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Research paper



Process safety management in manufacturing industries a review

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Abstract

The most common feature among the best known companies in the world is safety. In fact, process safety and manufacturing productivity go hand in hand. In the last century, a number of catastrophic accidents have drawn the attention of regulators towards process safety. In several developed, industrialized countries, strict regulations and standards are applied to emphasize process safety. In fact, in such countries, these are the required minimum for maintaining business license and permits. However, in developing and in under developed nations, the issue of process safety and their importance is still being debated. Process safety cannot just be driven by a set of rules, regulations, policies, etc. Multitudes of items are required in establishing and maintaining a safe and a reliable work environment. Such items, though can be expressed readily in paper, are quite arduous to establish in a highly competitive environment. The legislation, the government regulations, banking policies, management commitment, cumulatively share the responsibility in establishing organizations judiciously managing process safety. This paper reviews certain critical aspects in establishing a successful process safety management (PSM) program. Furthermore, the paper reviews the various elements that contribute towards the creation of a worthwhile PSM program.

Keywords: *Process Safety Management; Industrial Safety; Dupont PSM; Safety and Health Management*.

1. Introduction

Manufacturing industries can sustain only when their operations are reliable, safe and profitable. Likewise, the products from the manufacturing unit must conform to high quality standards, meet the customer's requirements and be priced competitively. Process safety management (PSM) techniques help the business by having sufficient barriers in place such that the business is managed safely, effectively, reliably and profitably. Additionally, PSM techniques support the business to deliver products conforming to high standards.

E. I. du Pont de Nemours and Company, commonly referred to as DuPont, originally came up with PSM techniques, and manufacturing and process units employ these techniques across the globe. The elements of process safety management system provided the basic framework for Occupation Safety and Health Administration (OSHA) standards in the United States. Any business unit operating in the United States must conform OSHA standards or DuPont PSM standards to obtain/maintain their business license and the necessary permits. Likewise, several industrialized countries across the globe have borrowed the concepts of DuPont PSM and have developed similar suitable safety and health standards that are backed by legislation.

In the last several decades, numerous accidents have occurred in industries around the globe and such catastrophic incidents have driven development of safety and health regulations. The cost, fatality, environmental impact, etc. associated with the accidents have driven the nations to establish adequate regulations for ensuring safe and reliable operation of business units. The concepts for such regulations originate from DuPont PSM techniques. Though these techniques and the various elements of PSM are widely discussed and implemented, PSM elements, standards, requirements for establishing an effective PSM program haven't yet been concisely reported in the available literature. The paper discusses certain critical aspects of managing safety and reviews the various elements of PSM program.

The pertinent papers involving industrial safety and reliability are discussed herein. Aziz et al. [1] considered the interrelations between PSM elements. From their analysis, it was determined that process hazard analysis and mechanical integrity have the highest interrelations among all the PSM elements. They developed a PSM matrix that shall be useful for the development of an integrated PSM system. Atherton and Gil [2] considered the incidents that define process safety. Events were described such that the audience were able understand the root causes, the consequences, the lessons learned and the actions that prevent an accident recurring. Long [3] considered the history of process safety accidents, the lessons learnt from such accidents and how PSM shapes up from such lessons. Brackey [4] brings out his practical experience and his views on his direct experience from PSM. He discusses challenges while practicing PSM in a process plant. Imran et al. [5] describe the implementation of PSM elements in a fertilizer plant and the difficulties in setting up the PSM programs with respect to various items that need to be executed in the plant. The article describes the necessity of PSM and the activities required within the plant from an operations engineer's viewpoint. Hanchey and Thompson [6] describes the challenges in implementing and maintaining an effective PSM program. They describe the required support systems in the plant in maintaining a good PSM program. Vaughen et al. [7] describe the integration of plant reliability and mechanical integrity element of PSM. The various steps required in the integration were detailed in the document. Silaipillayarputhur [8] considers maintenance engineering and discusses the key elements such as PSM required for successful functioning of a maintenance team in process plants.

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Klein [9] discusses the operation disciple in process plants and on how operational disciple reflects the process safety culture and the business performance of the organization. Likewise, Klein and Vaughen [10] discuss the necessity of the implementation of an operational disciple program to improve the process safety.

2. Managing safety and risk

There are several different elements in the PSM system. Each element has a distinct function and serves as a safety barrier, protecting the business from a potential safety incident. The required number of barriers for a given business is usually dependent on the nature of the business itself; the more hazardous is the business, the more barriers that are put in place to keep the business safe.

