AREVA

Proj 728

April 13, 2006
NRC:06:022

Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Interim Report of an Evaluation of a Deviation Pursuant to 10 CFR 21.21(a)(2)

AREVA NP Inc. has identified an issue related to the performance of the control rods during a LOCA. The issue is related to the possibility that the control rod could melt during a LOCA, potentially impacting the analyses performed to demonstrate compliance with the criteria in 10 CFR 50.46.

The following information is provided pursuant to the requirements of 10 CFR 21 to submit an interim report on issues for which the evaluation will not be completed within 60 days of discovery.

An interim report on the evaluation is attached, specifically; Interim Report No. 06-001, "Control Rod Performance During LOCA".

Those AREVA NP customers potentially affected by this issue have been notified and will receive a copy of this interim report.

Sincerely,

Ronnie L. Gardner

Ronnie L. Gardner, Manager
Site Operations and Regulatory Affairs
AREVA NP

Enclosure

cc: G.S. Shukla
Project 728

IE20
YG01

Interim Report 06-001

Subject:

Interim Report of an Evaluation of a Deviation Pursuant to 10 CFR 21.21(a)(2)

Title:

Control Rod Performance During LOCA

Identification of Basic Activity:

Analyses demonstrating compliance with 10 CFR 50.46 criteria.

Basic Activity Supplied By:

AREVA NP Inc.

Nature of Deviation:

AREVA NP performs analyses to demonstrate compliance with the criteria of 10 CFR 50.46 for customers to whom it supplies fuel. These LOCA analyses have been performed for changed plant conditions which may affect the control rod performance and change the potential for melting the control rods during a LOCA relative to the original licensing basis for the plants. The current issue relates to the applicability of historical control rod heatup analyses to demonstrate that those plants with full-length silver-indium-cadmium (AIC) control rods will not exceed temperatures at which they could affect the local core cooling, long-term core cooling, or coolable geometry criteria of 10 CFR 50.46. The challenge to these criteria comes from the potential melting of the control rod absorber material in combination with a breach of the control rod sheathing through eutectic melting and other mechanical effects during a LOCA.

This issue was identified as a result of a question from one customer (FirstEnergy) for which LOCA analyses for the Davis-Besse plant had been recently performed to support use of a new fuel design. The question was whether the control rod temperature analysis, which was described in the USAR, had been re-evaluated. An investigation into this question revealed that the control rod heatup analysis had not been updated and that the records of the original analyses could not be located. It is likely that the original analyses were completed in the early 1970s. A cursory review of the USARs for US customers to whom AREVA NP supplies fuel indicates that most USARs do not contain a description of any evaluations on control rod temperatures during a LOCA.

The melting temperature of the AIC control material is ~1470°F (800 ± 10°C). The neutronic properties remain the same as the material changes from a solid to liquid form, and any perturbation in the reactivity or the control rod geometry is not projected to be significant. There is only a very small gap between the absorber and the sheathing such that there is little relocation of the molten AIC material within the sheathing. Under these conditions there would not be any significant perturbation with regard to localized reactivity control. Therefore, it can be concluded that melting of the control material would not affect the ability of the control rod to perform its safety function.

A eutectic formation results in localized melting at the point of contact between dissimilar metals at temperatures that are less than the melting temperature of either metal taken separately. The eutectic temperature between the iron and nickel in the stainless steel (or inconel) control rod sheathing and the zirconium in the zircaloy (or M5) guide tube begins at approximately 1715°F. Tests have verified that the eutectic reaction at this temperature is limited only to the region of contact between the dissimilar metals, and that it terminates as these materials melt at the point of contact. Therefore, there may be some localized melting, but at these temperatures it is not expected to degrade the control rod to the point where there is a gross expulsion of the AIC control material.

Experiments at the NIELS facility are discussed in Section 6.15.3 of NUREG-1230. The experiments determined that failure of stainless steel sheathing at low pressures can occur at a temperature of 2138°F. Failure in this case was described as a small hole in the sheathing and guide tube that allows the molten AIC control material to flow into the rod bundle fluid channel. At this point, it can interact with the zircaloy cladding on the fuel rods and can solidify when it reaches the pool and potentially block some of the flow channel at a spacer grid or possibly the lower core end fitting. The NUREG concluded that the potential for control rod degradation in a LBLOCA is low, nevertheless, it recommended that detailed analyses be conducted to determine the control rod temperatures expected during a LBLOCA. If control rod temperatures reach 2138°F, the impact of potential flow blockage resulting from control rod failure needs to be included in the modeling of reflood heat transfer to assess core coolability.

