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New Nuclear Plants Need to Adopt an Outage Management Mentality

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American Nuclear Plant "New Builds" Need To Adopt the Outage Management Mentality

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Abstract

The Japanese and Koreans have successfully mastered the construction of new nuclear plants in their respective countries. The secret to their success is four-fold. It involves mature engineering, painstaking planning, a continuous and unwavering team effort, and the nuclear mentality of blending quality into every step of their process instead of force-fitting it in at the end. Americans can learn much from the success of the Japanese and the Koreans concerning nuclear plant construction.

American nuclear operating companies have little experience with large construction projects, but they have successfully mastered refueling outages. While not the same order of magnitude, refueling outages are similar to construction projects in many important ways. Many interrelated activities must be completed in a short period of time in the same physical area. Over the decades, outages at American nuclear plants have been reduced from months to weeks. Intense coordination, focused management, high level of attention to quality, investments in training and operational concern are applied to every step of the outage management process resulting in smoother post-outage restarts.

The industry's lessons learned to create successful outage management parallel the methodologies used by the Japanese and Koreans in new construction. Successful completion for construction of new plants in the US will require utilization of lessons learned in outage management and in Japanese and Korean new plant construction.

This paper examines the processes that have resulted in successful management of American nuclear plant outages. It extrapolates those processes into new nuclear plant construction projects and validates the contribution of the processes by recognizing the successes of Japanese and Korean new build construction projects that continue to use these methods. It draws conclusions about how new nuclear construction programs should be structured in America.

Introduction

At the end of the first wave of nuclear construction there were a great number of failed projects. Of the 170 plants that were granted construction permits, only 126 were successfully completed, and of the successful completions, many experienced delays and cost increases from original estimates. The problem was so dramatic that Congress demanded that the NRC look into the causes of the problems. Although euphemistically referred to as Quality Problems, the real issue was out-of-control projects that failed to meet project performance goals for a variety of reasons. Leading factors included one-of-

a-kind or project specific details and layouts, regulatory enhancements, and design changes driven by lessons learned from operating plant failures.

The result of the NRC's review was NUREG-1055[1]. Although it was published in 1984, it is mandatory reading for any utility executive contemplating the construction of a new, GEN III+ reactor design. While the information is specific about projects long completed, the conclusions are as up-to-date and as instructive as if it was written today.

In summary, the report has two major findings: 1. prior nuclear design and construction experience of the collective project team is essential, and inexperience of some members of the project team must be offset and compensated for by experience of other members of the team, and 2. management can be overwhelmed and demoralized by increasingly numerous regulatory, design, and hardware changes mandated during the design and construction process. Of the two findings, the first is clearly the more applicable to today's projects. Although some of the legacy companies that designed and constructed nuclear plants in the first wave still exist in some fashion, none of them have current nuclear construction experience in the US. If one looks more closely into the implications of the first conclusion, NUREG-1055 makes the following observations of successful projects. They were found to have:

(1) Management commitment in the form of committed resources; financial and personnel

(2) A realistic and firm schedule

(3) Clear decision-making authority

(4) Flexible project control tools

(5) Teamwork

(6) Maintaining engineering ahead of construction

(7) Early startup involvement

(8) Organizational flexibility

(9) Ongoing critique of the project

(10) Close coordination with the NRC.

While these are not typical of many of the current operating plants' construction experience, they are hallmarks of nuclear plant operations for which there is a great deal of experience: outage management.

Discussion

Over the last couple of decades, US nuclear operating companies have successfully mastered outage management at existing nuclear plants in America. Two metrics that demonstrate this statement are increases in the capacity factor of all-American nuclear plants and the decreases in average duration of outages. Figures 1[2] and 2[3] represent the

[1] "Improving Quality and the Assurance of Quality in the Design and Construction of Nuclear Power Plants," A Report to Congress, U.S. Nuclear Regulatory Commission, NUREG-1055, March 1987
[2] NEI Source – Energy Information Administration, updated 4/09

capacity factors and the average number of outage refueling days for US nuclear plants. Figure 1 illustrates a marked increase in capacity from values below 50% to the current 2008 value of 91.5%. A major contributor to that increase in capacity factor has been the decrease in average refueling outage duration. Figure 2 illustrates the marked decrease in average outage duration from 104 days to the current 2008 value of 38 days. There are four not-so-secret secrets to the success of the nuclear power plant outages in America – complete engineering, planning, team spirit, and a culture of quality.

