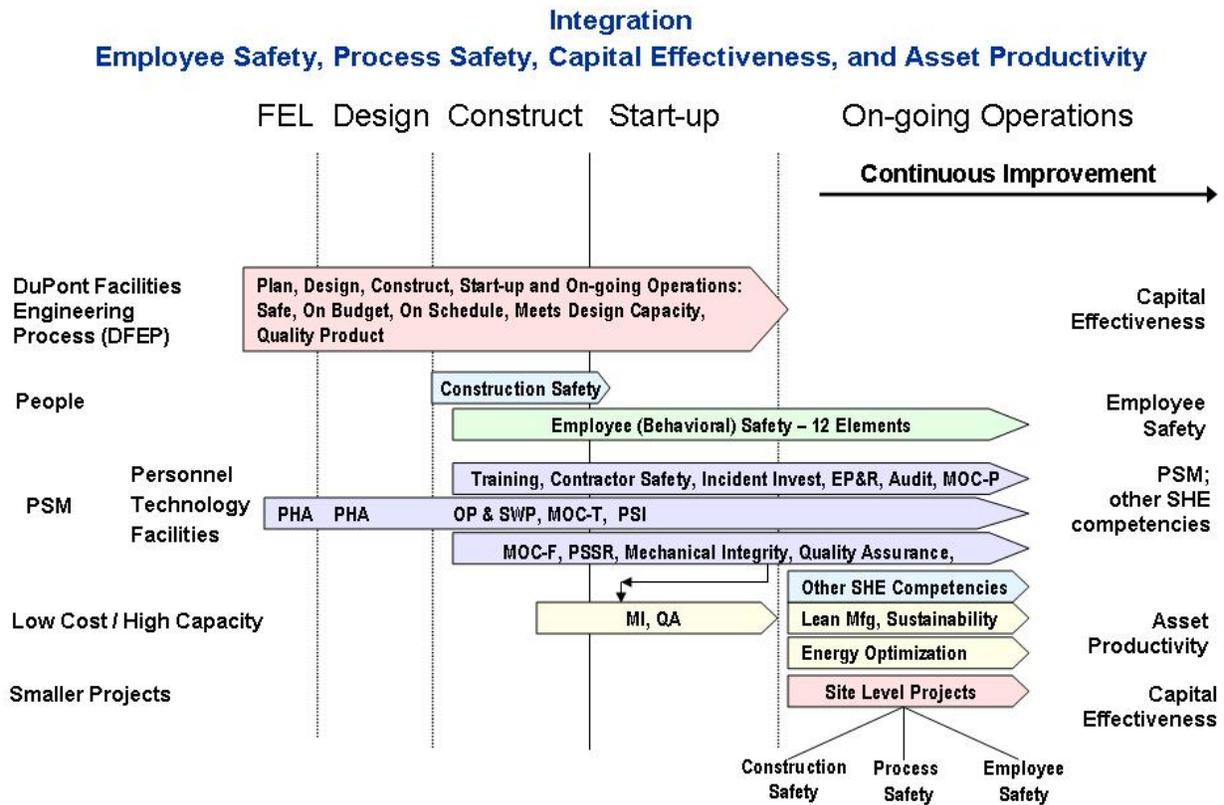
Large capital projects can be implemented on either a Greenfield or Brownfield site. On a Brownfield site, where there is an existing PSM program in place, the PSM elements that need to be addressed are the same as a small project. For a Greenfield site, with no PSM in place, all of the PSM elements need to be addressed.

Therefore, in addition to the small project requirements, large capital projects require the following:

- Incident investigation
- Management of change (facility and technology)
- Management of change – personnel (a DuPont requirement, not currently an OSHA 1910.119 requirement)

CONTINUOUS IMPROVEMENT PSM PROCESS VERSUS A LINEAR PROCESS

DuPont implements PSM in high hazard operations according to a continuous improvement plan, based on the Deming Plan-Do-Check-Act system. For capital projects, all of the required PSM tasks must be completed by turnover and start-up. Figure 1 contains a diagram showing the timing sequence for PSM project activities.



