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USE OF PROCESS HAZARD ANALYSIS TO CONTROL CHEMICAL PROCESS HAZARDS

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Use of Process Hazard Analysis to Control Chemical Process Hazards

This report summarizes observations concerning the conduct of a process hazard analysis for a chemical process covered by OSHA and EPA chemical process safety standards. Specifically, it provides insight into the use of one type of PrHA, the HAZOP study.

Overview of PSM

The Clean Air Act Amendment, enacted in November 1990, mandated initiation of two regulatory standards to prevent or mitigate potentially catastrophic chemical releases and resulting exposures to toxic chemicals, fires, or explosions—one by the Occupational Safety and Health Administration (OSHA) to protect workers, and the other by the Environmental Protection Agency (EPA) to protect the public.

OSHA's Rule for Process Safety Management of Highly Hazardous Chemicals (PSM Standard—29 CFR 1910.119) was issued in February 1992 with certain provisions effective in March 1992 and the remainder stayed until August 1992. This performance-based standard contains an integrated set of safety management elements which must be applied whenever the aggregate quantity of a chemical in a process exceeds the threshold quantity (TQ) for that chemical. A generic TQ of 10,000 pounds is established for flammable gases and liquids. Chemical-specific TQs are found in OSHA's "List of Highly Hazardous Chemicals, Toxics and Reactives" contained in the standard. Any manufacture of explosives or pyrotechnics is covered by this standard regardless of the quantity.

EPA's draft "Risk Management Program" (RMP Standard—40 CFR Part 68) emphasizes the same safety management elements and expands the requirements in some areas. The most notable additions include a requirement for a publicly-available risk management plan; a requirement for consequence analysis of a range of release scenarios, including the worst case instantaneous release of the total process inventory of the covered chemical; and registration of covered sites with the EPA. The EPA finalized its chemical-specific lists of toxic and flammable substances and TQs in January 1994. There are a number of inconsistencies between the OSHA and EPA TQ lists, due to differences in the specific chemicals listed and differences in the TQs levels which trigger application of the two standards. Thus, certain processes will require compliance with one but not both of these parallel standards. The final EPA standard has not been released.

Process Hazard Analysis—A Critical Safety Management System

Process Hazard Analysis (PrHA) has been called the cornerstone of chemical process safety management, because it serves as a tool to systematically identify the causes and consequences of potential accidents associated with equipment, instrumentation, utilities, human performance, and external factors. A PrHA proceeds from the point where hazardous chemicals enter the system, to the point where they leave it or are rendered nonhazardous. The PrHA provision of the OSHA PSM Standard specifies a variety of PrHA techniques, including:

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- What-If
- Checklist
- What-If/Checklist
- Hazard and Operability Study (HAZOP)
- Failure Mode and Effects Analysis (FMEA)
- Fault Tree Analysis, or
- "An appropriate equivalent methodology."

Potential Use of Chemical PrHAs in the DOE Safety Analysis Process

The DOE safety analysis process for a facility begins with a hazard analysis. Bounding accident scenarios are then selected for detailed risk assessment. The consequences of these scenarios are compared with risk acceptance criteria. The graded approach for the safety analysis and ultimate risk acceptance decision is made at a management level determined by the unmitigated consequences associated with that facility.

A PrHA can be used as the hazard analysis at the front end of the DOE safety analysis process for chemical processes covered by the PSM and/or RMP standards. The PrHA will support the consequence assessment and highlight areas that may require implementation of further control measures.

Application of PrHA in a DOE Chlorination Process

In 1993, the Department of Energy chose to conduct a sample PrHA on an EPA and OSHA regulated process[1]. A chlorination system for water treatment was selected because this is the most common covered process within the DOE. The purpose of this sample PrHA was to help DOE contractor personnel, many of whom had recently received training on the PSM standard and PrHA techniques, by demonstrating the use of a PrHA technique in an actual process.

One form of PrHA, the hazard and operability (HAZOP) study, has the potential to analyze chemical process hazards as well as the associated operating procedures. The HAZOP is a guide-word-stimulated brainstorming approach systematically applied to important process parameters to determine the impact of potential deviations from design conditions. The seven guide words used are *none*, *more of*, *less of*, *part of*, *as well as*, *reverse*, and *other than*. The HAZOP follows the flow of the hazardous chemical through the process, applying the guide words to segments of the process called study nodes. The HAZOP was specifically designed to be conducted by a team. It can aid in the identification of operability issues which may improve

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1 U.S. Department of Energy. 1993. Example Process Hazard Analysis of a Department of Energy Water Chlorination Process, DOE/EH-0340, U.S. Department of Energy, Washington D.C.

system performance and efficiency. For these reasons, it is becoming the dominant PrHA methodology in the chemical industry and was used for this demonstration PrHA.

A chlorination system at DOE's Hanford Site in central Washington State was selected for analysis. This system was undergoing a change from a positive pressure system to a safer vacuum system as recommended by the Chlorine Institute. HAZOPs were conducted on the new chlorination system configuration, and procedures for the installation and removal of one ton chlorine cylinders.

One objective of this project was to demonstrate how the PrHA could satisfy OSHA's requirements. OSHA requires that the PrHA address:

- the hazards of the process
- the identification of any previous incident which had a likely potential for catastrophic consequences in the workplace
- engineering and administrative controls applicable to the hazards and their interrelationships
- consequences of failure of engineering and administrative controls
- facility siting
- human factors
- a qualitative evaluation of a range of the possible safety and health effects of failure of controls on employees in the workplace.

In addition, OSHA requires that the PrHA must be conducted by a team with at least one member having expertise in engineering and process operations, one having experience and knowledge specific to the process being evaluated, and a team leader knowledgeable in the specific PrHA methodology being used.

Findings and Conclusions

Even though the chlorination system was relatively simple and several key components were packaged in a commercial chlorinator unit, there were a number of benefits to conducting the HAZOP on this system:

- The HAZOP study served as a good educational exercise. Personnel with years of experience operating and designing water treatment plants were impressed with the insights and understanding gained in conducting the HAZOP study.
- A dozen action items resulted from the HAZOP study. Actions items were divided among design issues, procedural issues, and additional vendor information. The specific action items are listed in the DOE report of this example PrHA. Some of these issues affect

operability of the process as well as the safety of the process in that they can prevent interruption of water chlorination and associated response actions.

- Critical procedures were in a state of flux due to the installation of a new system, and the HAZOP helped to validate those procedures.

- The HAZOP study incorporated a review of issues related to the design and operation of the chlorination system that might induce human errors leading to a release. A generic human factors checklist was developed to support the PrHA. The HAZOP format was able to accommodate causes of deviations associated with human factors.

- The qualitative determination of consequences from various chlorine release scenarios helped to support emergency planning and previous release modeling. One action item in the HAZOP study was developed to ensure that people in adjacent buildings received the necessary information on the proper response in case of a chlorine release.

- While most HAZOP study teams are not likely to have as many team members as this demonstration PrHA, it is worth noting that the HAZOP study served as a good analytic tool for a fairly large team because it could capture many varied inputs rapidly.

- The HAZOP study was equally effective in the analysis of procedures and in the analysis of the physical system. It forced team members to systematically consider potential deviations for each step of the procedure, using logical interpretations of the seven guide words in the context of a procedure.

The PrHA conducted for this chlorination process demonstrated the importance of such analyses in chemical process safety. It is hoped that this paper and the actual example PrHA report might serve as an aid to DOE contractors in the conduct of PrHAs for processes in which highly hazardous substances are used.

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