AREVA

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Response to an RAI on the Topical Report ANP-10278P "U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report" (TAC No. MD4978)

Ref. 1: Letter, Ronnie L. Gardner (AREVA NP Inc.) to Document Control Desk (NRC), "Request for Review and Approval of ANP-10278P Revision 0, 'U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report'," NRC:07:010, March 27, 2007.

Ref. 2: Letter, Getachew Tesfaye (NRC) to Ronnie L. Gardner (AREVA NP Inc.), "Request for Additional Information Regarding ANP-10278P, 'U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report' (TAC No. MD4978)," July 20, 2007.

Ref. 3: Letter, Getachew Tesfaye (NRC) to Ronnie L. Gardner (AREVA NP Inc.), "Acceptance for Review of ANP-10278P Revision 0, 'U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report' (TAC No. MD4978)," May 9, 2007.

AREVA NP Inc. (AREVA NP) requested the NRC's review and approval of topical report ANP-10278P Revision 0, "U.S. EPR Realistic Large Break Loss of Coolant Accident Topical Report" in Reference 1. A request for additional information (RAI) was provided by the NRC in Reference 2. The response to this RAI is enclosed with this letter, ANP-10278Q1 Revision 0, "Response to Request for Additional Information ANP-10278P."

AREVA NP plans to reference this topical report in its Design Control Document (DCD) for the U.S. EPR. Reference 3 states that the NRC plans to complete its review of the topical report and issue the draft safety evaluation by December 31, 2007. AREVA NP understands that this timely response to the RAI supports the scheduled deliverable of the draft safety evaluation.

If you have any questions related to this submittal, please contact Ms. Sandra M. Sloan, Regulatory Affairs Manager for New Plants Deployment. She may be reached by telephone at 434-832-2369 or by e-mail at sandra.sloan@areva.com.

Sincerely,

Ronnie L. Gardner

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Enclosures

cc: L. Burkhart
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Response to a Request for Additional Information – ANP-10278P

RAI-01: *In Section 4.1 of the Topical Report (TR) [Page 4-1, Core Departure from Nucleate Boiling (DNB)], it is stated that DNB is modeled in S-RELAP5 using the Biasi and modified Zuber Critical Heat Flux (CHF) correlation. Please provide your assessment of the impact of using AREVA's ACH-2 CHF new methodology and correlation, described in TR ANP-10269P, on the core pre and post-CHF heat transfer?*

Response 01:

The report cited, ANP-10269P, concerns only the determination of critical heat flux. It does not address pre- and post-CHF heat transfer. Incorporating the ACH-2 CHF correlation into the S-RELAP5 code would not affect pre- or post-CHF heat transfer. AREVA has no plans to incorporate the ACH-2 CHF correlation into the S-RELAP5 methodology.

During RLBLOCA methodology development, a sensitivity study assessed the contribution of DNB prediction on LBLOCA PCT. The DNB studies specifically examined the influence of both the high mass flux Biasi correlation and the low mass flux Zuber correlation; however, only the high mass flux condition was considered significant enough to be reported in the methodology PIRT (Table 3.4 in EMF-2103). Table 4.1 in EMF-2103 qualitatively summarized those sensitivity studies performed during methodology development. There it was reported that DNB, as represented by both the high and low mass flux correlations, was not significant to LBLOCA PCT. Given this result, AREVA chose to address the departure from nucleate boiling conservatively by biasing the application of the Biasi correlation. With the Biasi multiplier, the calculated heat-up starts earlier than measured. The bias on the Biasi correlation was evaluated using a set of 22 THTF (ORNL) tests. In addition, several LOFT, Semiscale, CCTF and SCTF benchmarks were performed that validated the collective set of code biases.

