

SAFETY AND RELIABILITY IN INDUSTRIAL ORGANIZATIONS --THE KEY FACTORS¹

Robert A. Cooke, University of Illinois at Chicago
Henry D. Sarkis, The Reliability Group, Lighthouse Point, Florida

Introduction

The level of safety and reliability achieved by a complex organization is proposed here to be related to its culture and associated organizational, work-unit, and job level factors. The "culture" of an organization is reflected in the assumptions, pattern of values, and beliefs that are shared by members and guide their behavior [1]. Those aspects of culture that most directly shape behavior are referred to as "norms and expectations," that is, shared and accepted beliefs regarding appropriate and inappropriate behaviors. While certain types of norms promote individual effectiveness and cooperation in organizations, others lead to dysfunctional behaviors that inhibit problem solving and coordination and ultimately interfere with reliability, adaptability, and safe operations. Expectations for these latter behaviors are often reinforced, generally unintentionally and unknowingly, by organizational structures and processes which make them seem appropriate or implicitly required. The position taken in this paper is that both organizational norms and the factors that reinforce them can be measured--and that the information generated by quantitative assessment can be used by organizations to change their cultures in a direction supportive of safety and reliability. Two relevant diagnostic instruments are described here: The Organizational Culture Inventory and the Human Systems Reliability Survey.

Measuring Organizational Culture

The Organizational Culture Inventory or OCI [2] is an instrument designed to measure twelve distinct but interrelated sets of behavioral norms and expectations in organizations. These norms were identified on the basis on two important distinctions regarding individual behavior in organizations--the distinction between behaviors directed toward the fulfillment of higher-order "satisfaction needs" versus those directed toward lower-order "security needs" and between behaviors reflecting a concern for people versus those reflecting a "concern for tasks" [3]. Considered together, the satisfaction/ security and people/task dimensions provide a conceptual framework for organizing in a circumplicial manner [4] many of the behaviors exhibited by people in organizational settings [5].

Following this framework, the OCI asks respondents to consider 120 statements (ten associated with each set of norms) and to indicate the extent to which the behaviors described help people to "fit in" and "meet expectations" in their department or facility. Responses by members of an organization or subunit are aggregated and profiled to provide a picture of the culture within which they operate.

The profile depicts the relative strength of norms and

expectations for the twelve behavioral styles and, in doing so, characterize the organization's culture as Constructive, Passive/Defensive, or Aggressive/Defensive. The twelve behavioral norms are associated with these three general types of culture as follows:

1. Constructive cultures prevail in organizations in which members are encouraged to interact with others and approach tasks in ways that will help them to meet their higher-order growth needs. Norms and expectations support four of the more satisfaction-oriented behavioral styles measured by the OCI-- Achievement, Self-Actualizing, Humanistic-Encouraging, and Affiliative.
2. Passive/Defensive cultures characterize organizations in which members are expected or implicitly required to interact with others in ways that will protect their own security. As measured by the OCI, behavioral norms support four styles that are security-oriented and reflect a concern for people-- Approval, Conventional, Dependent, and Avoidant.
3. Aggressive/Defensive cultures characterize organizations in which members believe they are expected to approach tasks in forceful ways to enhance their status and position within the system. Norms and expectations emphasize four OCI styles that reflect a concern for security in a task-oriented direction-- Oppositional, Power, Competitive, and Perfectionistic. Various research efforts and consulting projects suggest that these behavioral norms can be measured (in a psychometrically valid and reliable manner) and that the norms associated with Constructive cultures are consistently related to criteria of individual and organizational performance in a positive direction. Passive/Defensive norms generally have been found to be negatively related to such outcomes and Aggressive/Defensive norms do not appear to be strongly or consistently associated with effectiveness (in either a positive or negative direction). Research has further indicated that the three types of cultures are systematically related to a number of organization, work-unit and job-level factors--many of which are also directly related to safety and reliability.

