Safety Culture Lessons Learned from the U.S. Chemical Safety Board Incident Investigations – 14556

Lyndsey Fyffe **, Steven Krahn **, James Hutton *, Julie Goeckner *
* US DOE
** Vanderbilt University

ABSTRACT

In response to a Defense Nuclear Facilities Safety Board (DNFSB) Recommendation, the U.S. Department of Energy (DOE) began a complex-wide study to determine the current state of safety culture, whereby specific areas are in the process of being identified for improvement, to support implementing an action plan to strengthen safety culture. The following paper describes a benchmarking initiative with the chemical industry in which U.S. Chemical Safety Board (CSB) incident reports and safety bulletins were analyzed to determine safety culture issues. A semi-qualitative study of the U.S. Chemical Safety Board reports using content analysis is facilitated by a content analysis software to determine how frequently safety culture concerns were raised within chemical industry accidents. The results are described in terms of frequency of occurrence within the U.S. Chemical Safety Board documents. These results can be used to help identify trends in safety culture in the chemical industry which might be applicable to improving safety culture at nuclear chemical facilities.

INTRODUCTION

In 2011, the Defense Nuclear Facilities Safety Board (DNFSB) issued Recommendation 2011-1, Safety Culture at the Waste Treatment and Immobilization Plant, which identified several issues relating to safety culture at the Waste Treatment Plant in Richland, WA and recommended that the Department of Energy (DOE) evaluate safety culture at all of its defense nuclear facilities**. As a result of their review, the DNFSB found that despite a DOE commitment to safety culture, the prevailing safety culture at the Waste Treatment Plant (WTP) did not meet DOE's expectations, which are outlined in Attachment 10 to the Integrated Safety Management (ISM) Guide [1]. The DOE ISM Guide identifies several focus areas and attributes considered important to strengthening safety culture at DOE facilities.

Further, the DNFSB found that project management behaviors, both in DOE federal employees and contractors reinforced an environment in which timely reporting and acknowledgement of technical safety concerns was discouraged rather than encouraged, leading to a lack of timely resolution of such concerns.

The construction of the WTP at Hanford is just one example of DOE's recent expansion of nuclear facilities using chemical processes to complete its waste management mission; thus, an examination of the safety culture issues identified in the chemical industry was considered appropriate. A landmark example of such identified safety culture issues was documented by the Baker Commission in its review of the accident at Bay City, TX; in this report five observations were made about BP's safety culture including: a lack of effective process safety leadership; a lack of a positive, open and trusting environment for employees and managers; a

lack of resources for strong safety management; a lack of inclusion of process safety considerations into management decision making; and a lack of a common process safety culture from the company as a whole (as opposed to distinct approaches at each U.S. refinery) [2].

DESCRIPTION OF ANALYTICAL TOOLS

In terms of safety oversight, the chemical industry combines regulation by the Occupational Safety and Health Administration (OSHA) with detailed investigations performed by the Chemical Safety Board (CSB). As the DOE has recently undertaken several actions in response to DNFSB Recommendation 2011-1 complex-wide, research into chemical-industry specific safety culture issues and their application to nuclear chemical processing facilities, which contains both the radioactive hazards of nuclear materials and the reactive hazards of chemical processes, would be desirable.

The CSB is a congressionally mandated oversight board charged with performing root cause analyses of incidents at fixed chemical facilities in the U.S. to determine the conditions and circumstances which led to the accident and identify causes, to potentially prevent similar events from occurring [3]. The CSB performs two types of analyses: incident reports, which involve the investigation of a particular event, and safety bulletins, which involve the study of more general chemical accident hazards. Both types of analysis result in a report which includes recommendations to chemical industry and regulatory groups. Safety culture in the chemical industry has not been the focus of a more general safety bulletin, but analysis of safety culture has been performed during some of the incident reporting. The CSB investigation team varies from incident to incident, and reporting is based upon expert opinion. Previous research has illustrated the variability that can exist between terminology and phrasing used by these experts in CSB reporting [4, 5]. As such, in some reports, safety culture issues are identified by name, and in others, they are not. Thus, a structure by which to analyze safety culture issues is required.

Attachment 10 of the DOE ISM Guide [1] identifies three safety culture focus areas, along with a set of attributes for each focus area, that are useful for establishing and maintaining a strong safety culture: leadership, employee/worker engagement and organizational learning. The attributes provide additional information that describes a strong safety culture and supporting behavioral elements that indicate what a positive safety culture and Safety Conscious Work Environment look like and feel like***.