It must be recognized that barriers are always not perfect, and that there could be several defects that can cause the barriers to break down. The defects in the barriers can manifest in the form of human errors, human fatigue, low budget, short cuts, poor communication, weak team, poor coordination among the team, improper training, break down of equipment & controls, poor operations & maintenance practices, inadequate employee involvement, old procedures, and many more.

Therefore, having a PSM program with several defects adds no value to organization. Essentially, a certain strong foundation must be created before introducing a PSM program. Management leadership and commitment for safety and reliable operation serves as an essential foundation for the implementation of PSM program. Once the management leadership and commitment is in place, it is rather straight-forward to establish a good safety culture, implement an effective PSM program and initiate operational discipline.

The employees can recognize the management's leadership and commitment when a clear safety policy is established and every employee is held accountable for safety. Safety must be emphasized such that it is seen as a condition for employment in the business unit and that every employee must be held accountable for their actions. Likewise, the management must commit to the necessary resources for managing safety and risk. Resources can be in form of tools, training, equipment, controls, maintenance, staffing right employees, budgeting, etc. Involving employees, listening to their suggestions, rewarding employee involvement, can also demonstrate the management's commitment for safety. Likewise, it is essential for the management to directly participate in teams pertaining to safety and reliability. The employee must be able to perceive the management's commitment towards safety and this aspect is basic foundation for developing safety culture in an organization.

Development of a strong safety culture within the organization comes directly from the management's commitment towards safety. The management must set clear goals and objectives pertaining to safety and risk, must clearly communicate the employee's responsibility towards safety, have sufficient training programs, provide required staffing, enforce engineering standards, encourage enhanced communications, establish frequent audits on safety, follow-up on such audits, conduct thorough incident investigations, etc. Establishing such intense activities and programs automatically instills safety culture within the employees in the business unit.

Once a strong safety culture is promoted within the organization, it is the right time to drive an effective PSM program. As mentioned previously, PSM elements are beyond rules, regulations, polices, etc. They are safety barriers that protect the organization from the occurrence of a serious safety incident. Adequate employees must be trained to serve as champions for such elements and likewise, the success of a PSM program in an organization is directly dependent on the management's commitment and leadership.

3. Elements of PSM

An effective PSM program shall infuse operational disciple in the organization. This disciple will drive the organization to function safely and reliably. Discipline will also guide the employees to perform every job correctly, each time. Thus apart from safety, an effective PSM program shall certainly promote reliability, productivity, quality and helps the business to be profitable.

The original PSM elements shall be discussed herein. Each element has enough merit to be considered as an individual review article, and therefore for brevity, the information shall be kept as precise and concise as possible.

3.1. Process hazard analysis (PHA)

The process hazard analysis is thorough, orderly, systematic approach for identifying, evaluating and controlling hazards of processes involving hazardous chemicals. Such an analysis must be conducted for hazardous systems during the initial project phase and likewise, periodically conducted during the operational phase.

Operational knowledge, technical skills, maintenance activities, past experiences must all be considered during a PHA conducted during the operational phase. All employees that are involved with the hazardous system must be a part of the PHA. A comprehensive team will help to capture all potential hazards and failure modes in the system.

Several tools such as what-if analysis, hazard and operability study (HAZOP), failure modes and effects analysis (FMEA), fault tree analysis, etc. can be applied while conducting a PHA.

3.2. Operating procedures and safe practices

The employer must develop and implement written operating procedures that provide clear instructions for safely conducting activities in the plant. Procedures must be thorough, well thought out and must be completely relevant to the existing system in the plant. Such procedures must be reviewed periodically with relevant personnel and the procedures must be updated accordingly.

The employees must be trained to operate systems and equipment that they will be involved in. Likewise, periodical refresher trainings must be provided and documented as well.

3.3. Management of change (MOC)

A change in the process system, change to an existing equipment, etc. must be well thought out, thoroughly evaluated, appropriately approved and more importantly documented before a change is executed. Appropriate drawings must be modified to reflect such changes. Likewise, the procedures must also be modified and the employees must be trained adequately to operate the modified system.

MOC helps the organization to keep track of changes made in the existing system, and such changes are documented and are made available for any future evaluations.

3.4. Quality assurance (QA)

Quality assurance plays a major role during the implementation of any new project. All parts, equipment, controls, etc. associated with a system are assessed against the engineering standards before they are physically accepted in the receiving department. Material test reports, certificate of compliance, test reports for equipment, etc. are all evaluated before accepting the concerned item from the vendor. Such documents are documented for any future requirements. Likewise, the systems are checked for any potential defects per the engineering standards and regulations.