RAI-02: *Section 7.0 (Page 7-1), you only referenced Revision 0 of EMF-2103(P)(A). The latest NRC approved revision to this document is Revision 1. Both revisions of this document contain open items, action items and limitations. What is AREVA's plan to address these open items, action items and limitations?*

Response 02:

The topical report EMF-2103P Revision 1 is not an approved topical report. AREVA withdrew this topical report from review in July 2007. EMF-2103(P)(A) Revision 0 is referenced since it is the only approved version of the Realistic large break LOCA methodology. When ANP-10278P is applied, the analysis addresses the conditions (open items, action items, and limitations) imposed in the SE for EMF-2103(P)(A) Revision 0. This is demonstrated in Table A-4 of the ANP-10278P topical report.

RAI-03: *Regarding the information provided in Table A-3, "RLBLOCA Analysis Plant Parameter Values,"*

A. *Justify the core power range in 2.1-a.*
B. *Explain why a single failure is not assumed for the accumulators in 2.2-g.*
C. *Provide an explanation for IRWST temperature in 3.0-h.*

Response 03:

A. The EMF-2103(P)(A) Revision 0 methodology statistically treats the measurement uncertainty on a number of parameters including core power level. Core thermal power is measured using a continuous secondary side heat balance with feedwater flow rate. A heat balance measurement uncertainty of 22 MWt (~ ½% of rated power) is associated with the use of ultrasonic flow meters in the measurement of feedwater flow rate.

B. There are two reasons accumulators are not selected as a single-failure for RLBLOCA analysis: 1) Accumulators are passive devices. The only components located between the accumulator tanks and the respective RCS cold leg piping are check valves and motor operated isolation valves. As a standard step in each plant startup, each isolation valve is stroked open and source of electric power is disconnected. On this basis, an inadvertently closed isolation valve is not considered credible. Likewise, the accumulator check valves are regarded as passive and high reliable components therefore exempt from single failure consideration in the short-term. The check valves may be seen as passive because there is no external force or interfacing system involved with their operation. Although check valves must open for them to deliver water, the pressure differential across the valves to open becomes increasingly large as the primary system depressurizes because of the break. It is unlikely they would not open. 2) NUREG 1431 (standard Technical Specification for Westinghouse plants) states that all four ECCS accumulators shall be operable. Sensitivity studies reported in EMF-2103, Rev. 0 identified the worst single failure as the loss of one low-pressure safety injection pump. This is retained for the U.S. EPR.

C. The maximum IRWST of 140 °F is based on the mixed temperature of the primary system inventory and the original IRWST inventory. The maximum water temperature of the IRWST allowed by plant Technical Specifications for normal plant operation is 122°F. Specifically for the analysis of the U.S. EPR and specifically for the LOCA analysis, it is appropriate to increase this value as an allowance for much hotter liquid that spills from the RCS and falls into the IRWST. High IRWST temperature is conservative for evaluating LOCA from the perspective of the reactor coolant system.

RAI-04: *Table A-6, please justify the use of lower than 100 percent power.*

Response 04:

The statistical treatment of the core power level measurement uncertainty is addressed in the response to question 3a. Thus, the initial core power is one of the parameters that are sampled

probabilistically to define each of the 59 cases that are analyzed. It is conservatively assumed to range uniformly over the measurement uncertainty band of ± 22 MWt. For the limiting case presented in Table A-6, the sampled value is 4570 MWt. Through chance, this is the near the bottom of the range from 4568 to 4612 MWt.

RAI-05: *Does the RLBLOCA model determine whether Criterion 5 of 10 CFR50.46, long term cooling, has been satisfied?*

Response 05:

The RLBLOCA model does not determine whether criterion 5 of 10 CFR50.46, long term cooling has been satisfied. This will be addressed in the U.S. EPR DCD.

RAI-06: *Has AREVA performed any post LOCA flood-up calculation? If the answer is yes, what is the approximate post LOCA containment flood-up level compared to the IRWST elevation?*

Response 06:

This aspect of the LOCA will be addressed in the U.S. EPR DCD.

