EM-53 Lessons Learned Bulletin

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NRC Lessons Learned From Early Construction

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Statement:

The Nuclear Regulatory Commission (NRC) regulates the civilian uses of nuclear materials in the United States to protect public health and safety, the environment, and the common defense and security by licensing nuclear facilities and the possession, use and disposal of nuclear materials. The NRC issued NUREG 1055, "Improving Quality and the Assurance of Quality in the Design and Construction of Nuclear Power Plants," in May of 1984 (Reference 1). In December of 2009, the NRC issued a follow on lessons learned discussion based on the findings of NUREG 1055 entitled, "NUREG 1055 - Then and Now," (Reference 2) detailing the application of the lessons learned over the past twenty plus years of nuclear construction work in the United States. One project used as the basis for the 1984 report was the William H. Zimmer Power Station, located in Moscow, Ohio. Construction of this project was estimated at one point to be 97 percent complete, but poor construction and quality assurance led to the plant being converted to coal-fired rather than nuclear power generation. This discussion found that the same deficiencies were noted in 1984 as in 2009, including inadequate documentation, reporting of nonconformances, procedures and instructions, licensee audits, specifications, and corrective action programs, as well as drawing deficiencies, materials control deficiencies, and procedure violations. Other more recent nuclear projects, including Frances' European Pressurized Reactor (EPF) at Flamanville, Normandy, and the Okliuoto 3 Reactor in Eurajoki, Finland, have experienced delays due to construction quality issues. Three large DOE nuclear construction projects, the Salt Waste Processing Facility (SWPF) and the Mixed Oxide (MOX) Fuel Fabrication Facility at the Savannah River Site, and the Waste Treatment and Immobilization Plant (WTP) at the Office of River Protection, have also experienced such delays.

Discussion:

NRC discovered the same deficiencies in nuclear construction projects were occurring in 2009 as noted in NUREG 1055 from 1984. The majority of these deficiencies were related to vendor oversight, quality control, and implementation of NRC requirements. The cost of these deficiencies resulted in the cancellation of the Zimmer plant's construction as a nuclear power plant, as the project was nearly $2 billion over budget after 10 years of construction. These deficiencies were largely due to inexperienced vendors, poor specifications, insufficient quality assurance personnel, and inconsistent understanding and implementation of NRC requirements for commercial grade dedication and 10 Code of Federal Regulations (CFR) Part 21. The startup of France's EPF project has been delayed for over four years, with costs rising from $4.2 million to over $11 million over the period of construction. Inadequate construction quality oversight resulted in a quarter of the welds in the steel liner not being in accordance with welding norms, and cracks were been found it the concrete base (Reference 3). The Okliuoto 3 Reactor also experience welding and concrete quality issues, resulting in construction delays beyond the June 2012 delivery date forecast at the beginning of construction (Reference 4).

Large DOE nuclear construction projects have also experienced issues with quality and construction oversight. SWPF, originally estimated to cost $900 million and be completed in 2009 has experienced issues with vendor quality, contributing over to construction completion. Cost and schedule overruns were largely due to delays in manufacturing and delivering 10 large processing vessels. Quality issues with the original vessels required a new vendor to be selected, and the construction timeline was revised upon receiving the new vessels, with the final project cost now expected to exceed $2 billion and completion delayed until at least 2018 (Reference 5). Also at the Savannah River Site is the MOX Fuel Fabrication Facility, which has also experienced delays and cost overruns due to vendor quality issues regarding faulty rebar. Shortly after construction started, a construction worker attempted to shape a steel bar important to the reactor's safety when it broke instead of bent. That event set off an investigation leading to the contractor to return of 935 tons of rebar, supplied by a subcontractor whose work had not been inspected and didn't meet federal standards for nuclear construction. Another 135 tons of rebar were diverted to other uses and 14 tons already embedded in concrete were allowed to remain in place after special inspections by the NRC. Fixing the problem cost more than $680,000 (Reference 6). Finally, the WTP project experienced several construction quality oversight issues which resulted in costly rework and procurement changes. For example, the contractor ordered approximately 70 tanks with incorrect structural specifications to ensure the quality of their welds. These tanks, that will be located in inaccessible areas of the waste treatment plant, were in various stages of fabrication. Had this problem not been identified, the quality of welds for all of these tanks could have been flawed. One tank had already been installed using these incorrect specifications before the problem was discovered. The tank was installed because neither the supplier nor contractor had performed the required weld inspection. Furthermore, when the welds were first repaired the subcontractor used incorrect welding rods, requiring more rework to repair the repairs (Reference 7).

