UNITED STATES
NUCLEAR REGULATORY COMMISSION
ADVISORY COMMITTEE ON REACTOR SAFEGUARDS
WASHINGTON, DC 20555 - 0001

June 19, 2017

Mr. Victor M. McCree
Executive Director for Operations
U.S. Nuclear Regulatory Commission
Washington, DC 20555-0001

SUBJECT: DRAFT SAFETY EVALUATION OF PWROG-14001-P, REVISION 1, "PRA MODEL FOR THE GENERATION III WESTINGHOUSE SHUTDOWN SEAL"

Dear Mr. McCree:

During the 644th meeting of the Advisory Committee on Reactor Safeguards, June 7-9, 2017, we met with representatives of the NRC staff, the Pressurized Water Reactor Owners Group (PWROG), and Westinghouse Electric Company to review the draft safety evaluation for topical report PWROG-14001-P, Revision 1, "PRA Model for the Generation III Westinghouse Shutdown Seal." Our Reliability and PRA Subcommittee reviewed this matter during a meeting held on February 6, 2017. We also had the benefit of the referenced documents.

CONCLUSIONS AND RECOMMENDATIONS

1. The staff should issue the safety evaluation on topical report PWROG-14001-P, Revision 1, after addressing Recommendations 4 and 6 below.

2. Bayesian methods and the seal performance test results are used appropriately to derive failure rates for the shutdown seals.

3. The logic structure of the proposed event tree and fault tree models is adequate to evaluate the frequency and consequences of event scenarios that challenge operation of the shutdown seals.

4. The safety evaluation should state explicitly that the hourly failure rates derived from the Bayesian analyses are appropriate for use in all applications of the proposed models, but unavailability estimates derived from a nominal 24-hour mission time apply only for evaluations that use those specific success criteria.

5. We concur with the staff's condition that licensees with Model 93A reactor coolant pumps shall include failures of the seal assembly O-ring in their models for the shutdown seals.

6. The staff should re-examine the quantitative bases for the PWROG conclusion that inadvertent actuation of the shutdown seal can be omitted from the PRA models.

BACKGROUND

Probabilistic risk assessments (PRAs) have shown that scenarios which involve loss of all cooling and consequential failures of reactor coolant pump (RCP) seals are important contributions to the risk at many pressurized water reactor nuclear power plants. Confidence that the RCP seals will remain intact is an important element of plant-specific event response strategies.

In response to these crucial needs, Westinghouse has developed the Generation III shutdown seal as an additional protection for their RCPs. The shutdown seal is activated passively if a loss of all normal seal cooling occurs. It is designed to limit reactor coolant leakage through the existing hydrostatic seals to less than one gallon per minute. Operator action is not needed other than to ensure that the RCP is tripped in a timely manner.

In 2014, the NRC staff endorsed Westinghouse technical report TR-FSE-14-1-P, Revision 1, "Use of Westinghouse SHIELD® Passive Shutdown Seal for FLEX Strategies" and accepted use of the Generation III shutdown seals in evaluations to be performed for compliance with Order EA-12-049. The technical report describes the Generation III seal design, and it summarizes testing that was conducted to provide confidence that the seals will function as expected. Topical report PWROG-14001-P, Revision 1, uses the test results to derive failure rates for the shutdown seals. It also provides guidance for the development of PRA models to evaluate performance of the seals, and it recommends reactor coolant leakage rates to be used if the seals fail.

DISCUSSION

The topical report and the staff's draft safety evaluation address the PRA models for the shutdown seals and the failure rates to be used in those models. Details of the seal design, the model success criteria and logic structure, and numerical values for specific model parameters are proprietary information and are omitted from our report.

<u>Derivation and Use of the Shutdown Seal Failure Rates</u>

The topical report derives failure rates for two failure modes of the shutdown seal: a demand failure rate that accounts for failure of the seal to actuate after loss of all RCP seal cooling, and a time-dependent failure rate that accounts for failure of the seal after it has actuated.

Bayesian methods are used to derive these failure rates and their corresponding uncertainty distributions. Each analysis initially uses a Jeffrey's non-informative prior distribution to account for a sparse state of knowledge about performance of the seals before the testing program. Technical report TR-FSE-14-1-P, Revision 1, describes the tests that were conducted to examine seal performance for each failure mode. No seal failures occurred during the tests. The Bayesian analyses updated the prior state of knowledge with the evidence from the test results to develop better informed uncertainty distributions and to derive the corresponding mean value estimates for each failure rate. The Bayesian methods are applied to test data appropriately to derive these failure rates.

The topical report describes event tree and fault tree models that can be used to evaluate performance of the shutdown seal in an integrated PRA. The models apply for conditions that involve loss of all RCP seal cooling. They account for the operating status of each RCP, personnel actions to trip pumps that are running, performance of the shutdown seal, and reactor coolant leakage rates if the seals fail. The logic structure of these models is adequate to evaluate the frequency and consequences of event scenarios that challenge operation of the shutdown seals. The draft safety evaluation report contains appropriate cautions about the need to include all contributing hardware failures and plant-specific personnel actions in these models, and to account for dependencies among successive personnel actions.