Figure 1 -U.S. Nuclear Industry Capacity Factors
1971 - 2008

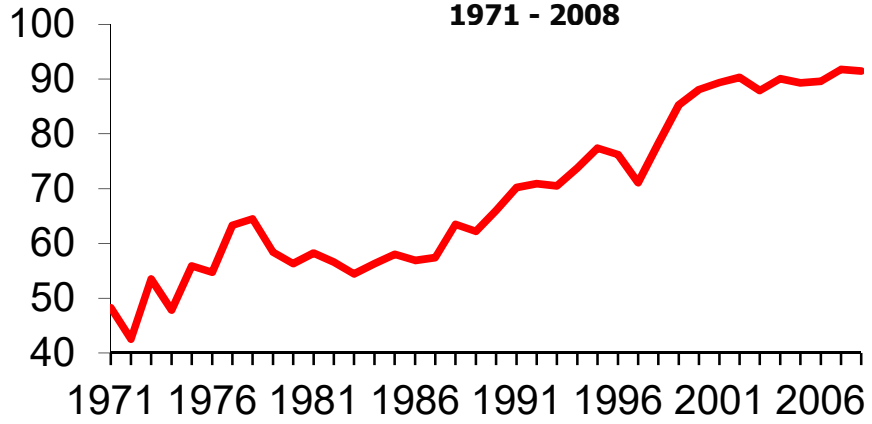
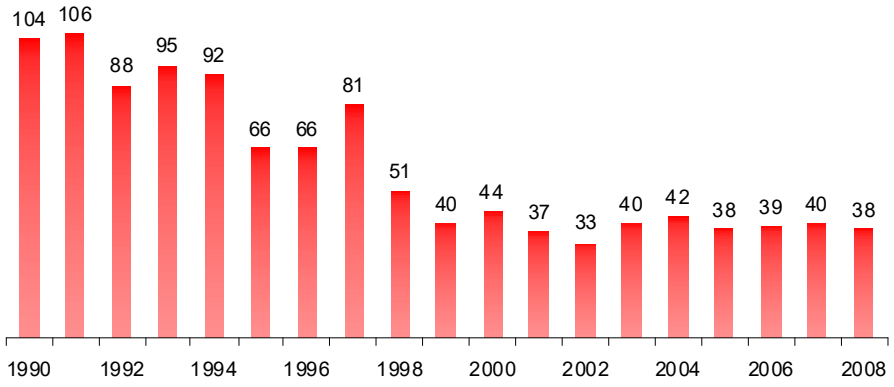


Figure 2 -U.S. Nuclear Refueling Outage Days - Average



[3] NEI Source – 1990-98 EUCG, 1999-2008 Ventyx Velocity Suite/Nuclear Regulatory Commission, updated 1/09

In order for a modification task to be included in the outage plan, all of the engineering needs to be completed well before the outage. Indeed, all procurement activities need to be complete and the materiel needs to be in the warehouse 3 to 6 months before the outage in order for the activity to remain in the outage schedule. This was not always the case and the predictable chaos that resulted from having an outage task being engineered on the fly was directly responsible for the adaptation of this rule generally across the operating nuclear plants. The early completion of engineering enables the proper planning of the construction and installation processes and is the first secret to success.

The reduction in the number of days a reactor is down for maintenance activities is inversely proportional to the amount of outage planning that occurred. In the early days little planning was undertaken in support of maintenance attempted during a refueling outage. "In the earlier years, mandated scope changes were often incorporated into the outage schedule before the engineering was complete. It wasn't unusual for engineering still to be underway even after the outage began."[4] In addition, the amount of maintenance activities was aggressive since little long range planning was done. It is true that amount of work scope has been reduced over the years to the minimum necessary to comply with regulations and other requirements. Regardless, plant managers are not only pre-planning a specific outage, they are intimately involved in 5 to 10 year (long-range) and 2 to 5 year (short-range) planning. The planning objective is to determine the scope and budget for future outages. The planning goal is to ensure the plant maximizes safety and operating capacity at the same time reducing personnel dose and minimizing unplanned cost expenditures. Rigorous planning for individual outages is now the norm in the industry and is the second secret to success. In fact, soon after a specific outage is complete and the paperwork wrapped up, engineering and planning for the next outage begins.

This rigorous planning is perhaps best illustrated at Entergy's Indian Point Energy Center, which is a two-unit site. Each year in the spring, an outage is executed. Both units are on a 24-month fuel cycle, which are staggered by 12 months. When the outage for one unit is complete, outage planning immediately begins on the other unit. Because an outage is occurring every year, the planning process is continuous and considered business as usual.[5]

The outage management planning process took on a life of its own across the nuclear complex both in the US and abroad. Early on plant managers were struggling to perform maintenance activities using the limited plant resources and plant procedures. In response to the concerns of plant managers, the Institute for Nuclear Power Operations (INPO) prepared and released best practice guidelines specifically for outage activities. In 2002, as a follow-up to a series of technical publications related to good practices for outage management and cost effective maintenance published in 1989, 1991, and 1997, the International Atomic Energy Agency (IAEA) produced a more focused technical report[6]

