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Outage Management: A Case Study*

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Abstract

Outage management issues identified from a field study conducted at a two-unit commercial pressurized water reactor (PWR), when one unit was in a refueling outage and the other unit was at full power operation, are the focus of this paper. The study was conducted as part of the U.S. Nuclear Regulatory Commission's (NRC) organizational factors research program, and therefore the issues to be addressed are from an organizational perspective. Topics discussed refer to areas identified by the NRC as critical for safety during shutdown operations, including outage planning and control, personnel stress, and improvements in training and procedures. Specifically, issues in communication, management attention, involvement and oversight, administrative processes, organizational culture, and human resources relevant to each of the areas are highlighted by example from field data collection. Insights regarding future guidance in these areas are presented based upon additional data collection subsequent to the original study.

Background

Over the past several years, there have been increased concerns regarding the safety of nuclear power plant (NPP) operations during shutdown. The Diablo Canyon Power Plant event of April, 1987 [1], which involved the loss of shutdown cooling, highlighted the fact that the operation of a PWR at reduced inventory (i.e., midloop) presents a particularly sensitive condition. More recently, the Alvin W. Vogtle Plant incident of March, 1990 [2], involving the loss of all vital AC power, emphasized the need for risk management of shutdown operations. This need was further exemplified by the loss of shutdown cooling at the Prairie Island Plant in February, 1992 [3]. In addition, the NRC and some foreign nuclear regulatory organizations, including the French and Swedish authorities, have concluded that the core damage frequency for shutdown operation can be a fairly substantial fraction of the total core-damage frequency [4].

The concerns regarding operational safety during shutdown have focussed attention on improving safety during outage operations. The NRC has reported that identified weaknesses stem primarily from the false premise that "shutdown" means "safe" [5]. In order to resolve this false assumption, the NRC has initiated a series of efforts to address a number of issues regarding safety during shutdown operations. Key areas of evaluation included outage planning and control, personnel stress, improvements in training and procedures, technical specifications, and safety during mid-loop operation in PWRs.

Based on their evaluations, the NRC has concluded that outage management, with an emphasis on outage planning and control, is considered to be the most important issue related to shutdown risk. Outage management should establish if and when a plant will enter circumstances likely to challenge safety functions and, in the absence of technical specifications control, establishes the level of mitigative equipment to respond to such a challenge.

The management of a scheduled refueling outage is one evolution of a low power and shutdown activity that serves as a primary means of enhancing safety during shutdown. Managing risks and maintaining safety functions during a multitude of outage activities requires a clear understanding of the plants' safety philosophy, appropriate involvement of organizational levels, planning and coordinating, communication, and the awareness of plant status by the personnel involved in those activities [6].

As such, there are specific organizational factors which can influence the performance of the plant during this phase of operation, as significantly as they impact full power operation. The focus of this paper is the discussion of the specific organizational factors with respect to their influence on outage management as observed from a field study conducted at a commercial NPP.

Data Collection

The primary source of data for this paper was collected at a two-unit commercial PWR, when one unit was in a refueling outage and the other unit was at full power operation. Over a period of approximately four months, two individuals from Brookhaven National Laboratory (BNL) and a four-person team from the University of California at Berkeley (UCB) conducted the field research. The primary purpose of the study was to collect data for part of the NRC's organizational factors research program.

Several data collection methods were employed as part of the study. Most of the data discussed in this paper were collected through the use of interviews and observations of plant personnel and organizational activities. A paper and pencil survey was also administered across the plant and data regarding organizational culture and work environment issues were obtained.

Organizational Factors

Five organizational factors were identified as useful in describing the data collected concerning outage management. These factors are communication, management attention, involvement and oversight, standardization of work and skills, human resources, and organization culture. Each factor is discussed below in terms of the dimensions relevant to what was observed during the field research.

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Communication

Communication is a critical organizational process in a NPP during any phase of operation. With respect to outage management, there are several dimensions which are especially important. The first of these is **intradepartmental communication**. The status of outage activities and the support required from each unit for those activities must be clearly understood within all organizational units in the plant. Each unit in the plant that we observed had at least one representative involved on the outage management team. That individual would provide information to their unit concerning outage activities and facilitate intradepartmental communications.

