CONTENT ANALYSIS OF DOE OCCURRENCE REPORTS AT NUCLEAR CHEMICAL FACILITIES

Lyndsey Fyffe[1], James A. Hutton[2], James H. Clarke[1], Steven Krahn[1], David Kosson[1]
[1]*Vanderbilt University: 2301 Vanderbilt Place/PMB 351831, Nashville, TN 37235, Lyndsey.Fyffe@Vanderbilt.Edu*
[2]*U.S. Department of Energy, Office of Environmental Management: 1000 Independence Avenue, Washington, DC 20585*

Nuclear chemical facilities combine the hazards of radioactive operations with complex chemical operations. Because the nuclear and chemical industries use distinct approaches to safety management, chemical hazards, which are commonly addressed in the chemical industry, may receive less coverage in nuclear facilities where radiological hazards are the predominate focus. This work presents a content analysis of accident reports at nuclear chemical facilities (using DOE Occurrence and Reporting System Reports) using a coding structure focused on chemical hazards derived from a previous analysis. This content analysis yields potentially important data that can be used to improve process safety management at these facilities. The occurrence reports contain potential trend information that can be used to determine lessons learned in the nuclear industry that could be applied to nuclear chemical facilities to improve process safety. An example result from this content analysis would be the frequency of incidents in which a key factor of incidents in the chemical industry, such as emergency planning and response, occurred in nuclear chemical facilities.

I. INTRODUCTION

I.A. Overview

The Department of Energy (DOE) has recently expanded the number of nuclear chemical facilities associated with its waste management mission. There are many facilities already in operation such as the plants for processing depleted uranium hexafluoride at Portsmouth and Paducah and the actinide removal process/ modular caustic side solvent solution (ARP/MCU) at Savannah River. While these facilities process radiological material, and thus must contend with the hazards of a typical nuclear facility, there is a key difference in their operating hazards from other types of facilities: complex chemical operations. In many cases, the process flow diagram for these nuclear chemical facilities more closely resembles a complex chemical operation than a nuclear reactor facility. The current approach for safety management at these nuclear chemical facilities is rooted in nuclear hazards analysis techniques and could benefit from lessons learned particular to chemical operations at nuclear chemical facilities. This research mines the data available in the DOE Occurrence Reporting and Processing System (ORPS) through content analysis in order to extract themes and trends in occurrences at nuclear chemical facilities.

I.B. DOE Occurrence Reporting

The DOE's safety management processes are focused on preventing accidents from occurring. However, if there is an occurrence, the DOE turns to the accident investigation process described in DOE Order 225.1B [1] and the subsequent causal analysis through Order 232.2 [2] to identify lessons to be learned.

DOE Order 225.1B defines the process for accident investigation of DOE occurrences. The first step in the investigation process is to appoint the Accident Investigation Board, which consists of a chairperson and 5-6 members, all DOE Federal employees with subject matter expertise and knowledge of DOE's ISM program. During the investigation process, the AIB will examine the accident scene, investigate interested and/or impacted individuals, organizations, management systems or facilities, examine DOE and contractor documentation, interview witnesses or personnel associated with the accident and perform engineering tests and analyses as appropriate. From these data sources, the AIB will derive causal factors (direct, root and contributing causes) associated with human performance and safety management systems which will be used to support the development of an accident investigation report. In closing out the investigation, lessons learned will be formally distributed, and corrective actions must be approved, completed and implemented.

The current framework for eliciting feedback provided by incident reporting, evaluation and analysis at DOE nuclear facilities is one in which the DOE utilizes a systematic, detailed occurrence analysis categorization process (documented in DOE Order 232.2, Occurrence Reporting and Processing of Operations Information and Standard 1197-2011, Occurrence Reporting Causal Analysis) [3]; the categorization process was informed by the practices of the commercial nuclear power industry and the Institute for Nuclear Power Operations (INPO). This process involves the application of a formal Causal Analysis Tree (CAT) with predesigned headings to an accident. Each category is numbered and documented for ease of incident analysis.

The main objectives of Order 232.2 are to keep the DOE and National Nuclear Security Administration (NNSA) informed about events that could cause potential negative effects to the health and safety of the public, the workers, the environment, DOE missions, or DOE credibility and to ensure DOE uses organizational learning to enhance mission safety and share effective practices in order to continuously improve process safety and manage process changes.

