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**SAFETY CULTURE MANAGEMENT:  
THE IMPORTANCE OF ORGANIZATIONAL FACTORS\***

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**ABSTRACT**

The concept of safety culture has been used extensively to explain the underlying causes of performance based events, both positive and negative, across the nuclear industry. Yet attempts to operationally define the concept of safety culture and assess it have been less apparent. The work described in this paper represents several years of effort to identify, define and assess the organizational factors important to safe performance in nuclear power plants (NPPs).

The research discussed in this paper is primarily conducted in support of the U.S. Nuclear Regulatory Commission's (NRC) efforts in understanding the impact of organizational performance on safety. As a result of a series of research activities undertaken by numerous NRC contractors, a collection of organizational dimensions has been identified and defined. These dimensions represent what is believed to be a comprehensive taxonomy of organizational elements that relate to the safe operation of nuclear power plants. Techniques were also developed by which to measure these organizational dimensions, and include structured interview protocols, behavioral checklists, and behavioral anchored rating scales (BARS).

Recent efforts have focussed on devising a methodology for the extraction of information related to the identified organizational dimensions from existing NRC documentation. This type of effort would assess the applicability of the organizational dimensions to existing NRC inspection and evaluation reports, refine the organizational dimensions previously developed so they are more relevant to the task of retrospective analysis, and attempt to rate plants based on the review of existing NRC documentation using the techniques previously developed for the assessment of organizational dimensions.

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## **1. BACKGROUND**

The research discussed in this paper is primarily conducted in support of the NRC's efforts in understanding the impact of organizational performance on safety. In particular, the NRC has "concluded that the inadequate management direction, control, and oversight of plant activities such as operations, maintenance, engineering, and safety assessment have a negative effect on both equipment and human reliability, thereby increasing the likelihood and potential severity of plant events...Accurate assessments of corporate and plant management capabilities continues to be a high priority..." [1].

As a result of the series of research activities, including field work and literature reviews, undertaken by numerous NRC contractors in response to the concerns described above, a collection of organizational dimensions has been identified and defined. These dimensions represent what is believed to be a comprehensive taxonomy of organizational elements that relate to the safe operation of nuclear power plants. Techniques were also developed by which to measure these organizational dimensions, and include the use of structured interview protocols, behavioral checklists, and behavioral anchored rating scales (BARS).

### **1.1. Organizational dimensions and definitions**

Table I presents the preliminary set of organizational dimensions identified in the research activities and their definitions.

### **1.2. Techniques to measure organizational dimensions**

Techniques were also developed by which to measure these organizational dimensions, and include the use of structured interview protocols, behavioral checklists, and behavioral anchored rating scales (BARS). The techniques developed to date to assess organizational factors are detailed elsewhere [2-3]. This report will discuss the organizational dimensions and the techniques for assessing those dimensions through a retrospective analysis of existing NRC documentation.

## **2. ANALYSIS OF ORGANIZATIONAL PERFORMANCE**

Recent efforts have focussed on devising a methodology for the extraction of information related to the identified organizational dimensions from existing NRC documentation. This type of effort would assess the applicability of the organizational dimensions to existing NRC inspection and evaluation reports, refine the organizational dimensions

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previously developed so they are more relevant to the task of retrospective analyses, and attempt to rate plants based on the review of existing NRC documentation using the techniques previously developed for the assessment of organizational dimensions.

## **2.1. Methodology**

A methodology for the extraction of information related to the twenty organizational dimensions from existing NRC documentation was developed and tested. Three plants were selected to test the methodology. The plants selected varied along the dimensions of NRC Region and Systematic Assessment of Licensee Performance (SALP) ratings. Additionally, only those plants which had undergone a SALP evaluation under the newly revised SALP methodology [4] were considered in this pilot application.

Plant data selected for review included: a) the most recent SALP report; b) ten Licensee Event Reports containing human errors and coinciding in the same 18 month time period as the SALP evaluation; and c) two inspection reports for the plant, one specific for a functional area (e.g., operations, maintenance) and one more general in nature, occurring during the later twelve months of the SALP evaluation period. The time frames selected for the plant data ensured that all data analyzed corresponded to the same general time period for any particular plant.

Three teams were involved in the analysis of information from the documentation selected for the three NPPs. The members on each team all had extensive experience in the assessment of organizational factors in NPPs. Each team was given a set of documents for one of the three NPPs for the purpose initial data collection. Positive and negative statements were extracted from the reports which reflected issues and/or occurrences related to the organizational performance of the NPP. After the statements for each plant had been extracted from the NRC documentation, organizational dimension codes were assigned to each statement by two of the three project teams. The team which had extracted the information always coded the plant for which they had extracted the statements. They also coded an additional list of statements provided by one of the other teams. Statements were coded by identifying which organizational dimensions were most strongly represented in the statement. An attempt was made to code a primary, secondary, and tertiary organizational dimension to each statement.

