Performing Criticality Analyses for Streamlined Regulatory Review

Summary

EPRI research supported the development of technical basis and guidance for performing criticality analyses associated with fuel type changes, enabling reduced review time and costs associated with license amendment requests. Similar license amendments historically have required long preparation times followed by an extensive regulatory review process. With the new guidance and accompanying technical basis, regulatory acceptance by the U.S. Nuclear Regulatory Commission (NRC) has enabled review fees to be reduced by two-thirds (from about $1.5M USD to $0.5M USD). Notably, much of the data used to support the technical basis has been reviewed by international standards organizations, supporting broader application of the guidance.

APPLICABILITY

All nuclear plants using spent fuel pool absorbers that are updating criticality safety analyses for the introduction of new fuel types.

VALUE

U.S. nuclear plants have reduced **regulatory review fees from about $1.5M to $0.5M** through regulatory acceptance of EPRI guidance.

EPRI PROGRAM

Used Fuel and High-Level Waste

Example – Member Application

To date, three U.S. nuclear plant owners have successfully used the EPRI guidance in conducting criticality safety analyses. The resulting impact is detailed in the "Value" section of this document. Several other U.S. and non-U.S. utilities have expressed interest in the approach and are preparing to implement when needed for future criticality analyses.

Background

Spent fuel pool criticality safety analysis (CSA) historically had been fairly simple since it only depended on the distance between fuel assemblies. With the need for increased storage space in spent fuel pools, however, the distance between fuel assemblies was reduced and neutron absorber materials were introduced to control criticality. Moreover, some plant owners had spent fuel pools with multiple absorber materials, of varying vintage and type. These factors increased the complexity of CSA, resulting in significant increases in application preparation time and regulatory review time. Guidance and consistency were needed for the applicants and reviewers.

Specific to U.S. nuclear power plant operators, they had been relying on an NRC memo (called the "Kopp memo") to characterize depletion uncertainty. Around 2009, the NRC staff challenged the technical basis for 5% reactivity decrement recommended in the Kopp memo, suggesting a possible move to a higher allowable reactivity decrement. Such a move would have had significant impacts on nuclear plant owners, limiting the flexibility in spent fuel pool storage operations.

EPRI's Role

EPRI research results captured in reports 3002016035 (*Benchmarks for Quantifying Fuel Reactivity Depletion Uncertainty-Revision 1-A*) and 3002017254 (*Utilization of the EPRI Depletion Benchmarks for Burnup Credit Validation-Revision 2-A*) directly informed regulatory reconsideration of the uncertainty assumption when evaluating credit for reactivity reduction due to depletion of fissile isotopes and buildup of fission product absorbers. The EPRI research also provided a best estimate value for the depletion uncertainty as a function of burnup. In addition, EPRI report 3002008197 (*Sensitivity Analyses for Spent Fuel Pool Criticality–Revision 1*) documented a number of sensitivity

analyses to address additional regulatory questions. This work was incorporated into guidance and a checklist that industry and the U.S. NRC used to ensure standardization of analyses and focus reviews on non-standard items.

In addressing the 5% uncertainty assumption, EPRI developed benchmarks based on flux map data from four reactors and 44 cycles. These benchmarks validated the 5% reactivity decrement and supported a determination of conservatism in the estimate, i.e., additional margins exist. The flux map data has significantly less measurement uncertainty than an alternate chemical assay approach that was being considered.

EPRI led the regulatory review process for the benchmarks and provided significant support for criticality guidance review. The regulatory review process included more than 20 public meetings, response to multiple rounds of RAIs for EPRI benchmarks and guidance, and two NRC audits.

After regulatory review, the EPRI benchmarks were approved via safety evaluation report (SER) and the approach proposed through an industry initiative coordinated through the Nuclear Energy Institute (NEI 12-16, *Guidance for Performing Criticality Analyses of Fuel Storage at Light-Water Reactor Power Plants*) was approved via Regulatory Guidance (RG 1.240). RG 1.240 cites the EPRI benchmarks for technical justification for using the Kopp memo. The EPRI benchmarks have also been reviewed by the OECD/NEA International Reactor Physics handbook for Benchmark Evaluation (IRPhBE) Working Group and approved for inclusion in the IRPhBE Handbook, supporting their use outside the U.S. as well.

IMPLEMENTATION GUIDANCE

EPRI benchmarks are now the technical basis used to validate reactivity decrement and support additional margin extraction when addressing depletion uncertainty. Utilities worldwide using spent fuel pool absorbers can reference this technical basis with their regulator to address CSAs associated with new fuel types. Due to acceptance by the U.S. NRC, U.S. nuclear utilities can simply refer to EPRI reports as the technical justification in performing their CSAs.

Furthermore, since many international regulators follow the U.S. NRC, the guidance can be used by many other countries. If necessary, the checklist that EPRI developed to support CSA execution could be adapted for use in other countries by conducting a cross-comparison with that country's regulations.

EPRI subject matter experts can serve as a technical resource for answering questions regarding the EPRI guidance and its applicability to other regulatory environments.

Value

Of the three U.S. nuclear plant owners that have successfully used the EPRI guidance in conducting criticality safety analyses, one utility noted that a decade ago, license amendments to allow use of rack inserts for criticality control at three sites would have averaged 40-50 requests for additional information (RAI) per application, but with the new guidance, a recent instance resulted in fewer than 10 RAIs across the three applications. Moreover, similar license amendments from a decade ago resulted in about $1.5M USD in regulator review fees; with the new guidance, regulator review fees have been reduced by two-thirds. A second utility reported only two technical RAIs for one plant, both of which were easily resolved, and approval in just 254 days, the shortest review time the regulator has ever spent on a full criticality safety analysis. This utility also noted that as a single-unit fleet, they cannot maintain a criticality specialist on staff and have to rely on vendor support to perform the CSA. The guidance and checklist provided the background and depth required for member personnel to become knowledgeable and efficiently monitor vendor work.

The third nuclear plant owner had no RAIs, despite receiving more than 90 RAIs in a submission prior to the guidance.

To support more effective technology transfer, EPRI is tracking implementation of key R&D activities.

Please access this link to provide input on your company's use of this particular research: https://www.surveymonkey.com/r/Q9R66GY

Access additional Value Guides and examples of EPRI R&D application at: https://interactive.epri.com/nuclear-value/p/1

Resources

- 3002016035, *Benchmarks for Quantifying Fuel Reactivity Depletion Uncertainty-Revision 1-A*
- 3002017254, *Utilization of the EPRI Depletion Benchmarks for Burnup Credit Validation-Revision 2-A*
- 3002008197, *Sensitivity Analyses for Spent Fuel Pool Criticality–Revision 1*
- NEI 12-16, *Guidance for Performing Criticality Analyses of Fuel Storage at Light-Water Reactor Power Plants*
- Support from EPRI subject matter experts

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