Measuring Variables Associated With Culture And Reliability

The Human Systems Reliability Survey [6] was developed on the basis of research on occupational safety and health as well as more general research in the fields of organizational behavior and human resource management. Theoretical as well empirical work in these disciplines was reviewed in depth and synthesized to provide the framework for the Survey. The instrument measures variables at all three levels of analysis considered to be relevant to a culture of reliability:

¹ This paper was presented at the American Nuclear Society's Conference on Risk Management, June 9, 1992 in Boston, and will be published in the Proceedings of the American Nuclear Society.

1. Organizational variables including such factors as management's commitment to safety, vertical communication, the distribution of influence, inter-unit coordination and human resource management practices (e.g., training & development, performance appraisal);

2. Work-unit characteristics including intra-group and inter-group factors (such as cooperation and teamwork, work group efficacy, and cross-job knowledge), supervisory dimensions (such as supportiveness and goal emphasis), and physical and ambient characteristics of the work place (such as physical conditions, psychological climate, quality and appropriateness of equipment);

3. Job-level factors including task characteristics (e.g., variety and autonomy), role characteristics (e.g., overload, clarity, consistency), and affective reactions (e.g., involvement and challenge).

The Survey also asks about accidents and "near-misses" experienced by the respondent, the causes and consequences of these events, the effectiveness of the organization's safety committee (if any), and incentives for safe and reliable operations. The theme of the survey, however, is that safety and reliability are possibly more strongly affected by organizational and subunit sociotechnical system variables than by factors more overtly and traditionally associated with these outcomes. These sociotechnical variables (e.g., job design, work-unit coordination, vertical communication) are hypothesized to promote reliability not only directly but also indirectly by means of their tendency to reinforce Constructive norms leading to individual and organizational effectiveness.

Factors Associated With Safety And Reliability

The strength of norms for Constructive behaviors has been shown to be positively related to performance in studies focusing on various types or organizations. Norms supporting Achievement-oriented, Self-Actualizing, Humanistic-Encouraging, and/or Affiliative behaviors have been found to be significantly related to, for example, measures of sales performance and growth in retail stores [7] and the motivation and satisfaction of members in a heterogeneous sample of organizations [8]. The question becomes, however, are these same Constructive norms and expectations associated with the performance of nuclear power plants and other organizations where effectiveness is synonymous with process reliability and safety? The answer appears to be "yes;" in fact, these norms might be even more important in organizations where reliability is critical.

The "Ideal Culture" for Reliability-Oriented Organizations

Managers and employees of a number of reliability-oriented organizations have been asked to complete the OCI in terms of what should be expected of members to attain optimal levels of reliability and performance. (These organizations include nuclear power and fossil fuel plants, chemical plants including a ferrosilicon facility, petroleum refineries, and air traffic control systems.) The "ideal" cultural profiles based on their responses strongly emphasize the importance and appropriateness of Constructive norms for these organizations. Uniformly, these profiles indicate that Passive/Defensive norms (e.g.,

Conventional, Dependent) are clearly inappropriate for such organizations and that Aggressive/Defensive norms also should be down played.

Corroborative Research

The validity of the Constructive ideal profiles proposed by the above respondents is supported by research carried out in various complex organizations under both normal and crisis operating conditions. Studies conducted by Tjosvold [9] and Foushee [10] suggests that the management of safety risks by flight crew members is promoted by constructive norms and behaviors. Relevant factors include cooperative goals, confident expectations, open discussion and positive affect (which correspond to the Achievement, Self-Actualizing, and Affiliative OCI styles). In contrast, the inability to solve problems, coordinate activities, and react to crises is associated with inappropriate attention to minor details (Perfectionistic), centralization of command and hierarchical structure (Power and Dependence), rigid role prescriptions (Conventional), and competitive goals (Competitive).

Similarly, ongoing research being carried out for the Defense Logistics Agency of the Department of Defense is generating parallel findings. Designed to identify the culture of high-performance units, this research involved the administration of the OCI to defense personnel both during and after the Desert Shield build-up. Preliminary results show that the cultures of the highest performing units, such as the Emergency Supply Operations Center of the Medical Directorate, were characterized by particularly strong Constructive norms (Self-Actualizing, Humanistic-Encouraging, and Affiliative). Norms for Competitive, Power-oriented, and Dependent behaviors were relatively weak. The Center did exhibit the same moderately strong norms for Perfectionistic and Conventional behaviors characteristic of other units, but these norms were possibly necessary to enable the Center to fit into the larger culture. A follow-up administration of the inventory showed that the same generally Constructive culture was characteristic of the Center during non-crisis operations.