## **2.2. Results**

As discussed above, a series of statements were extracted from selected NRC documentation for each of the three sample NPPs. In all, 117 statements were extracted

for Plant A, 154 statements were extracted for Plant B, and 136 statements were extracted for Plant C.

### 2.2.1. Frequency of occurrence of organizational dimensions

In order to determine the most frequently occurring organizational dimensions, the data were pooled across primary, secondary, and tertiary ratings as well as across project teams (e.g., raters). In other words, any time a dimension was mentioned for a statement, it was coded as having occurred. Thus, for any given statement, there were up to six possible organizational dimensions that could have been coded (e.g., the two rating teams used three non-overlapping codes). Table II presents the organizational dimensions in terms of their frequency of occurrence.

As can be seen in Table II, the four organizational dimensions of Roles and Responsibilities, Formalization, Problem Identification, and Coordination of Work account for over 45 percent of the total organizational dimensions used in the coding process. The organizational dimension of Centralization was not utilized by any of the three teams in their coding, while the organizational dimensions of Personnel Selection, Performance Evaluation, Organizational Knowledge, and Time Urgency were each used in less than one percent of the total coding completed for the three NPPs.

### 2.2.2. Agreement of statement coding

The results of an inter-rater reliability agreement analysis indicated that when using only the primary ratings, the teams agreed 34.4 percent of the time. When both the primary and secondary codes were used, agreement was produced 64.4 percent of the time. Finally, when the primary, secondary, and tertiary codes were all used, agreement was produced 72.5 percent of the time. Attempts to improve inter-rater reliability will be made using the revised organizational dimensions discussed below.

## 3. CONCLUSIONS

The initial products of this effort include the identification and definitions of the organizational dimensions most relevant to existing NRC documentation. This set of dimensions represents a slightly modified subset of the original organizational dimensions referred to above. A two-tier, four-factor model, representing 17 dimensions has been proposed and is presented in Table III.

Essentially, 13 of the original 20 organizational dimensions did not change from their original definitions, but the following four dimensions changed from the original list:

- **Communications - Internal:** In the original list of 20 organizational dimensions, this dimension was broken out into Interdepartmental Communications and Intradepartmental Communications. However, based on the pilot application of the dimensions to existing NRC documentation, it became clear that the documentation often did not specify who communications were between and in some cases the communications represented examples of both Intra- and Interdepartmental Communications.
- **Coordination of Work:** The definition of Coordination of Work from the original list of 20 dimensions was modified to include the organizational dimension of Roles and Responsibilities. This change took place because after the pilot application of the dimensions to existing NRC documentation, it became clear that the organizational dimension of Roles and Responsibilities is really a subset of the Coordination of Work dimension (e.g., defining roles and responsibilities of employees assists in and is an integral part of the coordination function). It was also a frequently co-occurring pair in the pilot study results.
- **Performance Quality:** Performance Quality is a newly termed organizational dimension from the original dimension of Ownership. Based on the pilot application, both the term and the definition of this organizational dimension were changed to reflect a more clearly observable organizational behavior.
- **Resource Allocation/Goal Prioritization:** Resource Allocation/Goal Prioritization as an organizational dimension represents a combination of two of the original 20 organizational dimensions. The decision was made to combine these two dimensions into a single dimension since the different teams appeared to be using the terms interchangeably (e.g., where team A identified Resource Allocation, Team B identified Goal Prioritization).

In addition, based on the pilot application, it was determined that five of the original 20 dimensions are not addressed in the documentation reviewed and evaluation based on existing documentation is not appropriate for these dimensions. These dimensions will require direct observation/interviews for an adequate assessment to be made. The five dimensions are: Personnel Selection; Performance Evaluation; Organizational Knowledge; Time Urgency; and Centralization. All of these dimensions accounted for less than one percent of the total organizational dimensions used in the pilot application.

Based on the infrequency of their occurrence, the project team also believes it is not appropriate, at this time, to attempt to include these dimensions in any further pilot tests using retrospective analysis. This is not to say that these dimensions are unimportant, but rather that these dimensions are not currently addressed in existing documentation to a level of detail to permit an evaluation.

A closer look at the organizational dimensions also suggested that the dimensions fall into four larger factors which can be further collapsed into two distinct categories or tiers. These two tiers represent dimensions that can either be inferred from the information read in the reports, and therefore represent less discrete and broader-impacting dimensions, or can be directly extracted from the information read in the reports. The first tier is represented by a higher-order factor labelled CULTURE. This higher-order factor represents more pervading types of dimensions that have a more broad reaching impact on both the organization as a whole, as well as on the remaining dimensions. The three second-tier factors are COMMUNICATIONS, HUMAN RESOURCE MANAGEMENT, and MANAGEMENT ATTENTION AND OVERSIGHT.