3.5. Mechanical integrity (MI)

Mechanical Integrity module plays a major role during the operational phase of the system. Necessary audits and monitoring pertaining to the maintenance of systems must be executed per the engineering requirements. Likewise, maintenance must be executed per the engineering standards and codes on all process critical equipment and control systems. Maintenance activities and reports

must be documented for future reference as well. Likewise, all necessary parts must be procured per the engineering standards and reports are documented for future requirements.

3.6. Pre start-up safety reviews (PSSR)

PSSR must be conducted for any new system or immediately after a change has been initiated in the existing system, before the actual startup. Conducting a thorough PSSR is an important activity before the actual startup of the system. PSSR team must consist of knowledgeable employees such that the potential hazards are identified before the actual startup of the system. Recommendations from PSSR must be completed and the system must be revaluated before the startup of the system.

3.7. Training and performance

All employees must be adequately trained to execute their responsibilities. Yearly refresher trainings must be provided to employees such that they do not deviate from the actual stipulated operating procedures. Employees' performance must be monitored closely and adequate constructive feedback must be provided on a regular basis.
It is also required to cross train employees to perform multiple functions in the organization. Wherever necessary, employees must be cross trained such that the organization is able to handle serious emergency situations.

3.8. Contractor safety

Contractors are not usually aware of all the systems and hazards in the plant. Hence, a thorough orientation must be given for contractors to handle emergency situations. Likewise, contractors may not be aware of the required permits, checks, etc. before executing a job. Likewise, they may not be aware of the required standards for systems. Such information must be clearly communicated and documented before the execution of their work permit.

3.9. Incident investigation

Whenever a safety incident is reported in the plant, a thorough investigation must be necessitated to determine the root causes for an incident. Such an investigation must be initiated immediately after the incident so that the facts are fresh in the minds of the concerned employees.
Usually there are multiple causes that contribute towards a safety incident. Incident investigation usually brings out interesting facts that may not otherwise be considered during the regular operation of the plant. Investigation must be conducted by a certified employee and must not be prejudiced, but must rather capture the items contributing towards the incident. Five whys analysis and fishbone analysis are usually employed during incident investigations.

3.10. Emergency planning and response

If, despite the best planning, an incident occurs, it is essential that emergency pre-planning and training make employees to execute proper actions during an emergency. For this reason, an emergency safety plan for the entire plant must developed and implemented.

3.11. Auditing

Regular safety audits and compliance audits must be conducted on all activities, procedures, equipment, and systems in the plant. The audit report describing the deficiencies must be corrected within the stipulated period. The reports and documents must be kept in file for any future reference.

3.12. Process safety information

Process safety information is an important module that compiles information on all hazardous chemicals employed or produced by the process. It also complies detailed technical information on systems and equipment used in the process. The compilation of process safety information provides the basis for identifying and understanding the hazards of a process. This module provides the necessary information for conducting a thorough PHA.
PSM elements (safety barriers) described herein involve humans, administrative controls, equipment, controls, etc. All of these can have defects and the objective is to keep the defect as small as possible such that the barrier doesn't fail and defeats its purpose.
With the brief description of the various elements of PSM, it can be clearly seen that a PSM program cannot sustain without the management's commitment, leadership and development of a strong safety culture within the organization. Several organizations try to implement this program without commitment. It is proven that such PSM programs shall not sustain and would be of no benefit to the organization.

4. Discussion

Ethically, providing a safe, reliable and a healthy work environment is a mandatory item for organizations around the world. Such an environment certainly promotes a happy work place and increases the productivity of employees. The best possible way of having a safe work environment is by eliminating hazards, which is certainly not possible in the continuous process plants and manufacturing units. Therefore, safety culture and safety barriers must be developed to keep the work place safe, reliable and healthy.
Due to increasing labor costs, industries are moving towards developing nations. Therefore, it is duty of the developing nations to understand the importance of process safety and encourage investors in setting up industries dwelling on process safety.
The government policies, banking, legislation must all support the organization and the management's initiatives towards process safety. Else, expecting such a dedicated commitment from the leadership is impractical considering the cost involvement and the stiff competition in the market. Without adequate support from all sectors and to sustain in the market, the organization will certainly take short-cuts, by-pass rules, employ substandard items, etc. All these may lead to an unfortunate catastrophic incident, culminating with huge monetary loss, fatalities, serious environmental impact, negative impact on foreign investments, etc. Therefore, considering all these, it is very logical to expect the government, financial institutions and legislation to support the industries on such process safety initiatives.

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