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THE SAFETY CLIMATE OF A DEPARTMENT OF ENERGY NUCLEAR FACILITY: A SOCIOTECHNICAL ANALYSIS

Allan E. Johnson, Ph.D.
Jerry L. Harbour, Ph.D.

Human Factors Engineering
EG&G Rocky Flats, Inc.
P.O. Box 464--T886C
Golden, CO 80402-0464

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ABSTRACT

Government- and public-sponsored groups are increasingly demanding greater accountability by the Department of Energy's weapons complex. Many of these demands have focused on the development of a positive safety climate, one that not only protects workers onsite, but also the surrounding populace and environment as well. These demands are, in part, a response to findings which demonstrate a close linkage between actual organizational safety performance and the organization's safety climate, i.e., the collective attitudes employees hold concerning the level of safety in their organization. This paper describes the approach taken in the systematic assessment of the safety climate at EG&G Rocky Flats Plant (RFP).

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INTRODUCTION

The significant role that management, human, and organizational factors play in initiating, mitigating, and preventing major industrial accidents is being increasingly recognized. Recent research suggests that management and organizational factors affects process safety, both in the chemical industry (Van Hemel, Connelly, & Hass, 1991) and the nuclear industry (Coffman, Persensky, Ryan, Ramey-Smith, Goodman, Serig, & Trager, 1989). In a study commissioned by the Nuclear Regulatory Commission and the National Research Council, for example, Moray (1989) and a distinguished panel of professionals reviewed the status of human factors research and nuclear safety, and concluded that an area needing urgent study is the effect of management and organizational factors on safety. The panel was particularly concerned with how to develop an organizational culture of "reliability." The panel further noted: "All the most serious accidents of recent years, including Bhopal, Chernobyl, Challenger, King's Cross, etc., are now known to have been driven by organizational factors to a far greater extent than by any of the more 'traditional' human factors causes."

What is "safety climate?" Safety climate is related to organizational culture, as it implies a shared, unified set of perceptions and beliefs that workers have about the safety of their organization. These perceptions guide and direct job behaviors, feelings, attitudes, and values (Schneider, 1975). Cohen (1977) identified the importance of the human factor, noting that effective safety programs depended on practices that successfully dealt with "people" variables. Many of the "people" or "human" factors identified as key components in successful safety programs can be effectively addressed within the context of an organization's safety climate.

Safety "climate" in industrial organizations. Zohar (1980) provides one of the best reviews of the affects of safety climate in industrial organizations. He found definite and distinct sets of employee perceptions toward safety. In each industrial organization studied, Zohar discovered general agreement among employees concerning the relative importance of safety. More importantly, he found a high correlation between employee beliefs and perceptions about safety and the actual safety performance of their organizations: When employees perceived that safety wasn't very important, the organization commonly had a correspondingly poor safety record. These perceptions are based on numerous cues present in the work environment, and serve as a frame of reference for guiding appropriate and adaptive task behaviors (Schneider, 1975).

Zohar's analysis supports the idea of a definable safety climate in industrial organizations, and the resulting safety practices are reflected in the safety climate. Knowledge of the organizational/safety climate can serve as a useful tool in understanding occupational behavior, as safety climate can be regarded as a characteristic of industrial organizations, and safety climate is related to the general safety level in organizations. *Knowledge of an organization's safety climate or*

culture, therefore, is a critical factor in developing a plan to improve organizational safety performance.

Characteristics of an excellent safety climate: Lessons from the literature. In his review of factors in successful occupational safety programs, Cohen (1977) argued that the more distinguishable elements of successful safety performance rest largely on *psychological or human factors considerations*. Cohen suggested that increased emphasis should be placed on non-engineering measures, as maximally effective safety programs will be dependent on practices that can successfully deal with "people" variables. Reason (1990, p. 151), who modeled the human elements of accident causation, found that *human* factors dominate the risks to complex installations; simple equipment breakdowns can usually be traced to prior human failure. Although organizations usually concentrate their efforts on reducing or eliminating active human errors, Reason suggests that attempts to discover and neutralize latent failures or "traps" inherent in systems will have a much greater beneficial effect upon improving system safety.