In conclusion, the work conducted to date on this project has led to the development of a two-tier, four-factor model of organizational dimensions and factors important to safe performance in NPPs. Of central importance to this model is the higher-order factor CULTURE, which includes the dimension of safety culture. This conceptualization may allow insights to be drawn regarding safety culture based on the measurement of dimensions within the second-tier factors. In addition, insights regarding the second-tier factors may be drawn based on an assessment of the dimensions included in the CULTURE factor.

#### 4. REFERENCES

- [1] STELLO, VICTOR JR., Memorandum to Chairman Zech, "Assessing Plant Performance as it Relates to Plant Management" (August 17, 1988).
- [2] JACOBS, R. AND HABER, S., Organizational Processes and Nuclear Power Plant Safety, Reliability Engineering and System Safety, Vol. 45, (1994) 75-83.
- [3] SHURBERG, D., HABER, S.B., AND JACOBS, R., Techniques to Assess Organizational Factors: Progress to Date, BNL Technical Report A-3956-1-7/94 (1994).
- [4] U.S. NUCLEAR REGULATORY COMMISSION, Systematic Assessment of Licensee Performance, Directive 8.6 (1992).

Table I. Organizational Dimensions and Definitions

<p><b>Centralization:</b> Centralization refers to the extent to which decision-making and/or authority is localized in one area or among certain people or groups.</p>
<p><b>Communication - Interdepartmental:</b> Interdepartmental communication refers to the exchange of information, both formal and informal, between the different departments or units within the plant. It includes both the top-down and bottom-up communication networks.</p>
<p><b>Communication - Intradepartmental:</b> Intradepartmental communication refers to the exchange of information, both formal and informal, within a given department or unit in the plant. It includes both the top-down and bottom-up communication networks.</p>
<p><b>Communication - External:</b> External communication refers to the exchange of information, both formal and informal, between the plant, its parent organization, and external organizations (e.g., NRC, state, and public).</p>
<p><b>Coordination of Work:</b> Coordination of work refers to the planning, integration, and implementation of the work activities of individuals and groups.</p>
<p><b>Formalization:</b> Formalization refers to the extent to which there are well-identified rules, procedures, and/or standardized methods for routine activities as well as unusual occurrences.</p>
<p><b>Goal Setting:</b> Goal setting refers to the extent to which plant personnel understand, accept, and agree with the purpose and relevance of goals.</p>
<p><b>Organizational Culture:</b> Organizational culture refers to plant personnel's shared perceptions of the organization. It includes the traditions, values, customs, practices, goals, and socialization processes that endure over time and that distinguish an organization from others. It defines the "personality" of the organization.</p>
<p><b>Organizational Knowledge:</b> Organizational knowledge refers to the understanding plant personnel have regarding the interactions of organizational subsystems and the way in which work is actually accomplished within the plant.</p>
<p><b>Organizational Learning:</b> Organizational learning refers to the degree to which plant personnel and the organization use knowledge gained from past experiences to improve future performance.</p>
<p><b>Ownership:</b> Ownership refers to the degree to which plant personnel take personal responsibility for their actions and the consequences of the actions. It also includes commitment to and pride in the organization.</p>



Table I. Continued

<p><b><u>Performance Evaluation:</u></b> Performance evaluation refers to the degree to which plant personnel are provided with fair assessments of their work-related behaviors. It includes regular feedback with an emphasis on improvement of future performance.</p>
<p><b><u>Personnel Selection:</u></b> Personnel selection refers to the degree to which plant personnel are identified with the requisite knowledge, experience, skills, and abilities to perform a given job.</p>
<p><b><u>Problem Identification:</u></b> Problem identification refers to the extent to which the organization encourages plant personnel to draw upon knowledge, experience, and current information to identify potential problems.</p>
<p><b><u>Resource Allocation:</u></b> Resource allocation refers to the manner in which the plant distributes its financial resources. It includes both the actual distribution of resources as well as individual perceptions of this distribution.</p>
<p><b><u>Roles-Responsibilities:</u></b> Roles and responsibilities refers to the degree to which plant personnel's positions and departmental work activities are clearly defined and carried out.</p>
<p><b><u>Safety Culture:</u></b> Safety culture refers to the characteristics of the work environment, such as the norms, rules, and common understandings that influence plant personnel's perceptions of the importance that the organization places on safety. It includes the degree to which a critical, questioning attitude exists that is directed toward plant improvement.</p>
<p><b><u>Technical Knowledge:</u></b> Technical knowledge refers to the depth and breadth of requisite understanding plant personnel have regarding plant design and systems, and of phenomena and events that impact plant safety.</p>
<p><b><u>Time Urgency:</u></b> Time urgency refers to the degree to which plant personnel perceive schedule pressures while completing various tasks.</p>
<p><b><u>Training:</u></b> Training refers to the degree to which plant personnel are provided with the requisite knowledge and skills to perform tasks safely and effectively. It also refers to plant personnel's perceptions regarding the general usefulness of the training programs.</p>

