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Managing process chemicals, technology and equipment information for pilot plant based on Process Safety Management standard

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ABSTRACT

Injuries, accidents or even fatalities while working in pilot plant are reported worldwide. The OSHA Laboratory Standard and Hazard Communication Standard have been used as a guideline to manage safety of laboratories and pilot plant. In spite of the implementation of these standards, incidents which result in injuries and property loss are continuously occurring. The implementation of OSHA Process Safety Management (PSM) Standard in pilot plant is expected to further reduce the risks of accidents. This paper presents a new system for managing process chemicals, technology and equipment information in pilot plant and the concept is developed based on Process Safety Information (PSI) element of PSM 29 CFR 1910.119(d). It provides organized strategies to manage documentations, communicate information, and written program for maintaining, revising and updating related information. Process and Instrumentation Diagram (P&ID) is used as a foundation for data management. Implementation of this system at the CO_2 Hydrocarbon Absorption System pilot plant as a case study is examined and discussed.

Keywords: Process safety information; Pilot plant; Process Safety Management; Hazardous chemicals; Process technology; Equipment information

1. Introduction

Pilot plant occupies a grey area somewhere in the middle of the spectrum from basic research to real process plant production. Some of the items are physically part of research unit operations, whereas others are part of the manufacturing operation. Pilot plant also handles hazardous chemicals such as acids, bases, corrosive, flammable, combustible liquids, oxidizers, water-reactive, explosive, compressed gasses, asphyxiants, toxics, and unstable chemicals. The inventories of hazardous chemicals in pilot plant are typically smaller than commercial plant and considered to be safe without the requirement of extra precautions. However, due to the novel operations and processes which are being used, high operation density of equipment, unproven or changing technology, lack of safety related information at developmental stages, waste generated by operation, and use of sophisticated instruments could give a significant hazardous impact that can cause injuries, fatalities and damage of properties (Langerman, 2008, 2009a; Reinart, 2003). As an example, in real process plant, the plant layout and equipment safe siting distance normally follows standards to avoid the damaging effect in the case of the accident. However, pilot plant does not have such a standard to follow and normally the users intend to design a compact pilot plant system. The users normally assume it is safe to operate in a compact design due to small quantity of hazardous chemicals to be handled. Due to high density of operating equipment, the risk of the accident may be significant. The various heating devices installed like furnaces, heaters and electrical equipment in the designated area could increase the

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risk. In the event of the accident such as fire or explosion, it may involve numbers of equipment that varies from reactors to compressors. These equipment have different hazard potential that installed close with each other will make the accident worst.

Most of the pilot plants are housed inside the buildings. In the case of chemical leaks, the accumulation of vapour could cause major problems. In addition, vapour cloud formation, pressure builds up, asphyxiation and short-term exposure to toxic gases could also endanger people present in the pilot plant. As hazards are considered minimal in the lab, the lab safety is not given priority due to the perception that small quantity of materials would not give a significant hazardous impact to people and environment (Langerman, 2009a). It is therefore, not surprising to know that rate possibilities of the lab accidents in schools and colleges are 100–1000 times greater than at Dow or DuPont as estimated by James Kaufman (Benderly, 2009).

Hazard recognition in laboratories and pilot plant is generally managed under, either Occupational Safety and Health Administration (OSHA) Laboratory standard 29 CFR 1910.1450 or Hazard Communication standard 29 CFR 1910.1200. According to Mason (2000), pilot plant is dedicated to the development of a potential new production process which is specifically exempted from the OSHA Laboratory standard because it fails to meet the definition of 'laboratory'. In addition, West (1999) in his studies classified that pilot plant and full-scale production has similarity in terms of typical stages in assessment of chemicals.

Investigation of the pilot plant incidents also reveals that the underlying causes are similar to those found in major full-scale plant accidents. Thus, the approach towards improving safety of pilot plant cannot be different from that of the full-scale plant. Therefore, a mandatory regulation imposed for full-scale plant that effectively controls the high risk operation could also be extended to the pilot plant. One of the established standards is Process Safety Management (PSM) Standard 29 CFR 1910.119. However, PSM applies to industrial processes handling more than 10,000 pounds of hazardous material. Due to rigour requirements and management programmes of OSHA PSM, it is therefore suitable to be implemented at any other plants including pilot plant. The application of the methods outlined in the OSHA PSM to pilot plant operations may provide significant reduction to the risks associated with the operations in this location (Aziz et al., 2012; Langerman, 2009b).

OSHA PSM is designed to provide specific guidance, which is needed to manage operational safety, particularly related to process hazards without excessive operational interference. In response to many major accidents in process plants, OSHA PSM was introduced in 1992 (OSHA, 1992). Many reports have been written on the implementation of PSM on the Chemical Process Industry (CPI) but none for pilot plant scale (Kwon, 2006; Langerman, 2009a).

PSM covers 14 integrated elements, including Process Safety Information (PSI) 29 CFR 1910.119(d) (Mason, 2001a,b). PSI focuses on process chemicals 29 CFR 1910.119(d)(1), technology 29 CFR 1910.119(d)(2) and equipment 29 CFR 1910.119(d)(3) management. The compiling of this information will provide a necessary resource to a variety of users, including the team that will perform the Process Hazards Analysis (PHA), the Operating Procedure (OP), and local emergency preparedness planners. However, the usefulness of PSI depends on the accuracy and reliability of the information. It is also essential that all employees know that the information exists, where it is located and how it can be accessed (Aziz et al., 2013).

Updating of process information is quite common in pilot plant, especially when changes involving hazardous raw materials, unproven or changing technology, facility issues, etc. Any changes of these components need to be adequately managed, so that process hazards and risk could be effectively controlled. Even though its implementation would drive a major improvement in pilot plant safety, lacking of a systematic technique for easy adoption of this standard had delayed its application in pilot plant. This paper presents a structured PSI management system, focusing on hazardous chemicals, technology and equipment information in pilot plant that complies with PSM standard.

2. Methodology

2.1. *Compliance with PSI 29 CFR 1910.119(d) requirements*

The objective of this section is to provide complete information concerning the management of process chemicals, technology and equipment in the pilot plant operation as required by OSHA PSI 29 CFR 1910.119(d). The framework based on this standard is given in Fig. 1.

The first step in PSI implementation is to check the availability of PSI program. If the information is not available, the end user is required to take necessary actions for the development of the PSI program as required under 29 CFR 1910.119(d)(1). Once the PSI program is established, the written information of the process is compiled and tracked following 29 CFR 1910.119(d)(1)(i–vii), 29 CFR 1910.119(d)(2)(i)(A)–(E) and 29 CFR 1910.119(d)(3)(i–iii) respectively. The availability of the information is monitored using checklist system and stored together with revision date, approval information and evidence location. For any incomplete information, the data should be obtained within suitable time frame prior to the development of hazards analysis and risk assessment.

2.2. *Using piping and instrumentation diagram (P&ID) as a foundation for data management*

In this work, a node system technique based on P&ID is used to manage and track documents of the process information. Fig. 2 shows the framework of how P&ID is utilized in managing the process information within a pilot plant. The P&ID is divided into several nodes. The number of nodes depends on the design intent and the number of equipment within the pilot plant considered manageable by the end users. The PSI implementation for each node is carried out according to 29 CFR 1910.119(d)(1)–(d)(3) standards as shown in Fig. 1. Once information has been compiled and updated for the selected equipment or stream, the end users can choose next equipment or streams within the selected node. After all the information within the node has been updated, the end users can select the next node to review or update the data. The updating information process will continue until all nodes in the P&ID are completed.