While seeking factors and specific practices of consequence related to successful safety programs, it is important to note that the literature does not imply or supply a blueprint for the specific make-up of such programs. The literature, instead, provides core ideas and examples of related practices that, based on empirical evidence, seem to improve safety program effectiveness.

Factors common to companies having outstanding safety performance. Multiple studies clearly indicate that the characteristics identifying an excellent safety culture/climate cut across industries, technologies, and company attributes (NSC, 1964 ; Planek, Driessen, & Vilardo, 1967; Davis & Stahl; 1967; Shafai-Sahrai, 1971; Mobley, 1974; Cohen, Smith, & Cohen, 1975; Accident Prevention Advisory Unit, 1976; Smith, Cohen, Cohen, & Cleveland, 1976; Cohen, 1977; Shaw & Sanders, 1989; Serig, 1989). The most influential and dominant factors of successful programs are:

- Strong management commitment to safety.
 - Motivation
 - Resources
 - Openness to new ideas
 - Safety thinking
- Top management publishes a policy expressing management's attitude on safety.
- Top management actively participates in safety matters.
- Safety officer(s) have high rank, status, and calibre.
- Frequent management/supervisor/worker interactions on safety matters.
- Workforce stability and good industrial relations/personnel practices.
- High level of housekeeping and effective environmental controls.
- Well-developed selection, job placement, and advancement procedures.

- Emphasis on early training for new workers and refresher/reinforcement training.
- Active safety committees.
- Conventional safety practices are followed meticulously.
- Safety practices are "tailored" to specific organizations.
- Well-developed procedures for investigating and reporting accidents.
- Reports are made on real accidents and "near misses."
- Regular updating of safety rules.
- Daily safety inspections.
- Well-established hazard recognition.

THE SAFETY CLIMATE AT ROCKY FLATS PLANT (RFP)

In order to establish a solid basis for evaluating the progress of RFP in developing and maintaining a positive safety culture, the Human Factors Engineering group administered a safety climate survey designed to document employee perceptions, attitudes, and opinions concerning safety at Rocky Flats.

The current study is grounded in sociotechnical theory, which suggests that one of the major aspects of an organization's social system is its "organizational culture" (Getty, 1992). Organizational culture is what a group learns over a period of time as it solves its problems of survival in an external environment and its problems of internal integration; the perceptions, language, and thought processes that a group comes to share will be the ultimate determinant of feelings, attitudes, espoused values, and overt behavior (Schein, 1990). Morisseau and Schoenfeld (1988), in their review of nuclear power plants, reported on a similar concept, "organizational environment/operator culture," which is the attitudes, norms, practices, and history of the utility and its personnel and the role these characteristics play in creating an atmosphere that can have either positive or negative effects on nuclear operational performance.

METHOD

Survey Process. The RFP survey, adapted from one developed and validated in 1988 by another DOE facility, the Idaho National Engineering Laboratory (INEL; Kaplan, 1989), is based on findings from various studies which strongly correlate employee attitudes about safety to actual plant safety records. The survey included 78 attitude statements with quantifiable features of a positive safety culture, four demographic questions, and three open-ended questions which allowed employees to provide positive, negative, and general comments regarding safety. For each of the 78 attitude statements, employees circled one response which best described their opinion, ranging from "disagree totally" to "agree totally." The concluding page of the survey contained three open-ended questions which provided employees with the opportunity to include personal comments about safety.

The survey was distributed to 6,606 RFP employees (proportional sampling)

in Golden, Colorado, and to 90 employees in Oxnard, California, during July and August of 1991. Participation in the survey was voluntary, and all responses were anonymous. Sixty percent (3,974) of the surveys were returned, yielding over 3 million individual data points and 6,871 written comments to the three open-ended statements.