Reporting under Order 232.2 is required for any occurrence that results from an activity performed by facility personnel; such occurrences must be reported by facility personnel in a timely fashion and investigated and analyzed by facility management as described in the Occurrence Reporting Model, using the cause codes provided in the CAT. This DOE approach to occurrence reporting and categorization is used to write the DOE occurrence reports that will be studied in this analysis.

II. DESCRIPTION OF WORK

The objective of this analysis is to develop an understanding of occurrences at DOE nuclear chemical facilities and their major causes and themes. The methodology for this work involves performing a content analysis of the occurrence reports to identify coherent and important themes using the entire text of the reports and then subdividing the data into categories, patterns and themes. This is completed in a process known as data labeling or indexing which is detailed in the 1996 GAO Guide 10.3.1 [4]. During this analysis, content analysis software will be used to allow for automatic text searches and coding. The semi-quantitative data assessment from the content analysis of this research will then involve studying the occurrence of categories through codes. By definition, codes are abbreviations or shorthand versions of the concepts to mark a series of text that then falls under a category. Counts for various words and phrases can also be measured across all documents and will allow for monitoring of the frequency of terms.

For this task, the unit of analysis is one occurrence report from a nuclear chemical facility. The methodology involves the application of a content analysis software for maintenance of coding, document searches and its many other functions. The content analysis software has several features which will prove useful in this analysis including: intelligent data management with external source referencing; a code manager with unlimited color-coded applications; annotated memoing functions; and auto search functions (among many others). The main advantage of using the content analysis software is that the program does the record keeping for the process. Once occurrence report has been uploaded into the data base, automatic text searches and coding are possible. All work is auto-saved and codes (see below) are documented. A single code can be run through the entire body of data with one click and the frequency of use analyzed.

Previous work [5] involved performing a content analysis of chemical industry accident reports to determine common causes and themes of incidents in the chemical industry. As a part of this analysis, a coding structure was developed based on the OSHA chemical industry standard for Process Safety Management (PSM) [6]. In a similar fashion to the nuclear industry, the chemical industry applies a systematic review of chemical processes with emphasis on the following categories: chemical hazards, process technology and equipment, process safety information, employee involvement, process hazard analysis, operating procedures, employee training, contractor requirements and responsibilities, pre-startup safety reviews, hot work permitting, management of change, incident investigation, emergency planning and response, compliance audits, trade secrets, and mechanical integrity. From these categories and their application to chemical facility process safety, a coding structure was created and applied to the chemical industry accident reports. In order to maintain consistency in coding and better understand the chemical hazards associated with nuclear chemical facilities, this OSHA PSM review category based coding structure will form the basis for coding the occurrence reports in this work as well.

This process involved applying the coding structure to each document using the content analysis software. Maintenance of the coding structure is essential to this work. A coding manual will be maintained in the research journal and in the content analysis software with a list of codes and definitions as well as overall coding guidance from the process. As such, a detailed hierarchy of categories, concepts, and codes will be maintained to ensure that the analysis is documented. This hierarchy of codes is illustrated in Figure 1 below.

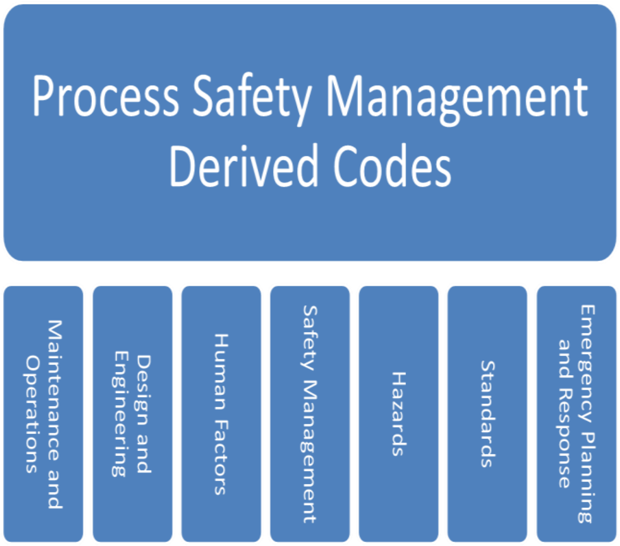

Figure 1: Process Safety Management Derived Coding Structure

The semi-quantitative data assessment from the content analysis (Task 1.3) of this research will involve two steps: first, the occurrence of words and phrases will be studied, and in the second step, the occurrence of categories through codes will be studied. In terms of studying word occurrence, the content analysis software will be used to gather numerical data on the appearance of various words and phrases throughout the unit of analysis. Counts for various words and phrases can also be measured across all documents and will allow for monitoring of the frequency of terms.