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Figure 1. Timing of PSM activities (for more detailed information, see Appendix A.)

In a DuPont capital project, business objectives are set during front-end loading (FEL). This is done in a business objectives letter that is issued when the need for a project is recognized and is completed prior to any gate reviews. This letter sets financial objectives and identifies key issues such as investment, volume, and schedule and sets safety, health, and environmental strategies. A key issue is setting project priorities. Project priorities in a DuPont capital project include consideration of:

1. Safety and environment
2. Investment/internal rate of return/investment intensity
3. Schedule
4. Manufacturing cost

5. Product quality
6. Proprietary information protection
7. Capacity
8. Reliability
9. Flexibility

In DuPont projects, safety and environmental protection are always number one priorities. In order to focus on these priorities, plus meet the other objectives, Process Safety considerations must begin early in the conceptual phase of the project. For the project referenced above, additional guidance emphasized design for zero leaks and a requirement to minimize toxic chemical inventories.

While the business objectives describe what needs to be accomplished, the project objectives detail how the project will be accomplished. The draft project objectives letter is prepared in the FEL. Following this step, DuPont completes 20-30% design, developing control strategies to manage hazards. This includes inherently safer processing technologies, process control, and safety interlocks. In this way, the project is adequately scoped to assure safe operation of the facilities prior to beginning production design.

The process hazards analysis (PHA) is the starting point for PSM-related activities. It is the responsibility of the project team to achieve a balance among priorities in order to meet the overall project objectives. An integrated project team at DuPont is assembled and includes members from the operating department, DuPont Engineering, the design contractor, and construction contractor.

In DuPont this is a staged process starting with a screening review, a pre-authorization review, a detailed review, and the pre-startup safety review. At the conclusion of the project, a project safety report is prepared that compiles all the PHA related activities.

Screening Review

The objective of the screening review is to identify potential acute hazards, any unknowns with potential process safety implications, and any other relevant concerns, and to develop broad recommended changes in scope to significantly reduce these hazards. A key activity in this review is to identify and consider the use of inherently safer technology. Identifying hazards early in the process and developing the scope to manage the risks of these hazards is a critical step in achieving a balance between capital cost, operability, and life cycle cost. In some cases, implementation of inherently safer processing strategies can add to the capital cost, but have a significant positive impact on operability and life cycle cost.

There are examples of projects that began the PHA reviews near completion of production design. This meant that implementing ISP strategies would add significant cost and delays in start-up. When the PHAs were completed, there were fewer options to manage risks. The result was a large number of safety interlocks, operability issues, and high maintenance costs to meet current IEC and ISA safety interlock design, inspection, and test requirements.

Pre-Authorization Review

The objectives of this study are to review the screening PHA, review any changes in scope or design intent since the screening PHA, confirm all process-related hazards and hazardous events have been identified, help ensure that the consequences of the identified events have been assessed, and determine if the current project scope is adequate to control all of the hazards. This assures that the project is adequately funded to control hazards.

Detailed Process Hazards Analysis

The detailed PHA includes a review of the earlier PHAs and an in-depth, systematic analysis of the process to identify and evaluate:

- All process-related hazards and hazardous events
- Potential routes to the hazardous events
- Adequacy of safeguards included in the process and facility design

Lastly, it is important to develop recommendations for further process hazards elimination or control. This review is done soon after the design drawings are released.

Pre-Startup Safety Review

The PSSR provides a final checkpoint for new equipment to confirm that all appropriate elements of PSM have been addressed satisfactorily and that the facility is safe to start up. For capital projects, planning for success with the pre-start-up review begins with assembling a competent project team. Effective project management, including careful planning and coordination of all PSM elements, is important to achieve a smooth start-up.