Rating Scale Construction

The survey instrument used was atypical because it was designed as a 6-point scale rather than the usual 5-point scale (see Gay, 1987, pp. 146-147) used in most attitude surveys. The 6-point variation of the Likert scale was used in order to force individuals to make positive or negative judgmental ratings (there was no "middle" or neutral point). The response category "neither agree nor disagree" used in the INEL survey and characteristic of Likert scales was not used in the RFP survey, since people seldom have no opinion or a "middle-of-the-road" opinion about safety. Additionally, individuals tend to favor certain types of responses: Extreme responses, neutral responses, "agree" responses, or "disagree" responses (Kerlinger, 1973, p. 496). It is known that individuals with a "response bias" pick ratings towards the middle value on scales with an odd number of alternatives, since the middle response is perceived as safe and comfortable. Individuals exhibit this response bias for a number of reasons: They may feel the question does not apply to them, they do not know the answer, or they do not want to reveal their true feelings, or they do not want to exert the energy to decide. By presenting a 6-point scale with no neutral or middle response such as the one used to survey RFP employees, employees were forced to choose a response which represented their decision regarding safety at RFP.

Data Analyses. The survey results were analyzed both quantitatively and qualitatively. The demographic information and the 78 negatively- and positively-worded attitude statements were analyzed quantitatively, while the three open-ended questions were analyzed qualitatively using content analysis (Gay, 1987, p. 207) to determine general trends in the data (content categories), and the frequency with which statements, both positive and negative, were made.

RESULTS

Survey demographics closely matched plant demographics. Quantitative differences regarding perceptions of safety at RFP exist among management, salary, and union personnel. In general, management perceptions yielded higher average responses or responses indicating a greater amount of agreement with the survey questions than the responses of either salary or union personnel. Perceptions of some management groupings were quite different numerically from the perceptions of salaried employees, especially among general support groups. Conversely, operational groupings exhibited more agreement. Average numerical values, corrected for negative and positive wording of the attitude statements, indicated that 62 of the 78 attitude statements had average responses greater than a mean value of 2.5, indicating an overall tendency towards the desired response (agreeing with

positively-worded statements, and disagreeing with negatively-worded statements).

Employees with less than one year on plantsite and those with greater than 20 years on plant-site had higher average overall response ratings than other groups, indicating that they tended to agree with the positively-worded statements and tended to disagree with the negatively-worded statements.

Content Analysis of Open-ended Questions

Three open-ended questions, with response rates in parentheses, were included in the survey to provide employees with the option of personalizing their comments about safety:

1. What are the positive things that you see in regards to **safety** at Rocky Flats (58%);
2. What are the negative things that you see in regards to **safety** at Rocky Flats (58.6%); and
3. Any additional comments about **safety** at Rocky Flats (42.2%).

Over 63% of all survey respondents (2,504) made one or more comments to the open-ended questions. A total of 6,871 comments were recorded and categorized. Most respondents made positive as well as negative comments; positive comments were more likely to be brief, general statements, while negative comments tended to be specific and numerous. Of the 6,871 recorded individual comments, 2,396 (34.9%) were positive and 4,475 (65.1%) were negative.

Strengths and Challenges

In order to better utilize the quantitative data, it was categorized into "strengths" and "weaknesses". A "strength" was defined as a survey question with an average response within one standard deviation of the idealized average (0 or 5), depending upon whether the question was negatively- or positively worded. A "challenge" was defined as a survey question with an average response more than two standard deviations from the goal or ideal response for each question.

The strengths and challenges are strongly supported by the quantitative and qualitative data. Although there are quantitative differences among management, salary, and union personnel, the "*pattern*" of results indicates that there was almost complete agreement among all groups regarding identified strengths and challenges.

Strengths

Positive findings or RFP strengths derived from analyses of the 78 attitude statements show that employees:

- Hold high expectations for working safely and following safety procedures;
- Are highly committed to working safely;
- Feel management is open to hearing employee concerns and issues regarding

- safety; and
- Think management is concerned about the personal safety of employees.