A second dimension of communication perhaps even more critical to the planning and control of outage activities, is **interdepartmental communication**. This aspect of communication was greatly facilitated at the plant through the use of an Outage Control Center (OCC). The OCC is a facility created for the outage, located near the control room, with modules for each of the foreman assigned to the outage management team as well as the outage manager and administrative support. The OCC also had a conference area which was utilized for the twice daily outage meetings. Outage meetings addressed various topics including the plant status and ongoing and scheduled outage activities. The OCC provided a single location for work coordination and enhanced communication between departments.

Another effective tool for enhancing interdepartmental communication is the concept of High Impact Teams (HIT). These teams were put together with managers from various departments to handle tasks that are on or could impact the critical paths during the outage. Several HITs were assigned prior to the start of the outage. A HIT was created during the outage when an unanticipated task emerged that was on a critical path or would significantly impact a critical path if not resolved in a timely manner. The HIT is an interdisciplinary team developed to address a specific task. As a management tool, it represents the highest potential for coordination and communication of work.

The last dimension of communication to be considered is **external communication**. This type of communication is particularly important with regard to keeping the NRC informed of the status of the outage and any unanticipated events that emerge from the activities associated with the outage. External communication is also important with other NPPs that may have encountered similar problems during their outages, and with the vendors of the plant in the event additional assistance is required.

During our observations, an unanticipated event occurred during the course of the outage, which reflected the need for all of the dimensions of communication discussed. The eddy current testing of flux thimbles in the reactor vessel yielded results which indicated more wear on the thimble tubes than had been anticipated. This had the potential to delay the outage schedule and would require more resources than had been planned. Immediately, the vendor was contacted, several other NPPs that had had similar thimble tube problems were contacted, and by the next morning a HIT was assembled to initiate work on the problem. Within functional units, personnel were informed so that resources could be shifted to deal with the problem effectively. This particular unanticipated event provided an excellent case study opportunity for many of the organizational issues to be discussed.

Management Attention, Involvement and Oversight

In order to ensure the effective control of an outage, management attention, involvement and oversight must be evident. Critical management functions include decisionmaking for prioritization of goals, oversight through presence, clearly defining roles and responsibilities, allocating resources, including financial and personnel,

provisions for proactive outage scheduling and planning and developing a mechanism for organizational learning.

An important function for management during outage activities relates to goal prioritization. This is especially true in the situation when at a two-unit site, one unit is still at full power operation. Decisions will have to be made, trade-offs evaluated, and priorities set, if the operating unit develops a problem. Management needs to clearly identify the roles and responsibilities of units which are most impacted by outage activities, e.g., maintenance and engineering, especially if their limited resources are also required by the operating unit to a greater degree than had been anticipated during outage planning and scheduling.

Management presence in the plant is as necessary a function during an outage as it is during normal operations. Schedules are tight, time pressures are great, and the workload is constantly increasing. Personnel respond to management if they know that management is concerned and their presence in the plant provides that knowledge and adds an air of importance to whatever is going on. Management presence can also facilitate the outage management team in meeting the requirements it has placed on various organizational units over which it usually has little authority.

The empowerment of the Outage Manager in the plant is an important function for management during the outage. Unless organizationally recognized and located otherwise, the Outage Manager typically has a great deal of responsibility with little authority over the personnel involved in the outage. Often the Outage Manager has great difficulty in achieving the accountability of supervisors in the plant, since they normally do not report to this individual. This poses a significant challenge to the Outage Manager and emphasizes the importance of plant management attention, involvement and oversight to facilitate the empowerment.

Management involvement plays a key role in the resource allocation for the outage, which clearly impacts how the outage will be managed. Staffing levels are typically decided prior to the outage and include resources available at the plant, as well as contractor personnel from outside the plant. Within the plant, the personnel selection decisions play an important role in terms of whether experienced personnel will be utilized for the outage, or whether opportunities will be provided to less experienced personnel in participating in the outage. Clearly, the Outage Manager would prefer more experienced personnel that will be able to handle more difficult situations in more efficient and expedient ways.

As part of outage control and planning, management needs to be proactive in order to provide opportunities for extensive scheduling and planning prior to the start of the outage. Decisions need to be made as early as possible to allow the Outage Manager and the rest of the pre-outage management team to initiate their planning. Unanticipated work is usually planned to a certain level, but is typically the largest factor in delaying an outage schedule. Often work is scheduled into an outage at the last minute, and can cause extended delays during the outage because of insufficient planning and scheduling.