In this analysis, the frequency of codes will be studied and associations monitored in the text. Counting the frequency of the codes in the content analysis software simply involves running the program across the different units of analysis and summing total occurrences. The total occurrences for each individual report will also be investigated as some reports may have many occurrences of a word or phrase, indicating its importance, but there may be only a few reports that contain that phrase. Finding associations between the various codes will require studying carefully the proximity of wording (or codes) in the report. The content analysis software also allows for searching various combinations of codes at a given time. This data will then also be evaluated by analyzing frequency of occurrence. For instance, if a code related to chemical leakage is often followed by a code related to fires, the instances of fires after chemical leaks might be an important result from the data. This process is more thoroughly described in Chapter 5 of GAO Guidance 10.3.1.

Ensuring a high-quality content analysis involves several judgments. In selecting categories to use during the process, it is important to be exhaustive. An insufficient number of categories could lead to missing important information that could be essential to developing performance measures. Developing a coding structure from the categories also must be mutually exclusive for similar reasons. Each code will represent a single potential occurrence from a single category and there will be no overlap between codes. This can be checked by reviewing the coding manual developed during this process.

III. RESULTS AND DISCUSSION

For this sample analysis, ORPS reports for the deconversion of depleted uranium hexafluoride at the Portsmouth facility were included. A selection of these reports is publicly available through the DOE ORPS Dashboard [7]. The Portsmouth DU facility represents one of the eighteen nuclear chemical facilities in the DOE complex. The full results of content analysis on operational DOE nuclear chemical facilities will be presented at the conference.

The first set of results of the content analysis includes the frequency of each derived code within the text of the units of analysis. These results indicate which codes occur most frequently in the text, and therefore, which codes could be most influential in occurrences. The frequency results can be used to select focus areas for potential improvement of safety or efficiency of operations at nuclear chemical facilities.

A preliminary content analysis of occurrence reports from the Portsmouth nuclear chemical facility yields the frequency of codes results presented in Table 1.

Table 1: Frequency of Codes from Preliminary Content Analysis of Portsmouth DU Facility

Content Analysis Code (Based on Process Safety Management)	Frequency of Code in Selected Occurrence Reports
Maintenance and Operations	77
Design and Engineering	27
Human Factors	18
Emergency Planning and Response	13
Hazards	11
Standards	11
Safety Management	10

The results in Table 1 illustrate the prominence of maintenance and operations codes in the Portsmouth DU facility. With 77 total coding occurrences, this code triples the next most frequent issue of Design and Engineering that occurs in the content of the ORPS. Design and Engineering is followed by Human Factors, Emergency Planning and Response, Hazards, Standards and Safety Management.

The frequency of the appearance of each code could provide some insight into areas that can be commonly associated with occurrences at nuclear chemical facilities. For instance, from these preliminary results on the Portsmouth DU facility, it appears as though a focus on issues associated with maintenance and operations might be particularly useful in improving safety and efficiency of operations at nuclear chemical facilities.

Each code has been applied using a series of coding notes that aid in consistency of application. The codes can provide additional information about the frequency of occurrence and potential focus areas for improvement actions at nuclear chemical facilities. In maintenance and operations, these include particular maintenance and operations issues, such as mechanical integrity, management of change, maintenance and housekeeping, operating procedures and work controls. For Design and Engineering, these detailed codes include engineering controls and safety systems. For human factors, more specific headings include contractor issues, employee training, and management oversight. More detailed analysis of the Maintenance and Operations code is included below.

A second area of study in the results of the content analysis involves looking for associations between codes in the text. An association can either be made by proximity of codes within the content being analyzed, or by co-occurrence in multiple sets of content (i.e. the same two codes appearing with high frequency in several different units of analysis). Associations can be used to postulate theoretical relationships between codes where they occur. For instance, in the case of Maintenance and Operations, a common code associated in the text is Standards. This could indicate that there is a relationship between implementation and adherence to standards and maintenance and operations issues at nuclear chemical facilities.