Analysis:

The failure of the Zimmer Nuclear Station construction project was determined to be related to several factors:

- Cincinnati Gas & Electric was a first time nuclear plant owner, and therefore did not have experience overseeing a nuclear construction project
- Kaiser Company had no nuclear construction project experience, and was unfamiliar with the regulatory and nuclear quality assurance requirements
- Evolving regulatory framework over the ten year construction lifecycle required design modifications after the start of construction
- An overall informal and undisciplined approach to construction oversight

Additionally, the NRC noted that there was a mindset that there was no immediate threat to public health until a plant became operational. Also, programs tended to categorize nonconformances to the lowest action levels, resulting in inadequate oversight and awareness by construction management and nuclear safety personnel. NRC personnel also had not yet standardized inspection procedures, which often relied on the inspector's engineering judgment. Implementation of nuclear safety and quality assurance programs varied across regions and were dependent on regional management approach and individual knowledge. Inspectors quality assurance knowledge and inspection skill was insufficient, and often focused on activities other than construction quality. Finally, NRC's regulations did not address the legal base for direct NRC inspection of vendors, and the vendor inspection program did not include material manufacturers or suppliers, which were the sources of many problems during construction.

To address the issues, NRC implemented the following responses to the lessons learned:

- Establish a near-constant onsite presence to conduct direct observations of construction activities
- Apply more attention to design activities, including requiring NRC staff to inspect and review design adequacy as early as receipt of the licensing application.
- Minimize diversions of inspectors for the purpose of investigating allegations, including developing guidance to evaluate the significance of findings and apparent violations to ensure clear and consistent conclusions
- Strengthened enforcement to encourage conformance to commitments
- Enhanced capabilities to detect QA program breakdowns, including unscheduled inspections to address emergent issues
- Establish in-process QC inspections for on-going construction activities, including developing an inspection schedule management tool which facilitates inspector observations of critical activities

Actions:

The lessons learned from NUREG 1055 and those from the Zimmer Nuclear Power Station can be applied to any DOE construction project, not just nuclear facility construction:

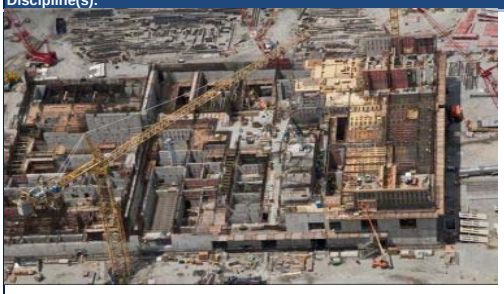
- Select contractors with appropriate experience for the scope of work required
- Implement quality assurance programs early in the project, to include preliminary design and permit applications
- Develop a positive working relationship with oversight organizations including NRC, Defense Nuclear Facility Safety Board, the U.S. Environmental Protection Agency, and state regulatory agencies
- Perform regular and stringent design and construction quality assurance inspections
- Inspect all areas of the project for quality assurance, including vendors and subcontractors
- Enforce all quality standards uniformly across the complex
- Consider utilizing independent verification programs to ensure performance meets quality standards

Critical Decision(s): All

Facility Type(s): Nuclear

Work Function(s): Acquisition, Project Management, Construction

Technical Discipline(s): Quality Assurance, Construction Oversight, Regulatory Compliance



LEFT: Construction on the NNSA's Mixed Oxide Fuel Fabrication Facility in 2010 (Reference 6).
CENTER: The reactor building dome of Okliuoto 3 was installed in September 2009 (Reference 4).
RIGHT: The Zimmer Power Station (Reference 8)

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