The attributes for leadership include: demonstrated safety leadership, risk-informed conservative decision making, management engagement and time in field, staff recruitment, selection, retention and development, open communication and fostering an environment free from retribution and clear expectations and accountability. For employee/worker engagement, the attributes include: personal commitment to everyone’s safety, teamwork and mutual respect, participation in work planning and improvement, and mindful of hazards and controls. Finally, for organizational learning, these attributes include: credibility, trust, and reporting errors and problems, effective resolution of reported problems, performance monitoring through multiple means, use of operational experience, and questioning attitude. [1]

These attributes have been identified using experience from the commercial nuclear industry as helpful to focus attention and action to the right areas. The wording associated with the

attributes was used to develop the coding structure for the content analysis of the CSB reports presented in this research. While in some instances, the CSB reports identify safety culture issues by name, more often safety culture issues identified in the reports are not specifically linked to safety culture. As such, a detailed analysis of the content of the reports is required to determine the frequency of safety culture issues.

This research is designed to analyze the large database available in more than 50 published chemical industry accident reports completed by the CSB over the past 15 years. Each incident report includes a root cause analysis of the accident by a team of experts and recommendations based on their findings to potentially develop lessons learned from the incident. Some of these lessons learned may help in the creation of a strong safety culture at nuclear chemical facilities. Each report includes several sections: expert identified Key Issues for each incident, an overview of the incident, the root causes of the incident, conclusions, and recommendations to key groups including industry and regulatory bodies. A previous analysis involved a detailed look at the occurrence of various CSB identified Key Issues from these reports, both naturalistically and through a derived sorting methodology to extract commonalities from the different incidents in the CSB database [4, 5].

CODING DATA

Analyzing available databases for chemical industrial accidents will involve performing a safety culture specific content analysis 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 [6].

For this objective, the unit of analysis is one CSB final incident report or safety bulletin. The first goal of the content analysis of the CSB reports is to use the word cloud and word cruncher functions in a content analysis software to determine what words and phrases occur the most frequently in the text and determine how often and where within a given report or bulletin these phrases appear the most frequently.

This process requires the application of a content analysis software for maintenance of coding, document searches and many other functions. In this research, ATLAS.ti, a document analysis tool created by ATLAS.ti Scientific Software Development was used [7]. 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 the CSB document has been uploaded into the data base, automatic text searches and coding are possible. All work is auto saved and codes are documented. A single code can be run through the entire body of data with one click and frequency analysis performed.

From this grouping, a coding structure can be created and applied to each document in the data base. Maintenance of the coding structure is essential to this work. A coding manual has been maintained with a list of codes and definitions as well as overall coding guidance from the process. By definition, codes are abbreviations or shorthand versions of the concepts (phrases) to mark a series of text that falls under a category. As such, a detailed hierarchy of categories

and codes will be maintained to ensure the overall importance of the code is documented. The coding structure for this work is based on the DOE Guidance for safety culture focus areas and their associated attributes found in Attachment 10 of the DOE ISM Guide. The overall code structure is identified in Figure 1.

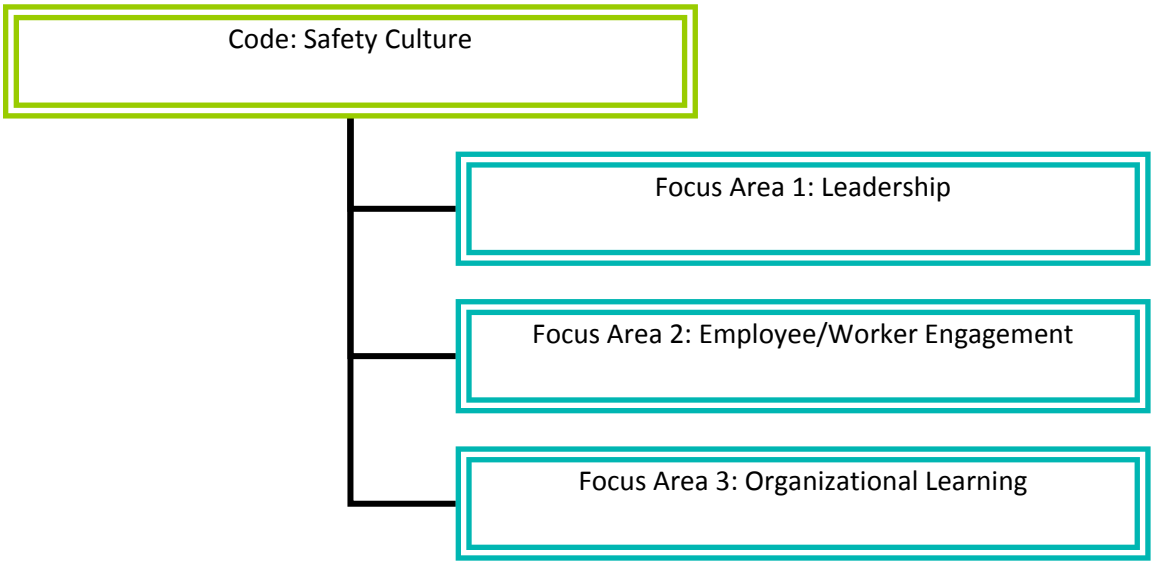

FIGURE 1: Code Structure for Document Analysis

The code heading represents the major code of safety culture which has been identified in the text of each CSB report. The three subheading focus areas have been used as notations, to better track the safety culture issues in the text. These focus areas have been identified using the associated attributes described in Attachment 10 of the DOE ISM Guide.

