

Quantitative Effects of Safety Culture on Nuclear Safety

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1. Introduction

Safety culture refers to an environment of safety consciousness, created by the practice of organizational polices, in which the chance of a deviation from normal to abnormal operation is greatly reduced, and the dynamic situations of abnormal operations will be well controlled. As organization and technology both become complex in a nuclear power plant, the safety culture becomes a significant factor in achieving high reliability at the plant. The importance of such a unique culture lies in the fact that people within the organization are then conditioned to use similar decision premises and assumptions, which, when they are invoked on individual basis, preserve coordination.

An example to illustrate this point is the Three Mile Island accident. Among the major causes, which contributed to the accident were inappropriate operator actions, which turned a minor equipment failure into a very serious event. Deficiencies in operator training, lack of clarity in operating procedure, and deficiencies in the design of the control room, all contributed. The same references further concluded that, given all these deficiencies, an accident like Three Mile Island was inevitable.

The accident at the Chernobyl nuclear power plant is also considered "inevitable." The lack of overall management control, the inadequate safety reviews of test procedures, the violation of safety procedures, and the failure of the plant operators and station management to demonstrate an adequate understanding of the safety implications of their actions as a whole, all contributed to this disaster. Based on similar findings, INSAG further proposed the concept of "safety culture" as one of the fundamental management principles which "governs the action and interactions of all individuals and organizations engaged in activities related to nuclear power"^[1].

In this paper, four characteristics of a nuclear power plant are introduced: the safety knowledge acquired by utility and plant personnel; the attitude of plant personnel toward plant operation; the choice of plant performance goals; and the establishment of lines of responsibility and communication. These characteristics are discussed in the following sections.

2. Factors of safety Culture

2.1 Safety Knowledge

For plant operation, it is important that everyone responsible possesses deep knowledge of plant behavior, severe accident consequences, and related subjects, thus leading to an overall state of pervasive safety thinking. Again, this can be achieved only through understanding of the functions of plant equipment, with special emphasis on the reasons underlying safety limits and the safety consequences of violation. The repeated violation of safety procedure occurring before and during the Chernobyl accident can be attributed to the lack of awareness of the consequences of such violations.

2.2 Attitude

Reliability is a non-event because, most of the time, nothing happens to a reliable system. The uneventful situation of routine nuclear power plant operation often makes its working environment boring rather than challenging. People involved in plant operation are often misled by the stagnant atmosphere of the plant, which can result in a slack and inattentive working attitude. This kind of attitude is often further amplified by the fact that the automatic feedback systems correct minor deviations and keep the system functional normal without interruption. Plant personnel, consequently, may overlook the dynamic nature of reliability and misinterpret stagnation as safety. A team with a slack and inattentive attitude toward plant operation is expected to experience more difficulties in bringing the plant back to normal operation after an abnormal occurrence.

There have been incidents in the past that show such inattention. For example, on March 31, 1987, the Nuclear Regulatory Commission (NRC) ordered the cold shutdown of Peach Bottom-3 of the Philadelphia Electric Company (PECO) on the basis that plant operators had been observed sleeping or being inattentive at their posts repeatedly, perhaps with the knowledge of immediate or higher level supervisors^[2].

2.3 Performance Goals

The goals of plant performance are set by plant managers at a higher organizational level, and will influence plant personnel in making decisions during plant operation. For example, if the operating team constantly receives pressure and encouragement from higher-level managers to achieve high plant availability and to increase the production of electricity during daily operations, it will not be a surprise if operators weigh economic consequences higher than safety

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consequences during emergencies. This is evident in the incident at the Davis Besse Plant on June 9, 1985, where, subsequent to a complete loss of main feedwater, nine abnormal events, including both operator errors and equipment failures, resulted in a loss of all sources of feedwater to this steam generators and a dryout of both steam generators. According to the emergency operating procedures, operators have to initiate the feed-and-bleed method for decay heat removal when both steam generators are dried out. It is known to the shift supervisor that this action requires a long cleanup effort and large economic loss. In spite of this requirement in the emergency operating procedures, the shift supervisor did not initiate feed and bleed; he waited for the equipment operators to recover the auxiliary feedwater system (AFWS). The Davis-Besse incident demonstrates that plant policies subconsciously set the priority of operator actions long before the plant runs into an emergency. This attitude not only causes a delay in carrying out safety actions, but also creates an over confidences attitude which can be harmful to plant safety (the shift supervisor at Davis-Besse thought that feed and bleed could be successfully initiated whenever necessary, even thought at no point was such a presumption sound; his delay could have caused severe consequences, if the AFWS was not recovered in time.) The choice of plant performances goals predefines the priority of actions in an emergency; therefore, it has a direct impact on the safety of a nuclear power plant.

2.4 Responsibility and Communication Lines

An environment of safety culture also relies on clear lines of responsibility and communication, so that actions during both normal operation and emergencies can be accountable, and information relevant to plant safety can be shared by plant personnel. In the cases of the operators sleeping during their shifts at Peach Bottom mentioned previously, the plant managers either knew about it and took no action or should have known about it. In either case, there was a defect at the PECO plant management in establishing lines of responsibility and communication.

No attempt to establish effective lines of responsibility and communication in a technology involving a large number of engineers, such as an effective management relies on more time spent of direct monitoring and performance consequence-related supervision, and effectiveness in communication is postulated to be the highest when people work face-to-face. However, engineers are generally less comfortable with face-to-face communication. The Independent Management Appraisal of Turkey Point Units 3 and 4, a plant ranking low in the NRC's Systematic Assessment of Licensee Performance (SALP) program points out that "Turkey Point tends to rely on written communication rather than verbal communication which, if necessary, can be later summarized in writing". Furthermore, "supervisors do not have sufficient time to be in the plant to directly observe and supervise the efforts of the work force"^[3].

Communication should not be limited to channels within a single organization. Lessons learned by any plant ought to be shared by the industry as a whole. The Report of the President's commission on the Accident at Three Mile Island pointed out that a memorandum, based on an earlier accident which bore strong similarities to the one at TMI, was written by a senior engineer of the Babcock & Wilcox Company. "He urged, in the strongest terms, that clear instructions be passed on to the operators. This memorandum was written 13 months before the accident at Three Mile Island, but no new instructions resulted from it". Such an observation indicates that, communication between organizations is important. It was not adequately addressed in the past, but INPO is improving the situations markedly.

3. Concluding Remarks

This paper introduces that the "safety culture" of the nuclear power industry is closely tied to its specific technology. Only through a thorough understanding of the licensee's knowledge of the response of plant systems and the potential consequences of accident sequences can one assign a proper measure to the importance of organization and management to plant safety. The safety culture consisting of 4 factors influences into the nuclear power plant safety. It can be also insisted that the plant safety assessed by PSA methodology can be improved by re-evaluating the frequency of the "other" category of failure scenarios, which is currently assumed negligible and by re-assessing probability distributions of the parameters such as failure rates, human error rates, and so forth to include these four safety factors.

REFERENCES

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