From the preliminary frequency results of this content analysis, it is clear that issues associated with maintenance and operations at this facility might warrant additional study to determine more specific focus areas that could be investigated to improve safety and efficiency of operations at this facility. Within the code of Maintenance and Operations, there are several more detailed codes that have been applied. Figure 2 illustrates the breakdown of these subcategories.

Figure 2 demonstrates the relatively high frequency of mechanical integrity issues and maintenance and housekeeping issues at the analyzed nuclear chemical facility. In this particular instance, many of the analyzed occurrences related to suspect or counterfeit materials, which may have caused an unusually high frequency of codes in mechanical integrity. These suspect material codes were strongly associated with incident investigation codes under safety management. This is due to the development and sharing of lessons learned related to these suspect materials with other facilities that had received similar parts.

Aside from this category of suspect materials, the mechanical integrity codes were related to issues such as the timely performance and documentation of inspections and tests, the timely correction of deficiencies, and equipment checks prior to operation. Further analysis of these categories could yield additional information relating them to occurrences at nuclear chemical facilities.

Results from the content analysis of all operational DOE nuclear chemical facilities will be presented at the conference in a similar fashion to those presented above.

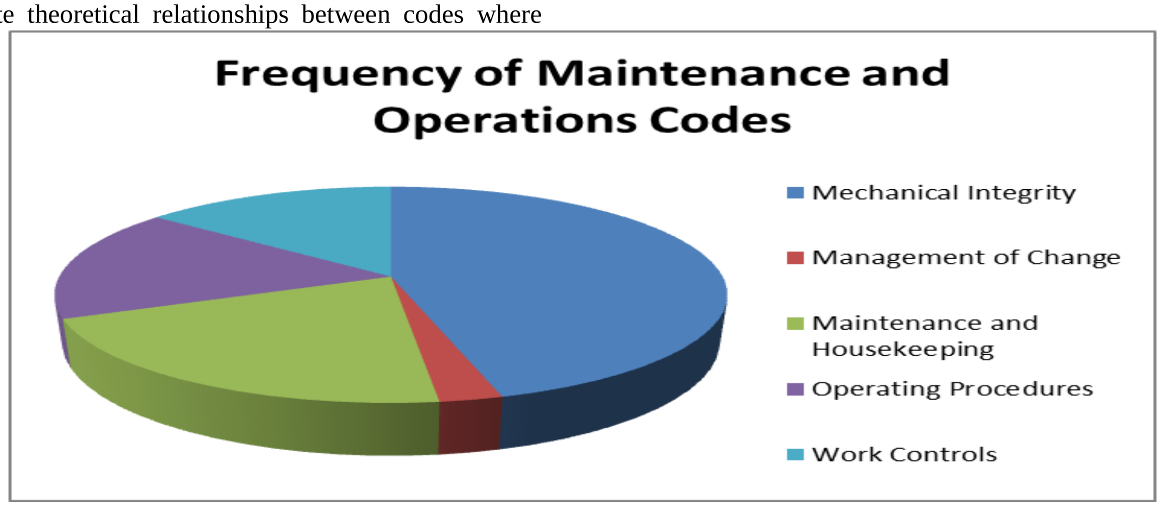

Figure 2: Maintenance and Operations Codes Comparative Frequencies

IV. CONCLUSIONS AND RECOMMENDATIONS

The results of this analysis will be combined with the content analysis of the other ORPS for nuclear chemical facilities to determine characteristics and trends in occurrences at nuclear chemical facilities.

This research is a part of a larger effort. The data from this content analysis, in terms of frequency of codes, and other analyses of chemical and nuclear industry incident reports will be used to develop theories about safety and efficiency of operations. Codes from this analysis may or may not be used as a basis for this theory development. After their development, these theories will be used to postulate a set of performance measures for nuclear chemical facilities that utilize knowledge from the chemical industry and currently operational nuclear chemical facilities to create a set of guidelines to strengthen safety culture at nuclear chemical facilities. The resulting performance measures will be vetted by industry experts. The final results are anticipated to be released in December 2015.

ACKNOWLEDGMENTS

Partial support for this work was provided to Vanderbilt University by the Department of Energy through a cooperative agreement in which the DOE funds the Consortium for Risk Evaluation with Stakeholder Participation (CRESP). The opinions, findings, conclusions, or recommendations expressed herein are those of the authors and do not necessarily represent the views of the Department of Energy or Vanderbilt University.

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