Challenges

- The survey also identified challenges or opportunities for improvement:
- Perceptions that management generally does not recognize or reward safe work behavior;
 - Feelings of lack of worker involvement, participation, and inclusion in such areas as procedure development, safety problem resolution, and work design; and
 - Perceptions that procedures, rules, and regulations are excessive and complex, making compliance difficult due to understandability and usability issues. Most concerns involving safety procedures refer to their technical usability and not their perceived relevancy.

DISCUSSION

Employee-held perceptions of a strong personal commitment to working safely and espoused opinions that working safely is expected at RFP are both very positive. That RFP employees recognize the importance, expectation, and relevancy of following safety procedures, as demonstrated in their positive survey responses, is also highly commendable and complimentary of the workforce. This expressed commitment and expectation to follow safety procedures and to work in a safe manner is extremely positive. In addition, the perception held by employees that management is (a) open and receptive to employee concerns regarding safety is also noteworthy, and (b) perceptions that management cares about employee welfare.

These results are very positive first-steps in creating and maintaining a "safety first" culture, since such views indicate a commitment to working safely at RFP at the employee level. Weiss (1975) noted that the values of decision makers, however, often determines how data is interpreted. Westrum (1988; in Reason, 1990), who developed a meaningful classification of the *ways in which organizations differ in their reactions to safety data*, believes that organizations, like individuals, exhibit a consciousness, memory, and an ability to create and solve problems. Organizational thinking strongly affects the generation and elimination of safety hazards.

How do organizations typically respond to safety data? Organizational responses to safety hazards, Westrum noted, fall into three groups:

- *Denial actions* are those of "suppression" and "encapsulation". During suppression, individuals are punished or dismissed, and the observations which led to the punishment or dismissal are expunged from the record. During encapsulation, individuals are retained, but the validity of their observations is disputed or denied.
- *Repair actions* are typically one of two types of actions: Public relations,

- and local repairs. During the public relations phase, observations emerge publicly, but their significance is denied and/or sugarcoated. During local repairs, conversely, the problem is admitted and fixed at the local level, but its wider implications are denied.
- The two most prominent *reform actions* include dissemination and reorganization. During dissemination, the problem is admitted to be global, and global action is taken. During reorganization, action on the problem leads to reconsideration and reform of the operational system.

Westrum indicates that the more effective the organization, the more likely it is to respond to safety data with reform actions, while those less effective will employ denial actions.

Westrum also categorized organizations along a scale of "cognitive adequacy", or the effectiveness of their ways of thinking about safety hazards. Organizations are either *pathological*, *calculative*, or *generative*. Pathological organizations have safety measures which are inadequate even under normal conditions, sacrificing safety goals in the pursuit of production goals, and in many instances actively circumventing safety regulations. Calculative organizations attempt to do the best they can by using 'by the book' methods, which are usually adequate under normal operating conditions but often fail when unforeseen circumstances arise. Calculative organizations may implement many safety practices but do not have effective disaster plans. *Generative organizations* are in a sense unconventional in furthering their goals, set targets for themselves beyond ordinary expectations, emphasize results rather than methods, and value substance more than form. *According to Westrum, all organizations should seek to become generative.*

How has RFP management responded to the results of the survey? The quantitative and qualitative results pointed out many areas of strengths and several opportunities for intervention at RFP. A retrospective analysis of the survey process, from initial conception of the idea to the actual surveying of plant employees, to the development and initiation of safety enhancement programs, has provided many lessons learned which can be used by other organizations as they assess the safety climate of their organization.

As a result of the survey, three areas were targeted for improvement efforts. This resulted in the development of specific interventions to resolve identified deficiencies, and the development and utilization of plant-wide performance indicators (Van Hemel, Connelly, & Haas, 1991).

