

November 12, 2015

Mr. Jack Stringfellow, Chairman
PWR Owners Group, Program Management Office
Westinghouse Electric Company, LLC
1000 Westinghouse Drive, Suite 380
Cranberry Township, PA 16066

Dear Mr. Stringfellow:

The U.S. Nuclear Regulatory Commission (NRC) staff has considered your request submitted on behalf of the Pressurized-Water Reactor Owners Group (PWROG) to endorse the Flowserve Corporation report entitled "White Paper on the Response of the N-Seal Reactor Coolant Pump (RCP) Seal Package to Extended Loss of All Power (ELAP)," Revision A, which was provided to the NRC staff by your letter dated August 5, 2015 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML15222A356). A non-proprietary version of the white paper is publicly available in ADAMS at Accession No. ML15222A357.

The NRC staff is evaluating nuclear reactor licensees' mitigation strategies to determine their compliance with NRC Order EA-12-049, "Order Modifying Licenses With Regard to Requirements for Mitigation Strategies for Beyond-Design-Basis External Events" (ADAMS Accession No. ML12054A735). An important aspect of licensees' mitigation strategies is determining whether the overall sequence of events, timing of those events, and phenomena affecting those events, appropriately reflects the expected plant behavior. Adequately assessing the rate of reactor coolant leakage from pressurized-water reactors' (PWRs) coolant pump seals following a loss of seal cooling is a significant factor in the evaluation of the extended loss of alternating current power (ELAP) event progression and the strategies licensees plan to use for event mitigation.

In support of licensees' mitigation strategies, Flowserve submitted information on the design and qualification testing of its N-Seal, and the expected seal performance during an ELAP. In particular, the white paper included an analytical method to determine the seal leakage rate as a function of time during the ELAP event and plant-specific calculations for all PWRs that have installed or are installing Flowserve N-Seals to support compliance with Order EA-12-049. According to variation in factors such as the controlled bleed-off flow rate and the exposure times and temperatures of elastomers in the coolant pump seals, Flowserve estimated upper-bound N-Seal leakage rates for each plant as a function of time during an ELAP event, all of which were less than 5 gallons per minute.

The NRC staff has considered the information submitted by Flowserve and concluded that the leakage rates proposed for the N-Seal design, as documented in Table 3 in the white paper, are acceptable for use in beyond-design-basis ELAP evaluations for demonstrating compliance with Order EA-12-049, with the following limitations and conditions:

- (1) Each licensee should confirm that its plant design and planned mitigation strategy are consistent with the information assumed in the calculation performed by Flowserve,

which is summarized in Table 1 of the white paper.

- (2) Each licensee should confirm that the peak cold-leg temperature prior to the cooldown of the reactor coolant system assumed in Flowserve's analysis is equivalent to the saturation temperature corresponding to the lowest setpoint for main steam line safety valve lift pressure.
- (3) The NRC staff did not specifically review and is not endorsing the final column in Table 3, which estimates the maximum leakage rate in the case of seal failure modes more severe than expected during an ELAP event. This information is considered beyond the scope of determining licensees' compliance with Order EA-12-049. In particular, because actuation of the Abeyance seal is not expected during the ELAP event for any plant considered in the white paper, the NRC staff did not specifically review and is not endorsing the functionality of this component.
- (4) In its white paper, Flowserve has generally specified leakage rates in volumetric terms. For converting the specified volumetric flow rates to mass flow rates, licensees should use a density of 62 lbm/ft³ (approximately 993 kg/m³) throughout the ELAP event. This condition reflects observations made during testing conducted by Flowserve that simulated a loss of seal cooling, wherein the seal leakage mass flow rate remained roughly constant as the test apparatus underwent a significant cooldown and depressurization.
- (5) The NRC staff conducted a sample audit of the plant-specific calculations performed by Flowserve for determining leakage rates as a function of time during an ELAP event. The NRC staff's audit calculations generally showed good agreement with the values calculated by Flowserve. Furthermore, licensees' mitigation strategies generally contain significant margin relative to the seal leakage rates calculated in the N-Seal white paper. However, if deemed necessary during plant-specific mitigation strategy audits, the NRC staff may perform additional audit calculations to confirm the appropriateness of the specific leakage rate assumptions and calculations for individual plants.

J. Stringfellow

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If you have any questions on this topic, please contact Stewart Bailey, of my staff, at (301) 415-1321, or via email to Stewart.Bailey@nrc.gov.

Sincerely,

/RA/

Jack R. Davis, Director
Japan Lessons-Learned Division
Office of Nuclear Reactor Regulation

Cc: Mr. Joseph E. Pollock, Vice President
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1201 F Street NW, Suite 1100
Washington, DC 20004

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