EM-53 Lessons Learned Bulletin

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Lessons Learned on Commercial Nuclear Power Plant Uprate Modifications

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Statement:

When a commercial power plant is licensed by the Nuclear Regulatory Commission, it is limited to a specific maximum power. This limit is based on the design and safety analyses of the reactor core's heat output and corresponding power level. Major modifications, or Extended Power Uprate (EPU) projects are undertaken at some operating commercial nuclear power plants to increase their power output.

EPU projects at nuclear power plants deliver significant benefits to utilities and to the communities that receive the electricity output. These uprate projects increase power capacity from existing facilities and modernize the plant in a fraction of the time and at significantly less cost than having to build a new power plant. As of mid-2014, 154 NRC-approved power uprate projects have resulted in an increase of over 7,000 MWe (megawatts electric) which is equivalent to adding electricity generation from seven new nuclear power plants at a significantly less cost and in a relatively short period of time.

Many of the lessons learned from these major construction modification projects can be applied to Department of Energy (DOE) projects, specifically emphasis on use of complete design engineering and planning, use of highly skilled labor, and use of efficient tools and processes.

Discussion:

These uprate projects are major projects and are very complex. They involve removing large components such as reactor vessel heads, turbine generators, condensers, steam generators, control systems, tubing, etc. and replacing with new components. The timeframe is condensed usually in consonance with planned outages to minimize downtime. These are very resource intensive projects with tight scheduling and activity planning required.

These uprate projects result in plant capacity increases as high as 20 percent. This major construction activity, like large DOE construction projects, require that highly detailed and complex planning is performed in order to meet schedule while maintaining the appropriate safety and quality standards. For commercial utilities, as well as for DOE field office management, a focused effort and approach, as well as appropriate staffing and process are needed to ensure that projects are successful in meeting stakeholder demands and project objectives and milestones. Similarly, DOE major projects have significant stakeholder requirements and milestones, and in some cases are enforced through regulators (EPA, State Environmental regulators, consent orders, Record of Decisions, etc.). DOE has specific regulatory milestones, and in cases of one-of-a-kind projects, must design, construct, and commission these facilities with limited previous experience.

Analysis:

Most large construction projects with complicated scopes, like EPUs and like many DOE construction projects (e.g., Waste Treatment Plant (WTP), Salt Waste Processing Facility (SWPF)), Low Activity Waste Pretreatment System (LAWPS), Portsmouth On-Site Waste Disposal Facility Cell 1, and Calcine Disposal Project) are extremely complex and challenging to successfully complete. EPU projects, unlike most DOE projects, are perhaps even more complex because modifications are being made to one operating unit while other nuclear units in the vicinity continue to operate. Focus must be maintained so that issues with the EPU project does not affect the operation of other units since that could cause a loss of power to the utilities' customer base.

Challenges associated with EPU projects, again similar to DOE project, is the necessity of having a large team of skilled and experienced staff, both manual and non-manual laborers. This problem has been encountered in the DOE complex as well, as major contractors have had trouble finding large numbers of skilled workers to relocate to some of the DOE sites such as Hanford, Idaho National Laboratory and the Savannah River Site. In addition, schedule pressure, similar to DOE projects, can be intense, perhaps more so for EPU projects since most of the construction is done during a power unit outage. Once again, detailed planning to ensure that the correct number and skill mix of resources are available to support the schedule is required. Construction schedules should be carefully generated such that multiple tasks in the same physical area are not planned which could cause a stack up of construction trades and activities. These same issues have been found at the WTP and SWPF, where significant amount of work, especially installing process piping, is done in a confined area. Finally, training of staff including the use of simulation activities where appropriate, is needed prior to the commencement of construction activities.

Actions:

The following are lessons learned from EPU projects and discussion of how they relate to major nuclear construction projects by DOE:

1. Ensure that the integration of engineering, procurement, and construction is well-coordinated so that detailed engineering and planning have been done before construction begins
   a. Ensure large and critical equipment arrives on time and has the proper quality assurance inspections performed.
   b. Use a team that is well-trained on tools and processes to enable seamless construction so as not to disrupt other operating units.