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[4] Power Engineering, Nuclear Power Plant Outage duration Continues to Decline, Teresa Hansen, Senior Editor, August 2008, (statement by Peter Kopyscianski, URS Director of Nuclear Construction

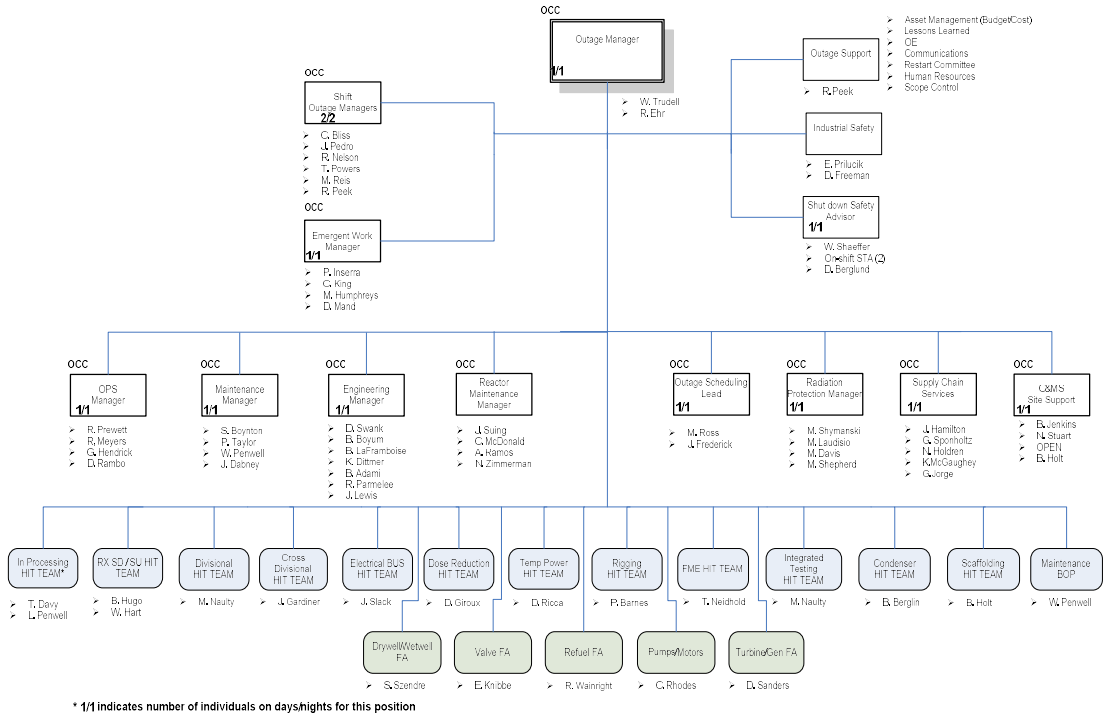
[5] Email to Charles Hess from Robert Nicholas, "Indian Point Outage Experience," 8/26/09

[6] IAEA, Nuclear Power Plant Outage Optimization strategy, IAEA-TECDOC-1315, October 2002

on good practices. British Energy[7] has been implementing a new 24-month outage planning process, which owes much to the procedures used by Exelon in the United States and by other utilities around the world. The British Energy outage preparation process is intense, having 64 milestones and three "Go/No Go Gates" for planning.

The third secret, fostering a team spirit, is more difficult to quantify but clearly as important as planning. In addition to the explosion of guidance documentation that has become available to plant managers, resources (outage management teams) have been carved out of the plant's personnel whose specific duties include the planning and execution of outages. Contractors who specialize in supporting refueling activities as well as those who specialize in large component replacement have helped to both shorten outages and enhance the outage management process. Outage plant personnel and contracting personnel come together as a team with one goal in mind – safely execute the outage plan as efficiently as possible within budget and schedule. Figure 3[8] illustrates the complexity of a modern outage organization. The lower 18 organizational groups are the additional outage team for the Columbia Station's 19th refueling outage, recently completed. Most of these outage organizational units were staffed either entirely or in part by contractor personnel, all of whom worked to an integrated outage schedule, for an intense period of time to achieve all of the activities planned for the outage.

Figure 3
R19 Outage Organization



[7] New Outage Preparation Process Set Out at British Energy's Hinkley Point B, Dick Kovan, Nuclear News, April 2008

[8] Email from W. Glenn Edmonds, Energy North West to M. F. Chrostowski, "Additional Org Chart," August 11, 2009

Outages seldom revolve around refueling activities only and just as seldom around performing a single maintenance activity in addition to refueling. Outages typically consist of multiple maintenance activities or "projects" being executed in addition to the standard refueling activities that occur during every refueling outage. Depending upon the amount of work being completed, the result is the outage is executed using plant personnel, the general site engineer, the general site maintenance constructor and additional contractors, as needed, to support major capital improvement modifications.