Final Project Safety Report

This report may be either a compilation of all the project PHAs (i.e., the screening, pre-authorization, and detailed PHAs) and related documentation for all other process safety related topics addressed during the project engineering phase, or it may provide a summary of the work completed in these other reviews and the key findings and recommendations, along with a reference to the complete individual reports. This report is prepared prior to the pre-start-up safety review (PSSR).

Below is a brief overview of some key PSM elements that apply directly to a capital project.

Note: Not all the requirements of OSHA 1910.119 and EPA RMP are described.

PROCESS SAFETY INFORMATION

The process safety information package provides a description of the chemical process or operation. It provides the foundation for identifying and understanding the hazards involved, which are the first steps in the PSM effort. The package consists of the following parts: hazards of materials, process design basis, equipment design basis.

Process safety information is critical to help ensure safe operation throughout the life of the facility. This information is needed by the PHA teams so they understand the impact of proposed changes and can perform cyclical reviews. Unfortunately, this information is very costly to reproduce if lost; therefore, permanent storage systems must be established. It is essential that the process safety information requirements need to be built into design and procurement packages.

MECHANICAL INTEGRITY/QUALITY ASSURANCE

Mechanical integrity (MI) covers the life of the facility from the initial installation through dismantlement. It focuses on maintaining and continuously improving a system's integrity to contain hazardous substances and control the mechanical hazards throughout the life of the facility. It addresses such topics as the following:

- Maintenance procedures
- Training and performance of maintenance personnel
- Quality assurance (QA)/quality control (QC) procedures
- Equipment tests and inspections, including predictive and preventive maintenance
- Repairs and changes
- Reliability engineering

The development of maintenance procedures and the equipment test and inspection program is a large effort, and the project team is normally responsible for developing these procedures.

In DuPont, quality assurance applies to project materials, whereas quality control applies to maintenance materials. The project team is responsible for QA, and activities may include correct specification of project materials, vendor inspections, inspections upon arrival, correct storage and preservation of project materials prior to use, and final inspection at installation.

Construction Safety

Many companies use contractors for construction of facilities. In DuPont, whether completed by site employees or by contract employees, it is essential that all tasks are completed safely and in accordance with established procedures and/or safe work practices and are consistent with the principles and essential features of PSM. For construction activities, particularly near or within an operating unit, additional activities such as a constructability analysis are required. This may include, for example, erection of physical barriers between operating units and construction activities.

Operating Procedures

Operating procedures are prepared by the project team during the construction phase of the project after drawings have been released. They should contain all the requirements listed in OSHA 1910.119. In the case where operating procedures are supplied by a vendor, they should be reviewed by the project team to help ensure operability with the actual unit under construction. These procedures are the basis for operator training.

Training

The project team is responsible for ensuring that all operating and maintenance personnel are properly trained. Initial training should include:

- An overview of the process, emphasizing specific safety, health, and environmental hazards
- Emergency procedures
- Operating procedures
- Safe practices applicable to the employees' job tasks
- Additional training such as basic skills and job task training

MANAGEMENT OF EMPLOYEE AND PROCESS SAFETY

In manufacturing processes that contain high hazards, it is important to build a strong safety culture. This is done by implementing both solid employee safety and process safety programs. Failure to implement either one of these has a negative influence on safety culture and may result in poor safety performance. For a Greenfield site, implementation of an employee program begins when operating, maintenance, and technical personnel are identified and the operating organization is established.

DuPont has developed a 12-element program for management of employee safety:

Management Commitment

Management commitment is the basic component of a successful safety management system. This commitment must exist at the top and then cascade to all levels of the organization, including partners and contractors. In addition, safety is an organizational value that must be considered as important as any other business decision-making parameter such as quality, productivity and cost.

Overall, management must demonstrate commitment and respect for safety through “example, attitudes, behavior, and follow up.” In addition, management must be consistent in all they say/speak/write and what they do. When done properly, this “felt leadership” will create an environment of trust that will be the foundation of safety improvement.