The semi-quantitative data assessment from the content analysis of this research involved two steps: first, the occurrences of words and phrases that indicate the safety culture code have been studied, and in the second step, the occurrences of the three focus area notations have been studied. The ATLAS.ti program 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.

RESULTS AND DISCUSSION

Safety Culture in CSB documented incident reports from the chemical industry is typically identified under a single Key Issue, Human Factors. By coding and extracting specific safety culture issues from these chemical incident reports, information relating more closely to safety culture issues in facilities with complex chemical hazards is collected.

The summary results of the prevalence of safety culture issues from this analysis are presented in Table I.

TABLE I: Preliminary Results of CSB Content Analysis for Safety Culture

Number of CSB Reports in which Safety Culture Issues were Identified	Percentage of total CSB Reports in which Safety Culture Issues were Identified
41	55 %

The content analysis of the CSB reports for safety culture indicates that safety culture issues were present in 41 of the 74 analyzed CSB reports. This represents 55 percent of the total incidents in the CSB database analyzed. The results indicate that safety culture issues, although not expressly identified as issues or root causes in the incidents, are associated, in one way or another, to more than half of the incidents.

A more detailed analysis of these safety culture issues identified in the CSB documents was desired to determine which focus areas, if any, identified in Attachment 10 of the DOE ISM Guide play a larger role in safety at chemical processing facilities. Thus, each instance of safety culture was categorized, where possible, in terms of its most closely associated focus area including leadership, employee/worker engagement and organizational learning. The results from this analysis are presented in Table II.

TABLE II: Preliminary Results of CSB Content Analysis of Safety Culture Focus Areas

Focus Area:	Leadership	Employee/Worker Engagement	Organizational Learning
Number of CSB Reports in which Focus Area Issues were Identified	16	32	14
Percentage of total CSB Reports in which Safety Culture Issues were Identified	22 %	43 %	19 %

As identified in Table II, the most frequent safety culture focus area that can be identified in the CSB reports is employee/worker engagement, followed by leadership and lastly, organizational learning. However, the most frequent occurrence of the safety culture issue does not necessarily indicate its importance over the others in the incident. In order to determine which focus area is the most prevalent in the incidents, the total number of incidents in which that focus area appears is essential. The percentages represent the percentage of the 74 total CSB incident reports in which each focus area is identified. This result is also presented in Table II. The pie chart in Figure 2 illustrates the prevalence of the three focus areas relative to each other out of the total number occurrences of safety culture issues in the CSB documents.

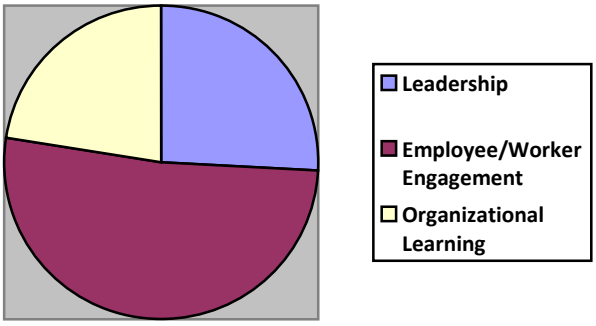

FIGURE 2: CSB Safety Culture Focus Areas

The relative frequency of each focus area in the CSB database can be used as an indication of which safety culture focus areas appear to be most frequently identified with accidents in the chemical industry. In this case, issues of employee/worker engagement were identified most frequently, which indicates that this focus area may be a starting point to develop safety culture improvement methods in nuclear chemical facilities. This focus area includes such things as teamwork and mutual respect, participation in work planning and improvements, mindfulness of hazards and controls and a personal commitment to everyone's safety, as well as employee concerns and differing professional opinions. One of the most frequently identified attributes which could indicate strong safety culture in the area of employee/worker engagement was mindfulness of hazards and controls. The associated characteristics of this attribute in DOE ISM Guide include: (1) organizational safety responsibilities are sufficiently comprehensive to address the work activities and hazards involved, (2) work hazards are identified and controlled to prevent or mitigate accidents, with particular attention to high consequence events with unacceptable consequences, (3) individuals understand and proactively identify hazards and controls before beginning work activities, and (4) individuals are mindful of the potential impact of equipment and process failures, demonstrate constructive skepticism and are sensitive to the potential of faulty assumptions and errors.