For example, Florida Power & Light Company's St. Lucie-2's 17th refueling outage started on September 30th, 2007 and ended on January 4th, 2008. Planning began in spring 2005. The work accomplished during the outage, consisting of 16,535 activities, represented an investment of more than $300 million in capital improvements.[9] Keeping in mind that the 38 days for an outage is an average, it would not be possible to better that average if the outage personnel did not behave as a cohesive team. It is not unusual to share resources across "projects" during an outage to help facilitate meeting the overall schedule. It is also not unusual for a plant to have several hundred workers executing the outage plan during a refueling. One cannot be naïve enough to think that plant personnel and contractors are on-site just for the glory of it all. Though, as one might expect, contractors perform their work with a keen eye on the bottom line, a spirit of cooperation is clearly present in the well-executed outages.

Continuity of supervision and management provided by alliances and teamwork between utilities and maintenance contractors is another key factor in successful outage management. The nuclear mentality of the culture of quality permeates the operating nuclear plants procedurally, organizational and professionally. Most of the outage workers who augment the operating company's staff during outages are drawn from a dedicated set of specialty contractors with experienced personnel who are steeped in the culture of quality that is the nuclear industry. It is a rare outage worker who has never worked at a nuclear plant before. This experience base is partially responsible for the improvement in nuclear outages.

The nuclear mentality is primarily adherence to a culture of quality, the fourth secret to success. Everything about the nuclear mentality alludes to personnel training and processes in place that ensure quality manifests itself in each step rather than force-fitting quality in at the end almost as if it were an afterthought. In essence, one uses the assessment and inspection process to confirm a job well done rather than invariably to capture last minute any flaws or failures. One clear example of outage management possessing a culture of quality can be seen in the Foreign Material Exclusion Program implemented during every outage. This program's sole objective is to ensure material does not end up where it does not belong. The goal of the program is to ensure that plant startup is smooth and without incident. Another example of the culture of quality is the extensive training required prior to an outage to ensure personnel are capable of doing the work to be performed. Coupled with the training is the real-time confirmation (done at the beginning of each shift) that a specific worker is qualified to perform a specific task prior to actually performing that task.

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[9] Steam Generators, Rector Head Changed Out at St. Lucie-2, Rick Michal, Nuclear News, April 2008

Conclusion

The nuclear industry has mastered the art of refueling outages. The secrets to success are engineering completion, planning, fostering a team spirit, and a culture of quality. These attributes are the hallmarks of refueling outages in the US now and make the American nuclear plants some of the best operating facilities in the world. So the lessons of performing a successful refueling outage have been mastered, and result in 18-month planning cycles for one-month events.

Cost estimates to engineer and construct new build nuclear plant are in the range of $7 billion with baseline schedules of 54 months, representing an average cash flow in excess of $30 million a week for four-and-one-half years. Therefore, it is prudent for nuclear licensees to exert proportional effort in ensuring complete engineering, planning, developing team spirit and expectations of quality for a new build as used in every cycle for their outages.

The lessons of the past must serve as guides for our future. Repeating the mistakes of the past will most certainly result in the same outcome. More importantly, repeating the steps that led to success in the past, provide valuable insights to the course that leads to successful construction projects. The lessons of leadership, clear lines of responsibility and authority, teamwork, thorough and complete engineering and planning will lead to success. This requires the dedication of resources early in the process and it requires the active risk management program to accommodate the enormous risks associated with a mega-project such as a new nuclear plant.

Below are the steps to ensure new American nuclear plant licensees adequately adopt the outage mentality:

- Incorporate relevant lessons-learned from NUREG-1055 into all project planning
- Ensure the project organization is structured and focused with clear lines of responsibility that are well documented and clearly understood.
- Continually challenge the validity of the organization's capabilities by evaluating actual problem-solving durations against pre-established guidelines similar to those in place during outage execution.
- Foster a team spirit at the very beginning of the project that continues throughout each phase, ensuring real-time feedback from team players is encouraged, evaluated and incorporated into the project organization
- Establish minimum standards for qualifications and experience for all positions and develop a corresponding training program to ensure those positions are filled from within existing organizations whenever possible. When not possible ensure the new hires meet the minimum standards for qualifications and experience.
- Track the quality of all deliverables and evaluate the work completed against the validity of the schedule making continuous adjustments to remaining scheduled work to reflect lessons learned. This will also provide feedback to needed changes in the training program.

- Develop ONE detailed integrated resource-loaded schedule that covers all phases of work, created with input from all relevant organization leads, but controlled by the licensee such that schedule milestones are treated as firm achievable commitments to stakeholders