May 19, 2004

Mr. James F. Mallay
Director, Regulatory Affairs
Framatome ANP
3815 Old Forest Road
Lynchburg, VA 24501

SUBJECT: FINAL SAFETY EVALUATION FOR TOPICAL REPORT EMF-2310(P), REVISION 1, "SRP CHAPTER 15 NON-LOCA METHODOLOGY FOR PRESSURIZED WATER REACTORS" (TAC NO. MC0329)

Dear Mr. Mallay:

On August 12, 2003, Framatome ANP (FANP) submitted Topical Report (TR) EMF-2310(P), Revision 1, "SRP Chapter 15 Non-LOCA Methodology for Pressurized Water Reactors," to the Nuclear Regulatory Commission (NRC) staff. On March 17, 2004, an NRC draft safety evaluation (SE) regarding our approval of EMF-2310(P) was provided for your review and comments. By letter dated April 1, 2004, FANP commented on the draft SE. A call was held on May 3, 2004, to discuss the staff disposition of the comments. The staff's disposition of FANP's comments on the draft SE are discussed in the attachment to the final SE enclosed with this letter.

The staff has found that EMF-2310(P) is acceptable for referencing in licensing applications for Westinghouse and Combustion Engineering designed pressurized water reactors to the extent specified and under the limitations delineated in the TR and in the enclosed SE. The SE defines the basis for acceptance of the TR.

Our acceptance applies only to material provided in the subject TR. We do not intend to repeat our review of the acceptable material described in the TR. When the TR appears as a reference in license applications, our review will ensure that the material presented applies to the specific plant involved. License amendment requests that deviate from this TR will be subject to a plant-specific review in accordance with applicable review standards.

In accordance with the guidance provided on the NRC's TR website, we request that FANP publish accepted proprietary and non-proprietary versions of this TR within three months of receipt of this letter. The accepted version shall incorporate this letter and the enclosed SE between the title page and the abstract. It must be well indexed such that information is readily located. Also, it must contain in appendices historical review information, such as questions and accepted responses, draft SE comments, and original TR pages that were replaced. The accepted version shall include a "-A" (designating accepted) following the TR identification symbol.

If the NRC's criteria or regulations change so that its conclusions in this letter, that the TR is acceptable, are invalidated, FANP and/or the licensees referencing the TR will be expected to revise and resubmit its respective documentation, or submit justification for the continued applicability of the TR without revision of the respective documentation.

Sincerely,

/RA/

Herbert N. Berkow, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 728

Enclosure: Safety Evaluation

If the NRC's criteria or regulations change so that its conclusions in this letter, that the TR is acceptable, are invalidated, FANP and/or the licensees referencing the TR will be expected to revise and resubmit its respective documentation, or submit justification for the continued applicability of the TR without revision of the respective documentation.

Sincerely,
/RA/
Herbert N. Berkow, Director
Project Directorate IV
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Project No. 728

Enclosure: Safety Evaluation

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

EMF-2310(P), REVISION 1, "SRP CHAPTER 15 NON-LOCA METHODOLOGY

FOR PRESSURIZED WATER REACTORS"

FRAMATOME ANP

PROJECT NO. 728

1.0 INTRODUCTION

By letter dated August 12, 2003 (Reference 1), Framatome ANP (FANP) requested review and approval for referencing in licensing actions Topical Report (TR) EMF-2310(P), Revision 1, "SRP Chapter 15 Non-LOCA Methodology for Pressurized Water Reactors," in particular EMF-2310, Section 5.6, "CVCS Malfunction That Results in a Decrease in the Boron Concentration in the Reactor Coolant (Boron Dilution)."

The noted section has been revised to address the dilution front model used when the residual heat removal (RHR) system is in operation, all control rods are inserted in Modes 4 and 5, and complete mixing of the fluid is assumed prior to entry of the diluted fluid into the core.

EMF-2310(P) methodology incorporates S-RELAP5 as the systems analysis code and was previously reviewed and approved by the NRC staff for application to Chapter 15 non-loss-of-coolant accident (non-LOCA) events on May 11, 2001 (Reference 2).

2.0 REGULATORY BASIS

The regulatory bases for the boron dilution events are found in the General Design Criteria (GDC) (Reference 3) and the Standard Review Plan (SRP) (Reference 4). The specific applicable GDCs are:

(1) GDC 10, *Reactor Design*

(2) GDC 15, *Reactor Coolant System Design*

(3) GDC 26, *Reactivity Control System Redundancy and Capability*

The applicable SRP Section is 15.4.6, "Chemical and Volume Control System Malfunction that Results in a Decrease in Boron Concentration in the Reactor Coolant (PWR)."

3.0 TECHNICAL EVALUATION

FANP has revised Section 5.6 of EMF-2310(P), Revision 0 in three areas. Each is discussed below.

3.1 The Dilution Front Model will be Used when the RHR System is in Operation

When one or more reactor coolant pumps are operating it is assumed that complete, instantaneous mixing of boron with the reactor coolant system (RCS) water occurs. Section 3.3 of this safety evaluation discusses this further. For modes where the RHR, or shutdown cooling system, is in operation, flow rates may not be sufficient to assure complete mixing of the reactor coolant system. Under these conditions the mixing front approach is applied.