The Present Research

The Human Systems Reliability Survey and the OCI have been used in various organizational development projects designed to promote reliability and reduce accident rates. Data collected on four organizations are analyzed here to identify the cultural norms and other factors associated with accidents. The organizations/sites providing the data include a wood products producer (multiple sites), a large refinery, a plant producing a highly-explosive chemical, and a major construction site.

Respondents who experienced accidents (within the last three years) were compared to those who had not along all the variables measured. Discriminant analysis, a statistical procedure that forms linear combinations of independent variables, was used to identify the Survey and OCI measures that most accurately classified respondents into the two groups (i.e., those who has experienced accidents versus those who had not). The variables that were identified as the best "predictors" were then examined further through analysis of various procedures. That is, the mean scores along these variables for those who had experienced accidents were compared to the

mean scores for those who had not, and the significance of the differences tested through the use of the F statistic. Some of the variables along which differences are significant are shown in Table 1.

With respect to behavioral norms and expectations, the OCI style most strongly associated with safety is Self-Actualization-- a Constructive norm. Additionally, Achievement norms are related to safety and Conventional, Competitive, Avoidance, and Power norms are associated with accidents at these reliability-oriented sites. These findings are consistent with the above-mentioned "ideal" cultural profile which cites Constructive norms as appropriate, and Defensive norms as inappropriate, for reliability-oriented organizations.

Of the organizational-level variables measured by the reliability Survey, effective human resource management practices with respect to "employee selection and placement" are most strongly associated with safety. Work group variables are less strongly related to accidents in this particular sample. Nevertheless, work group "autonomy and authority" (the degree to which members have sufficient freedom to make necessary decisions) shows a significant and negative relationship to accidents.

Results for several work place characteristics are statistically significant including two single-item measures of psychological climate: "depressing/cheerful" and "stressful/pleasant". Respondents who had experienced accidents reported their work place as being relatively depressing and stressful, a finding consistent with studies showing that stress is negatively related to performance in organizational settings [11]. A rating of procedures in terms of "natural versus awkward" is another important variable related to safety for this sample. This result is consistent with human factors as well as biomechanics and ergonomics research on occupational safety and health [12]. Several job-level variables emerged as significant predictors of work place safety. "Job satisfaction" (measured in part by asking respondents if they would recommend their job to a close friend) is consistently one of the key correlates of a safe work place. "Job challenge" (the extent to which employees can use their skills and abilities) and "role clarity" (the degree to which people know what is expected of them) are other examples of job-level variables related to safety. Finally, the occurrence of "near misses" or "close calls" also discriminates between those who have and those who have not had accidents.

Conclusions

The results reported here focus on a subset of the organizational, work-unit, and job-level variables found to be associated with the occurrence of accidents in the four

organizations studied. Analyses of these (and other data) show that most of these variables are also systematically related to Constructive norms which, as noted above, can encourage behaviors which further promote cooperation, effective problem solving, and system reliability. While these results have direct implications for organizations such as nuclear power plants, it is noted that the generalizability of these data are somewhat limited. First, while certain factors appear to be related to reliability across different types of organizations, the unique technology and environment of nuclear power plants require that they be surveyed directly to identify the variables with the greatest explanatory power for such systems. Second, the survey data reported above were collected after the occurrence of accidents. As such, it could be argued that the experience of an accident led to less positive perceptions of one's job, work-unit and organization rather than vice versa.

Related studies indicate, however, that cultural norms and the variables measured by the Human Systems Reliability Survey are the causal factors and lead to safety and reliability. For example, the management of one of the wood products facilities included in this sample initiated a full-scale program to improve its culture and address issues raised by the survey. Training programs were introduced to encourage teamwork and communication; work groups became more "self-managing" and were given authority over safety-related issues; programs were introduced to recognize group safety accomplishments; and more intensive training was introduced for new hires. These and other initiatives were followed by changes in the measures indicating a more constructive culture and stronger safety-emphasis in a follow-up survey. Other measures of safety improvement included a 76% reduction in the number of lost-time cases due to accidents and almost a 90% reduction in the number of lost work days due to accidents [13].