The topical report and the draft safety evaluation often quote parameter values that are the product of a time-dependent failure rate and an operating mission time for the shutdown seal. The models in the topical report use a nominal mission time of 24 hours to quantify the probability that the seals may fail after they are actuated. Different mission times may apply for some applications of these PRA models. For example, the mission time for evaluation of some plant-specific accident mitigation strategies might be 72 hours, or longer. The staff should state explicitly that the hourly failure rate derived from the Bayesian analyses is appropriate for use in all applications of the proposed models, but the 24-hour unavailability applies only for evaluations which use that specific mission time.

Model 93A Reactor Coolant Pump O-Ring Failures

Westinghouse Model 93A RCPs contain a seal assembly O-ring that is not present in other pump models. Failure of that O-ring can affect functional performance of the shutdown seal in a manner that is different from the other pump models. One of the Limitations and Conditions in the staff's draft safety evaluation report indicates that licensees with Model 93A RCPs shall include failures of the O-rings in their PRA models for the shutdown seals. The staff's discussion of this issue notes that the O-ring failure rate should be derived from the available test data using a Bayesian methodology that is consistent with the methods used to derive the shutdown seal failure rates. We concur with the staff's assessment and their requirement.

The staff's Limitation and Condition for this issue cites a specific numerical unavailability that is the product of the O-ring hourly failure rate and a nominal 24-hour mission time. In a manner similar to that for the shutdown seal failure rate, this requirement should state explicitly that the hourly failure rate derived from the Bayesian analyses is appropriate for use in all applications of the proposed models, but the 24-hour unavailability applies only for evaluations which use that specific mission time.

Inadvertent Actuation of the Shutdown Seal

Inadvertent actuation of the shutdown seal during normal RCP operation will result in damage that prevents the seal from achieving its desired function. This condition may not affect pump operation or performance of the primary hydrostatic seals, and it may not be discovered until the RCP seals undergo inspection. The likelihood that the shutdown seal may be damaged before it is needed depends on the frequency of inadvertent actuation, the frequency of events that require operation of the seal, and the time between seal inspections. The topical report contains an evaluation which concludes that the frequency of inadvertent actuation is sufficiently low to justify omission of this failure mode from the PRA models. The staff's draft safety evaluation concurs with that assessment.

The PWROG evaluation of this failure mode relies on an expert panel assessment of several conditions that may contribute to inadvertent actuation of the seal. The assessment accounts for adverse conditions that may occur during manufacturing, assembly, installation, and operation of the seal. The scope of the assessment and its supporting models are adequately comprehensive. The quantitative evaluation of the frequency of this failure mode seems, however, to rely on a liberal interpretation of recommendations in NUREG/CR-6771, Table 4.1, for associating approximate numerical probabilities with subjective assessments of relative likelihood. We are concerned about the PWROG use of some numerical probability estimates of $1x10^{-3}$ and $1x10^{-4}$ that do not seem consistent with the intent of the guidance in NUREG/CR-6771. We also question use of that guidance to estimate annual frequencies of occurrence, rather than conditional probabilities for particular detrimental events that may occur during seal manufacture, assembly, or installation.

The staff should re-examine the quantitative bases for the PWROG conclusion that inadvertent actuation of the shutdown seal can be omitted from the PRA models.

Mr. Matthew Sunseri did not participate in the Committee's deliberations regarding this matter.

Sincerely,

/RA/

Dennis C. Bley
Chairman

REFERENCES

1. U.S. Nuclear Regulatory Commission, "Draft Safety Evaluation by the Office of Nuclear Reactor Regulation: PWROG-14001-P, Revision 1, 'PRA Model for the Generation III Westinghouse Shut-Down Seal'," May, 2017 (ML17143A091).

2. Pressurized Water Reactor Owners Group, PWROG-14001-P, "PRA Model for the Generation III Westinghouse Shutdown Seal," Revision 1, July 2014 (ML14190A333).

3. Westinghouse Electric Company, LLC, "Revisions to Topical Report PWROG-14001-P/PWROG-14001-NP, Revision 1, 'PRA Model for the Generation III Westinghouse Shutdown Seal'," April 12, 2017 (ML17125A087).

4. Westinghouse Electric Company, LLC, TR-FSE-14-1-P, "Use of Westinghouse SHIELD® Passive Shutdown Seal for FLEX Strategies," Revision 1, March 2014 (ML14084A496).

5. U.S. Nuclear Regulatory Commission, "Endorsement Letter for Westinghouse Electric Company Technical Report TR-FSE-14-1-P, Revision 1 and TR-FSE-14-1-NP, Revision 1, 'Use of Westinghouse SHIELD® Passive Shutdown Seal for FLEX Strategies'," May 28, 2014 (ML14132A128).

6. U.S. Nuclear Regulatory Commission, Order EA-12-049, "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," March 12, 2012 (ML12054A735).

7. U.S. Nuclear Regulatory Commission, NUREG/CR-6771, "GSI-191: The Impact of Debris Induced Loss of ECCS Recirculation on PWR Core Damage Frequency," August 2002 (ML022410135).

6. U.S. Nuclear Regulatory Commission, Order EA-12-049, "Issuance of Order to Modify Licenses with Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events," March 12, 2012 (ML12054A735).

7. U.S. Nuclear Regulatory Commission, NUREG/CR-6771, "GSI-191: The Impact of Debris Induced Loss of ECCS Recirculation on PWR Core Damage Frequency," August 2002 (ML022410135).

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