Policy and Principles

The organization shall establish and implement safety policy and principles that are based on the corporate values, mission, and vision. The safety policy and principles are effectively communicated through the line organization, and their understanding and adherence by members of the organization are continuously evaluated. In short, the actions of all members of the organization shall be guided by the policy and principles.

Integrated Organizational Structure

An integrated organizational structure facilitates efficient management of safety through involvement of all levels of the organization, and is applied to everyone from the head offices and administrative areas to the operational sites. Typically, a management committee headed by the highest level of the organization should lead the overall safety effort by developing and improving safety management systems. In addition, line management has accountability for planning, developing, implementing, controlling, evaluating, and validating the safety management system, and for involving all people in their area of responsibility.

The management committee will sponsor a network of subcommittees throughout the organization. Subcommittees are responsible for guiding and supporting the implementation and continuous improvement of safety programs and procedures. Subcommittees are multifunction teams led by line managers and often include safety specialists, experts, and operational representatives.

Line Management Accountability and Responsibility

An effective safety organization is achieved when roles and responsibilities are clearly defined and implemented. The Safety Management System is based on line responsibility and states that leadership should be actively engaged and committed to safety, taking responsibility for their performance and the performance of those reporting to them. This commitment should be reflected in the people management processes (HR), which should consider both individual and organizational Safety performance in career and development plans.

Goals Objectives and Plans

Like any other important management system, Safety Management Systems achieve excellence through continuous improvement concepts, establishing challenging goals and objectives, and developing action plans accordingly. These goals set the overall direction of the system, and the objectives define the targets that must be met. In establishing challenging goals and objectives, the organization develops safety programs and management system improvements and drives safety performance.

Safety Personnel

Safety professionals are responsible for providing support to the line organization on regulatory and technical issues and on the Safety Management System improvement process. Usually, safety professionals:

- Serve as an advisor to leadership;
- Support and coordinate the safety management model;
- Influence, advise, and assist the entire line organization on safety management and program implementation;
- Participate in field audits to be used as reference for trend analysis;
- Periodically audit the safety performance and management model;
- Interpret safety regulations and interact with external agencies.

Procedures and Performance Standards

High operational standards are achieved by high-quality operating procedures, use of best practices, and best-in-class installations. Procedures should be written, disseminated widely, followed, and reinforced.

Operating procedures should also provide a clear understanding of the parameters of operation and the risks to people, community, and environment. Processes must exist to continuously improve and check for adherence to those procedures in order to guarantee operational discipline. In addition, installations are continually checked for improvement opportunities in safety.

Training and Development

The Safety Management System helps ensure that people are prepared for their jobs physically, mentally, and technically. Selecting people and training are basic principles that increase personal capability and awareness of risk when dealing with operational hazards. In addition, proper selection and training help to improve personal and team performance. A people development process including initial orientation certification for special activities, professional progression, and retraining should be in place.

Effective Communication

Information related to safety needs to be clearly, objectively, and promptly communicated in a way that enables all levels of the organization and the local external community to interact effectively to improve safety performance. Communication processes are based on a two-way approach throughout different levels of the organization, ensuring that both employee understanding and active leadership participation is achieved. Often, these processes use different communication vehicles for different objectives.

Motivation and Awareness

Safety motivation and awareness occur when the management system includes programs and processes that continuously promote safety and connect individual contributions to an effective results-oriented system. Leadership participation and initiatives are designed to help ensure that rules and procedures are followed and that people are motivated to follow them.

Audits and Observations

A continuous improvement system is based heavily on safety audits and inspections with effective leadership participation at all levels of the organization. Processes exist to enter, report, and monitor implementation effectiveness and to complete periodic, critical analysis for all audit conclusions and recommendations. Use of the overall safety management audit and the three audit levels (first, second and third party) are consistently used as a reference guide.