Reliability-oriented organizations, as a group, do not appear to differ significantly from other types of organizations in terms of the overall constructiveness or defensiveness of their cultures. The cultures of some such organizations, however, tend to be somewhat defensive and hierarchical-- that is, reported norms and expectations become increasingly less constructive and more defensive at lower levels of the hierarchy [14]. There is nothing inherent in the nature of these organizations that requires such a culture; instead, these types of norms result from certain assumptions about management and organization and are inadvertently reinforced by organizational and unit-level structures and processes that evolve over time. Our examples show that these factors can be effectively changed in ways that enhance the culture as well as the reliability of the system. ■

Table One

Variable	Accidents		No Accidents		F ³
	Mean	Std. Dev.	Mean	Std. Dev.	
Self Actualizing Culture	2.80	1.23	3.29	1.17	59.08
Employee Selection/Placement ¹	2.19	0.93	2.52	1.00	32.83
Autonomy and Authority ¹	2.99	1.21	3.25	1.08	11.91
Depressing/Cheerful ¹	2.78	1.10	3.28	1.14	71.22
Stressful/Pleasant ¹	2.34	1.10	2.81	1.14	64.45
Awkward /Natural Procedures ¹	2.99	1.01	3.38	1.12	44.49
Job Satisfaction ¹	3.07	1.21	3.68	1.17	97.51
Near Misses ²	2.00	1.00	2.55	0.84	139.10

¹ Scale ranges from 1 to 5 (5 is most favorable)

² 1=near miss; 3=no near miss

³ F-statistics for all ANOVAS are significant at p<.001

References

- Ott, J.S., The Organizational Culture Perspective, Dorsey Press, Chicago, 1989.
- Cooke, R.A. and Lafferty, J.C., Organizational Culture Inventory, Human Synergistics, Plymouth, MI, 1987.
- Lafferty, J.C., Life Styles Inventory, Human Synergistics, Plymouth, MI, 1987.
- Guttman, L., "A New Approach to Factor Analysis: The Radex," in P. Lazerfeld (ed.), Mathematical Thinking in the Social Sciences, The Free Press, Glencoe, IL, 1954.
- Cooke, R.A., Organizational Culture Inventory Leader's Guide, Human Synergistics, Plymouth, MI, 1989.
- Cooke, R.A., Human Systems Reliability Survey, Center for Applied Research, Northbrook, IL, 1988.
- Klein, M.I., Corporate Culture and Store Performance: Differences Between High Performance and Low Performance Stores, Ph.D. Dissertation, Temple University, Philadelphia, PA, 1992.
- Cooke, R.A. and Szumal, J.L., "Interpreting the Cultural Styles Measured by the OCI" in Organizational Culture Inventory: Level V Leader's Manual, Human Synergistics, Plymouth, MI, 1987.
- Tjosvold, D., "Flight Crew Collaboration to Manage Safety Risks," Group & Organization Studies, vol. 15, June 1990, pp. 177-191.
- Foushee, H.C., "Dyads and Triads at 35,500 Feet: Factors Affecting Group Process and Aircrew Performance," American Psychologist, vol. 39, pp. 886-893.
- Motowidlo, S.J., Packard, J.S., and Manning, M.R., "Occupational Stress: Its Causes and Consequences for Job Performance," Journal of Applied Psychology, vol. 71, pp. 618-629.
- Grimaldi, J.V. and Simonds, R.H., Safety Management, Irwin, Homewood, IL, 1989.
- Sarkis, H.D., "How to Ensure Success in Safety and Operating Reliability," Proceedings of the Forest Industries Clinic (Portland, OR), March 1992.
- Cooke, R.A. and Fisher, D.J., The Organizational Culture of the Federal Aviation Administration, Human Synergistics, Plymouth, MI, 1985.