Finally, the most important function management can provide for maximizing outage performance by its attention, involvement, and oversight is a mechanism for organizational learning. Organizational learning refers to the degree to which individuals and the organization use knowledge gained from past experiences to improve future performance. This knowledge can come from within the organization itself, or from outside organizations with similar experiences. If the plant can capitalize on the lessons learned from prior outages, it will almost certainly be effective and succeed in meeting its new goals in future outages. Organizational learning, however, requires several processes within the plant, including effective communication, a

lessons learned and root cause analysis program on prior outages, resources to analyze the results, and an effective way to implement the changes necessary to enhance performance.

Standardization of Work and Skills

Identified as one of the most important characteristics of an operating NPP in previous work conducted by the senior author [7], the standardization of work and skills are also very important during an outage. The development, implementation and revision of procedures, as a mechanism to standardize work, is a critical aspect to outage planning and control. Once the outage has begun the process is a dynamic one, and the organizational influence of plant procedure review committees is pervasive. The volume of work during an outage is significantly higher than during normal operations, and the impact on procedures is similar. This was particularly true in our observations when the work involved design change notifications.

Another mechanism utilized to standardize work, was the formalization and centralization of outage work through the OCC. The OCC provided a focussed location from which work was initiated, implemented, and critiqued. It also served as a specified location in which resources necessary to complete work could be obtained or located.

Similarly the emphasis on standardization of skills is seen in the increased resources required for training of personnel. Training for plant access for contractor personnel, procedures required by vendor work, and quality control efforts are among the obvious areas that are impacted by outage activities. Within the management and professional development arena, a lot of training time was spent on team-building efforts.

One potential impact of the lack of standardization of work, evident during an outage, is due to the unavailability of technical specifications for equipment during shutdown. While the plant is in power operation, the rules governing the required availability for safety systems are very clear and well-defined. Once the plant is in a low power or shutdown condition, similarly defined standards do not exist which could potentially lead to higher risk conditions. This is an area in which priority attention is merited.

Human Resources

The impact of human resource issues on the management of an outage is significant. Conditions and situations were constantly observed which could potentially impact performance across all functional units and organizational levels within the plant. The most obvious and easily discernable example of this is the tremendous increase in workload. Not only is the increase obvious in the technical areas and the work requests, but the additional administrative procedures and documentation requirements impact the support staff as well.

Workload burden also contributes to the heightened stress among plant personnel. Although the pressures may vary across different organizational levels within the plant, their impact on personnel can be observed. In addition, in several cases, it was observed that organizational changes which had been implemented just prior to the start of the outage increased the pressure on certain individuals to ensure that the changes were being effected during the outage, as well as ensuring that all of the other time urgencies and milestones were met.

A significant human resource issue is the conflict that arises with the availability of overtime during an outage. Especially during difficult economic times, overtime during normal operations is usually minimized within a plant. During an outage, overtime is significantly increased as a mechanism to meet time urgencies in the outage schedule. Overtime is, of course, financially desirable to plant

personnel, and consequently, the potential for delaying the completion of an outage to maintain overtime availability is a concern of the outage management team.

The use of incentive programs to minimize the potential negative impact of the desirability of overtime was used at the plant we observed. At the plant we were observing, plant personnel received one vacation day for every five days under the scheduled outage completion date the plant achieved. Personnel could also cash in the days if they chose to. This program was not as effective as plant management would have hoped, but the outage was completed within a reasonable window of the plant's expectations.

Another important human resource consideration during the management of an outage is the large transient population of contractors that work at the plant. Efforts are made to rehire contractors that worked in the last outage and minimize the large cost in introducing new personnel into the plant, e.g., familiarization, access, and training.

Organizational Culture

The culture of an organization can clearly influence the behavior of the individuals working in that organization, consequently impacting personnel performance. From the work that has been conducted by the authors on the organizational culture of high reliability organizations, in particular, NPPs, there appears to be a consistent profile of the NPP culture during normal operations. The characteristics of this culture include a perfectionism in work, a critical and questioning attitude, and a level of competitiveness both within and outside the organization. Based upon our field research observations and the survey administration conducted as part of the research effort, these characteristics appear to exist during an outage as well.