Incident Investigations

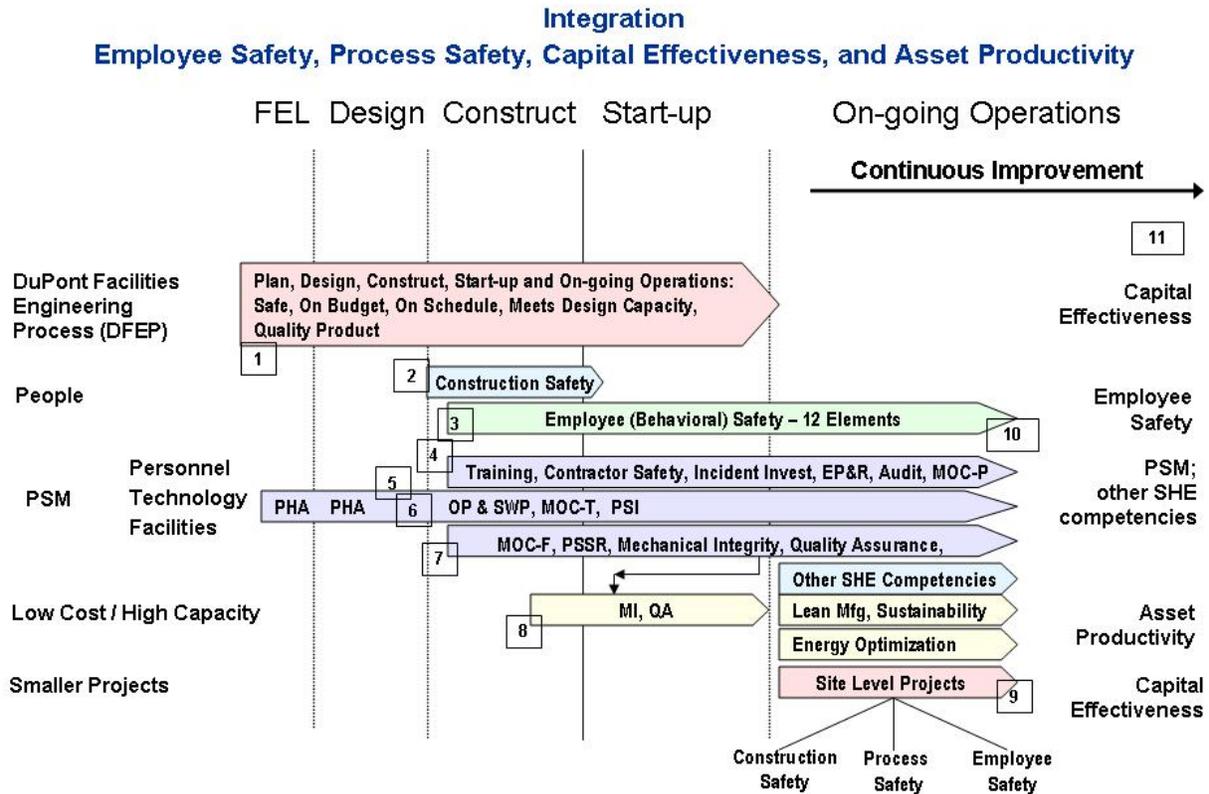
The learning process from undesirable events occurs in a structured way, uses the line responsibility concept, and is treated as a priority by the whole organization. The accidents and incidents investigation process includes activities from classification to analysis of all possible causes, as well as follow up on the effectiveness of the actions taken. Support of investigations methodologies exists to guarantee high quality results.

CONCLUSION

PSM must be embedded into capital projects to help achieve a safe start-up. This is the foundation for assuring safe operations throughout the life of the process, especially in the construction of facilities for high-hazard processes.

The PSM system practiced by most companies today is a Deming-based, plan-do-check-act system that strives for continuous improvements. The capital project process is very different. To meet the competing priorities in a project, PSM considerations need to start very early in a capital project, with specific starting and ending points that are driven by cost and time. The objective is to have a full PSM program in place at the time of start-up.