RAI-07: *In contrast to a traditional safety analysis which assumes conservative fuel rod properties consistent with Appendix K, 10 CFR 50 requirements, a realistic analysis should characterize the fuel condition most likely to be present during normal plant operation. In Section 4.3 (Page 4-6, Core-Entrainment/De-Entrainment), it is noted that twelve feet fuel rods were used in the tests assessing the applicability of the entrainment modeling. Please provide AREVA's plan to assess the impacts of using the U. S. EPR fuel type (14 feet fuel) to the RLBLOCA analysis and to the entrainment modeling?*

Response 07:

Entrainment of water droplets by the steam flow in the core is an important phenomenon that can affect the predicted core cooling flow. The primary determinant of entrainment is the drag exerted on the liquid droplets by the steam flowing up through and out of the core. This drag, in turn, depends on the vertical flow regime within the core model. The determinants of the model applicability to a PWR LBLOCA are primarily local and, in the core, principally related to the conditions within the flow channel between the fuel rods on a control volume basis. The S-RELAP5-based RLBLOCA methodology does not account for spacer-effects that will de-entrain a significant amount of liquid from the flow field resulting in more coolant in the core and on fuel rod surfaces near spacers. Neglecting this mechanism for de-entrainment results in lower core liquid levels and, consequently, dryer conditions above the two-phase mixture level. As such, without a spacer-effect model the overall core entrainment is independent of length.

The liquid entrainment in the core has been demonstrated to be conservatively calculated by the code and methodology nodalization, and is shown in the assessments performed for CCTF, UPTF, and FLECHT-SEASET, which were reported in Section 5.6 of EMF-2101(P) Revision 0.

In all three test facilities, the model overpredicted liquid carryout from the core to the upper plenum. The CCTF facility, which is full length and scaled orthogonally, featured a 12 foot electrically heated core. The UPTF facility, which is full sized, featured a 3.3 foot non-heated core. The FLECHT-SEASET facility, which consists of only a fuel bundle, featured a 12 foot electrically heat core. In all three test facilities, the amount of liquid carry out of the core into the upper plenum was overpredicted. Given these results from three different test facilities, it is concluded that the code and methodology prediction of core entrainment is conservative and that this conservatism is applicable to all geometries that resemble U.S. PWR fuel rods regardless of length. Therefore, AREVA believes that the current RLBLOCA methodology conservatively accounts for entrainment in the U. S. EPR 14 foot fuel and that further assessment is unnecessary.

RAI-08: *Has AREVA performed sensitivity studies investigating the effects of radial power shape on PCT?*

Response 08:

Sensitivity studies have been conducted to investigate the affects of radial power on PCT by comparing the following cases:

Base case, nominal power
1) HA>SA>AA=CA

High power cases
2) HA>SA=AA=CA
3) HA>SA=AA>CA
4) HA>SA=AA>>CA
5) HA>SA>AA=CA

The radial peaking factors are identified by HA for the hot assembly, SA for the surrounding assemblies, AA for the average assemblies, and CA for the cold assemblies. The study, documented in Appendix B of EMF-2103(P)(A), showed that flatter power distribution profiles in the surrounding assemblies, average assemblies, and cold assemblies (Case 2) produce higher PCTs. As such, the procedure for ranging radial power is biased toward these flatter radial distributions to conservatively bound the selection of radial profiles.

RAI-09: *Is zirconium oxide spallation during a LOCA modeled in realistic codes?*

Response 09:

No. The realistic LOCA methodology initiates the LOCA transient with a corrosion thickness of 0.0 for the purpose of the transient high temperature oxidation calculation. Real corrosion thicknesses, appropriate for the burnup being evaluated, are used in the determination of the initial cladding and fuel temperatures. The use of a 0.0 corrosion layer to initialize the transient oxidation maximizes the rate of oxidation during the transient calculation. Proceeding in this manner maximizes both the cladding temperature excursion and the transient oxidation prediction. Consistent with the assumed 0.0 corrosion layer, the methodology does not include modeling of cladding oxide spallation during the LOCA transient.

Although the possibility for transient spallation or ablation of the corrosion layer exists, it is an improbable occurrence and not of consequence to the prediction of cladding temperature or the absorption of hydrogen or oxygen during a LOCA. When observed, transient spallation or ablation has occurred only during cooldown. Therefore, the process does not rise to a level that warrants inclusion within the realistic LOCA methodology.