DOE has further reinforced this in the October 26, 2015 memo from the Principal Deputy Assistant Secretary for Environmental Management (EM) on "Project Management Policies and Principles". The memo requires that DOE EM projects building Hazard Category 1, 2 or 3 facilities must achieve at least 90% design completion prior to authorization of construction. For non-nuclear construction projects, a Design Plan must be prepared at project initiation to define anticipated levels of design maturity at each Critical Decision (CD) to achieve at least an 80 percent confidence level at CD-2.

2. Use appropriate staffing
   a. Ensure that the correct quantity of laborers needed are properly trained and have appropriate skills.
   b. Ensure that safety and security are paramount since much of the construction work is being done in congested spaces

DOE Order 413.3B, Program and Project Management for the Acquisition of Capital Assets, is the order that controls major construction projects for the Department of Energy. This order requires that at the appropriate Critical Decision for a major project, that a staffing estimate is performed. DOE Guide 413.3-9, Staffing Guide for Project Management, provides direction in preparing staffing estimates. In addition, on major projects, more detailed and extensive staffing estimates have been performed.

3. Prepare for the unexpected due to the inability to fully determine all existing conditions of an operating plant and its equipment
   a. Design for flexibility based on the physical conditions that are found during discovery
   b. Utilize other design alternatives that can be quickly implemented while meeting plant requirements and maintaining safety.
   c. Plan for validation of physical conditions as early as possible to allow for design corrections to be made without affecting the overall schedule.
   d. Utilize an "issues manager" on site whose sole purpose is to oversee issues so that other project and site managers can focus on moving the project forward.

The DOE Memo on Project Management Policies requires that a responsible program office must conduct an independent analysis of alternatives (AoA) for ensuring that the proper technology is selected. In addition, there is a requirement for projects greater than $750M, or first-of-a-kind projects must undergo a Technology Readiness Assessment and achieve a minimum Technology Readiness Level at certain Critical Decision points to ensure that there is good level of certainty with the use of a particular technology. These requirements are intended to prevent unexpected issues arising from the use of new technology on major projects.

At complex DOE construction projects, such as WTP, SWPF or IWTU, the idea of using an "Issues Manager" seems like a role that could be very effective for field site to utilize.

4. Combine effective tools and processes
   a. Use specific daily schedule and cost reports to help the team pinpoint potential issues quickly so that they can be escalated and dealt with swiftly.
   b. Use an experienced team that is skilled at the flexible application of their tools and processes
   c. Ensure that effective monitoring programs have been implemented to help decrease errors
   d. Ensure that proper training for situational awareness, self-checking, procedure use and adherence, and effective communication

Major DOE projects require the use of Earned Value Management System (EVMS) for cost control and an Integrated Master Schedule (IMS) for schedule control. The use of these tools and their federal oversight are frequently reviewed during periodic peer reviews.

Critical Decision(s): CD-1 to CD-4

Facility Type(s): All

Work Function(s): Project Management, Engineering, Construction, Operations

Technical Discipline(s): All

Calvert Cliffs in Maryland was the first US nuclear power plant to implement an uprate

Carpenters loading a scaffold cart during the St. Lucie nuclear EPU project

References:
1. Laszlo Von Lazar, "Lessons Learned from Successful Nuclear Uprate Projects" Power Engineering Magazine, August 12, 2013.
2. "Backgrounder on Power Uprates for Nuclear Plants" United States Nuclear Regulatory Website, April 2014.
3. Will Davis, "Nuclear Power Uprates: What, how, when, and will there be more?", American Nuclear Society, Nuclear Café Website, June 26, 2014.
4. Memorandum from Mark Whitney, Principal Deputy Assistant Secretary for Environmental Management, to Distribution, "Project Management Policies and Principles", October 26, 2015.