The management at RFP has chosen to respond to the survey findings with what Westrum terms "*reform actions*." The following represents a sample of the actions taken to date in response to the survey findings:

1. Plant-wide management/supervisory meetings have been held to present and explain survey results and the implications for management changes and actions.
2. The survey findings in an abbreviated format have been distributed to all plant personnel, including the perceived plant strengths and challenges, and planned corrective actions.
3. Employee involvement has been increased in areas such as the development of procedures, engineered changes, new equipment/workplace designs, task/maintenance activity design. In addition, employee input in resolving safety issues and concerns has been solicited and utilized. By soliciting and utilizing employee input, employee feelings of value, responsibility and "ownership" have increased. These efforts are consistent with the continuous improvement model described by Imai (1986), who noted that the continuous involvement of all employees in operational matters is the cornerstone of quality efforts in Japan (e.g., Total Quality Management, Total Quality Control and Company-wide Quality Control). A major focus of these efforts is soliciting employee suggestions on how to continuously improve the work process, and then recognizing/rewarding and implementing these suggestions. The striving for constant, incremental improvement through employee involvement and recognition is commonly expressed under the Japanese concept of *Kaizen* (1986).
4. There has been increased management responsiveness and timeliness to employee safety concerns and issues. Greater management presence, involvement, and communication has occurred, much of which has been accomplished through enhancing the "management by walking around philosophy" (Peters, 1987).
5. The usability of technical and administrative procedures has been improved, thereby increasing employee efficiency and effectiveness. Plant procedures are beginning to incorporate human factors principles and current technology of text concepts and for enhanced user comprehension.
6. Several interventions have been developed and implemented to improve the RFP safety culture, and to measure its continued progress.
7. Efforts necessary to more closely coordinate and integrate safety and quality have been developed and implemented. Although quality and safety efforts are typically managed independently, there is strong evidence that such programs are organizationally interdependent and can mutually benefit one another. Although quality and safety efforts are typically managed independently, there is strong evidence that such programs are organizationally interdependent. For example, Smith and Larson (1991) studied the interactional effects of quality and safety programs, and suggested that concomitant improvements in both safety and quality are a result of the interactive effects of the two programs. Smith and Larson further concluded that quality and safety programs can mutually benefit one another, and advocated that an integrated management approach be taken in their

development and implementation.

CONCLUDING COMMENTS

The 1991 Safety Climate Survey systematically, quantitatively, and qualitatively measured employee perceptions regarding safety at RFP. Analysis of the findings from the survey, based on over 3 million individual quantitative data points and 6,871 qualitative written comments, resulted in the categorization of the data into identifiable strengths and challenges, a better understanding of employee perceptions concerning safety. Although positive safety attitudes are insufficient by themselves to guarantee a safe work environment, they are nevertheless an important and crucial component in developing and maintaining a successful safety record, one that protects RFP workers, the surrounding populace, and the environment as well.

As Zohar noted, the significance of organizational safety climate is that management commitment to safety, with its multiple expressions, is a major factor affecting the success of safety programs in industry. Safety should be regarded as an integral part of the production system (Grimaldi, 1970); it should not be detached from general management responsibilities.

The results suggest that the variance between the existing safety climate and the desired one exemplified by the characteristics of companies with excellent safety climates is not as great as previously believed or portrayed by many officials and other outside groups (Harbour, 1992). The plant already has in place numerous positive and desired safety-related characteristics; focus groups have suggested ways in which to continually improve upon these strengths.

The willingness of RFP management to respond to the challenges identified by the survey is, in and of itself, demonstrative of the type of safety culture that management wishes to achieve. Numerous studies, summarized by Pasmore (1990), have found that effective organizations are those which produce excellent results by any measure of cost, quality, safety, productivity, or efficiency, while simultaneously enhancing the energy and commitment of organizational members to the success of the enterprise.

It is crucial that RFP management continue to build on plant strengths. By adopting a guiding philosophy of constant self-appraisal and continued improvement, recognized strengths will continue to mature. No less important is the need for management to objectively address perceived challenges by taking appropriate actions to resolve them. Through the resolution of identified challenges, management will not only reaffirm its commitment to providing a safe work environment for RFP employees, but will also increase overall plant effectiveness and productivity through the striving for, and development of, a culture of reliability, safety, and quality.

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