Other dominant dimensions of culture which appeared in the survey data collected may be indicative of outage attitudes in this plant. Scores on scales measuring teamwork and achievement in work were higher than at another NPP which was not in an outage at the time we were there. This data supports the effectiveness of the efforts of the plant in the outage with their creation of the OCC and HIT concepts.

We also observed that decision-making and problem-solving in the plant during the outage was participative and collegial in nature. Management did not often act in an authoritative and hierarchical manner. These characteristics have recently been hypothesized to be effective for organizations that need to deal with unanticipated strategies in their operation [8]. Such circumstances were clearly observed during the outage as well.

One aspect of culture which needs to be addressed is the need for increased vigilance and awareness of plant status during the outage. Equipment unavailability is often encountered in the shutdown mode and personnel need to be aware of the characteristics which may be indicative of potential safety consequences.

Additional Data Collection

Observations and interviews at another two-unit NPP, a boiling water reactor, with one unit in a refueling outage and the other unit at full power operation, highlighted some of the observations just discussed. In particular, outage management at this second plant indicated the following organizational dimensions as important to the effective management of an outage:

- Management presence in the plant;
- Proactive planning and scheduling;
- Experienced personnel performing outage activities.

- Effective communication and coordination;
- Role of the first-line supervision accountability; and
- Organizational authority of the Outage Manager.

Conclusions

The results of the field research regarding the organizational factors that impact outage management seem to indicate that these factors are pervasive during an outage. Not surprisingly, they are factors which also have a significant impact on performance in a NPP during normal operations and are also hypothesized to be important during accident situations. As indicated from the research, some of the issues surrounding these factors have the potential to significantly impact the effectiveness of outage management.

The concepts developed by the plant that we observed to address some of these organizational factors appeared to work effectively. The OCC in particular was very useful in dealing with communication, management attention, involvement and oversight, standardization of work, and organizational culture issues. The HIT concept was also useful for facilitating communication, management attention, involvement, and oversight, and organizational culture issues. Incentives for time urgency seemed effective in dealing with potential negative human resource and organizational culture issues.

Based upon the field research and the additional data collection, it appears that concepts such as OCC, HIT and human resource incentives along with programs that would enhance organizational learning, proactive planning and scheduling, team-building and communication would greatly facilitate the effectiveness of outage management from an organizational perspective. Many of these programs probably already exist in the typical NPP and they need only be focussed on a different evolution of plant operation, that of low power and shutdown operation. The attitude that shutdown automatically means "safe" can no longer be acceptable.

References

- [1] U.S. Nuclear Regulatory Commission, "Loss of Residual Heat Removal System," (Diablo Canyon), NUREG-1269, Washington, D.C., June 1987.
- [2] U.S. Nuclear Regulatory Commission, "Loss of Vital AC Power and the Residual Heat Removal System During Midloop Operation at Vogtle Unit 1 on March 20, 1990," NUREG-1410, Washington, D.C., June 1990.
- [3] U.S. Nuclear Regulatory Commission Inspection Report No. 50-306/92-005, Prairie Island, Unit 2, "Loss of RHR (February 20, 1992)," Augmented Inspection Team Report, March 17, 1992.
- [4] U.S. Nuclear Regulatory Commission, "Shutdown and Low-Power Operation at Commercial Nuclear Power Plants in the United States," NUREG-1449, Washington, D.C., February 1992.
- [5] U.S. Nuclear Regulatory Commission, "Shutdown and Low-Power Operation at Commercial Nuclear Power Plants in the United States," NUREG-1449, Draft, Washington, D.C., February 1992.
- [6] Nuclear Management Resources Council, "Guidelines for Industry Actions to Assess Shutdown Management," NUMARC 91-06, Washington, D.C., December 1991.
- [7] Haber, S.B., O'Brien, J.N., and Ryan, T.G., "Model Development for the Determination of the Influence of Management on Plant Risk," Proceedings of the IEEE Fourth Conference on Human Factors and Power Plants, New York, NY, 1988, pp. 349-352.
- [8] Shurberg, D.A., and Haber, S.B., "Organizational Culture During the Accident Response Process," ANS Embedded Topical Meeting, Risk Management, Boston, MA, 1992.

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