While this particular attribute of employee/worker engagement is the most frequently identified in the accidents, the other attributes of employee/worker engagement and the other two focus areas have played a role in more than one in five incidents in the chemical industry, and thus each may warrant further research to better improve safety culture across the DOE complex. In many of the safety culture identified incidents, a key attribute of a healthy safety culture was missing, such as a lack of demonstrated commitment to safety from leadership through decisions and behaviors at the facility.

CONCLUSIONS

Safety culture issues in the CSB incident reports contain trend information that can be used to evaluate potential lessons learned in the chemical industry that could be applied to nuclear chemical facilities. The results indicate that safety culture issues are identified with regularity in CSB incident reports from the chemical industry, and wording indicative of safety culture concerns was identified in many incidents reported by the CSB. The most common ISM Guide safety culture focus area identified in these reports is employee/worker engagement, which

occurred approximately two times more frequently than the other two focus areas (leadership and organizational learning); in fact, it was mentioned more frequently than the other two combined. This indicates that in a nuclear chemical facility, which combines the traditional hazards associated with nuclear processing with high hazard chemical risk, may want to pay special attention to the attributes of the employee/worker engagement focus area and that improvements in this area may reduce the likelihood of incidents and strengthen the safety culture at the facility.

The rich database available from more than 50 incident reports analyzed by the CSB has the potential to provide significant insights in improving safety management of the nuclear chemical facilities of the DOE. This paper looked at potential lessons in the area of safety culture.

FUTURE WORK

The results of this safety culture focused content analysis of the CSB reports will help inform DOE's response to DNFSB R2011-1 and used to potentially identify trend and improvement methods to strengthen safety culture at nuclear chemical facilities. This process will involve the review of these results by a team of safety culture experts involved in the DNFSB R2011-1 Response Team for potential enhancement measures to improve safety and efficiency of operations at nuclear chemical facilities.

This research is a part of a larger initiative to study chemical industry incidents reported by the CSB to identify a more comprehensive set of safety and performance measures which could improve safety and efficiency of operations at nuclear chemical facilities. Previous research has included a preliminary analysis of CSB identified Key Issues in the final incident reports and a content analysis of the reports using a Process Safety Management based coding structure [4, 5].

After the completion of this phase of the research, several selected CSB reports will undergo analysis through the application of the DOE Causal Analysis framework and subsequent guidance. Once this review has been completed, a comparative analysis will be performed to determine the relationship between the CSB Key Issue and report framework and the DOE Causal Analysis framework. The ultimate goal of this work is the creation of a set of performance measures to improve safety and efficiency of operations at nuclear chemical facilities.

ENDNOTES

* The CSB body of data can be found at the U.S. Chemical Safety Board Website: www.csb.gov.

** Information associated with DNFSB 2011-1 can be found on the DNFSB Website: www.dnfsb.gov.

*** The safety culture and safety conscious work environment attributes have been adopted from the Nuclear Regulatory Commission's Safety Culture Policy which can be found in NUREG/BR 0500 and is available at the NRC Website: www.nrc.gov.

REFERENCES

1. UNITED STATES DEPARTMENT OF ENERGY. Integrated Safety Management System Guide. Guide 450.4-1C. (2011).

2. BAKER ET. AL., *The Report of the BP U.S. Refineries Independent Safety Review Panel,* January 2007.

3. Clean Air Act Amendments of 1990, Pub. L. No. 101-549, 104 Stat. 2399 (1990) (codified as amended at 42 U.S.C.A. §§ 7403-7671q (West Supp. 1991)).

4. MORGAN, L., HUTTON, J., CLARKE, J., KRAHN, S. "U.S. Chemical Safety Board Reports and Relevant Guidance for Nuclear Chemical Facilities," *Trans. of the American Nuclear Society Winter Meeting,* Vol. 107, pg. 307.

5. FYFFE, L., HUTTON, J., CLARKE, J., KRAHN, S. "Developing Operational Safety Performance Measures for Nuclear Chemical Facilities." *Trans. of the American Nuclear Society, 14th International High Level Radioactive Waste Conference,* pgs. 311-315.

6. UNITED STATES OFFICE OF GENERAL ACCOUNTING. "Content Analysis: A Methodology for Structuring and Analyzing Written Material." Ed. Division, Program Evaluation and Methodology1996. 75. Vol. 10.3.1. Print.

7. ATLAS.ti. Version 7. [Computer Software]. Berlin, Scientific Software Development. (1999).

ACKNOWLEDGEMENTS

Partial support for this work was provided to Vanderbilt University by the Department of Energy through a cooperative agreement in which DOE funds the Consortium for Risk Evaluation with Stakeholder Participation. 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.