Table II. Frequency of Occurrence of Organizational Dimensions

DIMENSION	FREQUENCY	PERCENTAGE OF TOTAL
Roles and Responsibilities	246	12.8%
Formalization	224	11.6%
Problem Identification	210	10.9%
Coordination of Work	206	10.7%
Technical Knowledge	144	7.5%
Safety Culture	133	6.9%
Goal Prioritization	129	6.7%
Training	111	5.8%
Organizational Learning	89	4.6%
Resource Allocation	83	4.3%
Communication-Interdepartmental	77	4.0%
Organizational Culture	69	3.6%
Communication-External	49	2.5%
Ownership	49	2.5%
Communication-Intradepartmental	42	2.2%
Personnel Selection	18	0.9%
Performance Evaluation	17	0.9%
Organizational Knowledge	16	0.8%
Time Urgency	12	0.6%
Centralization	0	0.0%
<b>TOTAL:</b>	<b>1,924</b>	<b>100.0%</b>

Table III. Revised Dimension Definitions

FACTORS/DIMENSIONS	DEFINITIONS
<b>I. CULTURE (higher order factor)</b>	
a. Organizational Culture	Organizational Culture refers to plant personnel's shared perceptions of the organization. It includes the traditions, values, customs, practices, goals, and socialization processes that endure over time and that distinguish an organization from others. It defines the "personality" of the organization.
b. Organizational Learning	Organizational Learning refers to the degree to which plant personnel and the organization use knowledge gained from past experiences to improve future performance.
c. Safety Culture	Safety Culture refers to the characteristics of the work environment, such as the norms, rules, and common understandings that influence plant personnel's perceptions of the importance that the organization places on safety. It includes the degree to which a critical, questioning attitude exists that is directed toward plant improvement.
d. Time Urgency*	Time Urgency refers to the degree to which plant personnel perceive schedule pressures while completing various tasks.
<b>II.-1 COMMUNICATIONS</b>	
a. Internal Communications	Internal Communication refers to the exchange of information, formal or informal, within the plant.
b. External Communications	External Communications refers to the exchange of information between the plant, its parent organization, and external organizations (e.g., NRC state, and public).
c. Organizational Knowledge*	Organizational Knowledge refers to the understanding plant personnel have regarding the interactions of the organizational subsystems and the way in which work is actually accomplished within the plant.
<b>II.-2 HUMAN RESOURCE MANAGEMENT</b>	
a. Training	Training refers to the degree to which plant personnel are provided with the requisite knowledge and skills to perform tasks safely and effectively. It also refers to plant personnel perceptions regarding the general usefulness of the training program.

Table III. Continued

FACTORS/DIMENSIONS	DEFINITIONS
b. Technical Knowledge	Technical Knowledge refers to the depth and breadth of requisite understanding plant personnel have regarding plant design and systems, and of phenomena and events that impact plant safety.
c. Performance Quality	Performance Quality refers to the extent to which plant personnel adhere to their job requirements, carry them out correctly, and take personal responsibility for their actions and the consequences of those actions.
d. Performance Evaluation*	Performance Evaluation refers to the degree to which plant personnel are provided with fair assessments of their work-related behaviors. It includes regular feedback with an emphasis on improvement of future performance.
e. Personnel Selection*	Personnel Selection refers to the degree to which plant personnel are identified with the requisite knowledge, experience, skills, and abilities to perform a given job.
<b>II.-3 MANAGEMENT ATTENTION/OVERSIGHT</b>	
a. Coordination of Work	Coordination of Work refers to the identification of the roles and responsibilities of plant personnel, their work activities as well as the planning and integrating of these activities.
b. Formalization	Formalization refers to the extent to which there are well-identified rules, procedures, and/or standardized methods for routine activities as well as unusual occurrences.
c. Problem Identification	Problem Identification refers to the extent to which the organization draws upon knowledge, experience, and current information to identify potential problems.
d. Goal Prioritization and Resource Allocation	Goal Prioritization/Resource Allocation refers to the extent to which the plant sets and communicates goals and applies both human and financial resource toward the acquisition of those goals.
e. Centralization*	Centralization refers to the extent to which decision-making and/or authority is localized in one area or among certain people or groups.

\* May require direct observation/interviews.