APPENDIX A – TIMING OF PSM ACTIVITIES



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NOTES:

1. The DFEP relies on a strong front end loading to assure the project meets budget, SHE, capacity, quality, and manufacturing cost objectives. In addition, it makes effective use of best practices and value improving processes and sound contracting strategies. The project team is composed of DuPont Engineering and Manufacturing representatives, plus others as design, construction, and technology representatives.
2. Construction Safety is targeted at assuring safety in capital projects during construction. It is very similar to contractor safety, which is part of Process Safety Management and targeted at ongoing maintenance and other activities in an existing facility.
3. Employee safety is based on 12 elements and targeted at the entire organization to assure full participation and commitment to building a strong safety culture. It builds the operating discipline necessary for continued safe operation of the facility and is a foundation for Process Safety Management activities. In a capital project, the activities must begin when the operating team is assembled, and activities continue throughout the life of the process.

4. Process Safety Management focuses on three areas: Personnel, Technology, and Facilities. There are six areas in the Personnel part of PSM. Certain activities, such as Training, Emergency Planning and Response, and Contractor Safety must be complete by start-up. Also, at start-up, the plant converts from the project Incident Investigation system to the plant system. After start-up the plant needs to implement a first- and second-party audit system and a Management of Change/Personnel system.
5. There are 14 elements of Process Safety Management in three major areas: Personnel, Technology, and Facilities. Four elements are common with Employee safety: Audits, Training, Incident Investigation, and High standards of Performance, which includes Operating Procedures and Safe Work Practices. For Greenfield Project, the project team and site operations team are responsible for developing a comprehensive PSM program plus building a safety culture and having it in place for start-up. For existing sites, the project team is responsible for integrating project PSM activities into the site program.
6. The PHA process begins very early in the project with a screening review, followed by a pre-authorization review. The objective of these reviews is to assure project funds are adequate to manage process related hazards. A detailed PHA is done at the completion of the design step. For ongoing operations a base line review (detailed Review if available) is necessary, followed by periodic updates. Changes of Technology or Facilities could trigger additional PHAs.
7. The Facilities part of PSM covers four areas: Management of Change/Facilities (or Subtle Change), Pre-start-up Safety Review, Mechanical Integrity, and Quality Assurance. The project team is responsible for the conversion of the project change system to the plant change system. The PSSR is done upon project completion and turn-over to the site operations team. A major task of the project team is to address project requirements for Mechanical Integrity including Maintenance Procedures, Training and Performance of Personnel, Quality control Procedures, Equipment tests and Inspections, Repairs and Changes, and Reliability Engineering. A Quality Control program, aimed at parts and supplies for plant maintenance, and a Quality Assurance program, aimed at equipment for plant projects, must be developed.
8. The Mechanical Integrity and Quality Assurance Program developed under PSM are targeted to assure containment of hazardous materials and control of risks from high energy and other mechanical equipment. This program provides the basis for further equipment improvements targeted at reducing maintenance costs, replacement costs, capacity increases, and other sustainability efforts. This is done through the Asset Productivity programs as Lean Manufacture and Sustainability.
9. Smaller or site level projects are done to implement site driven improvements in safety, health, and environmental, process safety, cost reduction, capacity improvement, and replacement. A streamlined version of the DuPont Facilities Engineering Process is normally used. Site level projects require the same elements of FEL, design, construct, and start-up as the larger projects. They must also include Construction Safety and the project elements of PSM and integrate them into the site system. The training required for Employee Safety depends on the experience of the operating group.
10. The project team is responsible for development of the Process Safety Information package. Key areas are Hazards of Materials, Process Design Basis, Equipment Design Basis, and Process Technology Documentation. For the project team, pulling this information together is a substantial effort.
11. The typical area where DuPont works is in on-going operations, where the facility is built and in operation. The site wants to make improvements in safety culture, PSM, capacity, quality, reduce cost, etc., or add a new facility. These can be done through programs and projects. The management system in place uses the continuous improvement process of envision, plan, implement, and check.

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