Discovery Date:

This issue was determined to be a deviation on February 15, 2006.

Corrective Actions to Date:

Preliminary evaluations have been performed for reactors representative of those for which AREVA NP supplies fuel; Babcock and Wilcox (B&W), Westinghouse (W), and Combustion Engineering (CE) designed pressurized water reactors (PWRs). These preliminary evaluations indicate that while the control rods may experience some melting, the degree of melting will be insufficient to cause a violation of the 10 CFR 50.46 criteria.

The original Davis-Besse control rod temperature evaluation concluded that the maximum predicted temperature of the control rod during the LOCA transient was 1180° F, which was well below the melting temperature of the AIC control material (~1470°F). The control rod sheathing temperature was predicted to remain below a maximum temperature of 1250°F, which was well below the eutectic formation temperature for the stainless steel control rod sheathing and the zircaloy guide tube (~1715°F). The original analysis did not challenge any acceptance criterion since the sheathing and AIC control material remained well below the temperatures at which any melting would be postulated. Since no melting was expected, the control rod was postulated to remain intact and to maintain its reactivity control.

Two sets of preliminary analyses have been performed for plants with full-length AIC rods. One was based on a representative B&W-designed plant and the other on a representative 4-loop Westinghouse-designed plant. These results illustrate the characteristics of the control rod heatup during a LOCA. No analyses were performed for plants with other types of control rods such as all B_4C or hybrid designs containing a short lower AIC tip with the remainder B_4C. The melt temperature for the B_4C is roughly 4400°F, which means that melting and flow blockage is not a concern. Also, no analyses have been performed for reactors with control blades containing AIC absorber material. These blades are exposed directly to the flow in the fuel bundles and were judged to be less limiting from a control rod temperature perspective since they are not insulated by a guide tube structure.

New preliminary post-LOCA control rod temperature analyses were performed using the BWNT LOCA EM (BAW-10192P-A) and new methods for the Davis-Besse unit based on the material described in Section 6.3.3.2.1 of the Davis-Besse USAR. These preliminary analyses utilized conservative inputs and predicted a maximum control rod temperature that was considerably higher than the temperature given in the USAR. Comparisons with the material presented in the Davis-Besse USAR led to the conclusion that the previous analysis may have credited too much cooling inside the guide tube with the control rod inserted. While the predicted temperature is above the melting point for the AIC and the corresponding eutectic temperature, it remains below an experimentally determined failure temperature of 2138°F described in Section 6.15.3 of NUREG-1230.

The analytical methods used for the B&W plant control rod temperature analyses were used to develop a realistic control rod heatup model for use in a representative four-loop Westinghouse ice-condenser plant LBLOCA analysis using the RSG LOCA EM (BAW-10168P-A Rev. 3). This plant was selected because of the peak cladding temperature response and the length of time before core quench. These characteristics make it generally applicable to the Westinghouse or CE plants that have full-length AIC rods. The preliminary analyses predicted temperatures above the AIC melting point and the eutectic temperature; however, temperatures remained below the range at which the absorber could be expelled through the sheath and guide tube into the fuel bundle. These analyses support the conclusion that additional flow blockage does not need to be considered and the control rod reactivity is preserved such that there are no additional challenges to the 10 CFR 50.46 acceptance criteria. Therefore, the control rods for W and CE plants remain operable during the LOCA and there are no new challenges to safe plant shutdown or continuous core cooling.

The preliminary evaluations defined two acceptance criteria for the control rod temperature evaluations during a LOCA. Development of these control rod criteria was necessary because no existing criteria were found in the regulations or other licensing records appropriate to address this issue.

1. After initial insertion of the control rod, the control rods must continuously provide at least the minimum reactivity requirements credited in the LOCA analyses.
2. After initial insertion of the control rod, the maximum control rod temperature shall not result in a consequential degradation of the fuel assembly coolable geometry thereby challenging the local or long-term core cooling of the fuel bundle.

The preliminary analyses, evaluations, and engineering judgment provide sufficient evidence to support the conclusion that the control rods will continue to satisfy their safety function during a postulated LOCA with higher control rod temperatures. This conclusion is valid for both large and small break LOCAs.

Those AREVA customers affected by this current control rod heatup issue have been provided information to support operability evaluations. The preliminary evaluation performed to date indicates that all plants continue to meet the applicable safety criteria. It is expected that the final evaluation will conclude that this issue is not a defect.

Evaluation Completion Schedule Date:

January 15, 2007