The mixing front approach assumes that the diluent mixes with the RCS and results in reduced boron concentration at the mixing location. The dilution is then viewed as a series of dilution fronts progressing through the RCS. Dilution mixture transit time to the bottom of the core is based on the volume and the flow rates of both the diluent and RCS flows. The result is that dilution flows are fully mixed in the lower plenum prior to entrance into the core.

The NRC staff has reviewed the model as presented in EMF-2310(P), Revision 1, Section 5.6, and finds it acceptable. If operator action is required to terminate the transient, the time to dilution below the critical concentration must provide sufficient margin that the operator has the following times to take corrective action:

(a) During refueling: 30 minutes.

(b) During startup, cold shutdown, hot standby, and power operation: 15 minutes.

3.2 All Control Rods will be Assumed to be Inserted in Modes 4 and 5

Control rod insertion is permitted in Modes 4 and 5, but during refueling operations the analysis must assume withdrawal of all control rods. This is stated in SRP Section 15.4.6, Acceptance Criteria, parameter assumption (vi).

FANP has stated that if a plant has procedures that increase the shutdown boron requirements to compensate for a stuck rod, then the critical boron concentration is determined assuming that all rods are inserted for Modes 4 and 5. Otherwise, the critical boron concentration is determined using the assumption that the most reactive rod is stuck in the fully withdrawn position.

The NRC staff finds this consistent with the requirements of GDC 26 and the guidance of SRP Section 15.4.6, Acceptance Criteria and, therefore, is acceptable.

3.3 Complete Mixing of the Fluid is Assumed Prior to Entry of the Diluted Fluid into the Core

Support of the complete mixing model is based on supporting calculations performed with the STAR-CD computational fluid dynamics (CFD) code for the International Standard Problem ISP-43. ISP-43 is a voluntary participation problem of a test performed at the University of

Maryland 2x4 Thermal-Hydraulic Loop. The test was performed by holding the vessel coolant at a constant temperature of 347K (165°F) while injecting water into one cold leg. Mixing was determined through thermocouple measurements. Boron was not injected in this test, but the measure of success in predicting the test is to predict the temperature distribution as measured by the exit of the downcomer.

Results of the STAR-CD simulation indicate very close agreement with the test data over most of the range of the test. The initial temperature, the end state temperature, and time of the end state temperature are predicted very accurately. There is a few percent difference in the slope of the temperature decay as the entering fluid mixes. The difference is not significant, however, and demonstrates that the complete mixing assumption is valid for the flow conditions in the test.

FANP, in Attachment A of Reference 1, has stated that "[t]he analysis of a boron dilution event depends on the rate of dilution and the plant design. The plant layout dictates whether the dilution can be treated symmetrically or asymmetrically.... If the charging line for residual heat removal flow is not in the same cold leg as the dilution flow, or if the RHR flow is distributed across the other cold legs, the boron dilution event is asymmetrical." FANP review of the specific application of the EMF-2310(P) methodology must be performed to ensure the situation warrants use of the complete mixing assumption.

4.0 CONDITIONS

The parameters and assumptions used in the analysis should be suitably conservative. The following values and assumptions, as delineated in SRP Section 15.4.6, are considered acceptable, and should be evaluated if appropriate:

(1) For analyses during power operation, the initial power level is rated output (licensed core thermal power) plus an allowance of 2 percent, or justified amount, to account for power-measurement uncertainty.

(2) The boron dilution is assumed to occur at the maximum possible rate.

(3) The core burnup and corresponding boron concentration are selected to yield the most limiting combination of moderator temperature coefficient, void coefficient, Doppler coefficient, axial power profile, and radial power distribution.

(4) All fuel assemblies are installed in the core.

(5) A conservatively low value is assumed for the reactor coolant volume.

(6) For analyses during refueling, all control rods are withdrawn from the core.

(7) For analyses during power operation, the minimum shutdown margin allowed by the technical specifications is assumed to exist prior to the initiation of boron dilution.

(8) For each event analyzed, a conservatively high reactivity addition rate is assumed taking into account the effect of increasing boron worth with dilution.

(9) Conservative scram characteristics are assumed, i.e., maximum delay time with the most reactive rod held out of the core.

5.0 CONCLUSIONS

The NRC staff concludes that the FANP methodology described in this TR is capable of addressing the thermal-hydraulic response of the boron dilution event in a conservative manner and is, therefore, approved for reference in licensing actions.

6.0 REFERENCES

(1) Letter from Framatome ANP to NRC, Requesting Review of EMF-2310(P) Revision 1, "SRP Chapter 15 Non-LOCA Methodology for Pressurized Water Reactors," August 12, 2003 (ADAMS Accession No. ML032460852).

(2) Letter from NRC to Framatome ANP, Acceptance for Referencing of Licensing Topical Report EMF-2310(P), Revision 0, "SRP Chapter 15 Non-LOCA Methodology For Pressurized Water Reactors" (TAC No. MA7192), May 11, 2001 (ADAMS Accession No. ML033580677).

(3) Title 10 of the *Code of Federal Regulations* Appendix A to Part 50, General Design Criteria for Nuclear Power Plants.

(4) NUREG-0800, Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants, Revision 2, April 1996.

Attachment: Resolution of Comments

Principal Contributor: Ralph Landry

Date: May 19, 2004

RESOLUTION OF COMMENTS

ON DRAFT SAFETY EVALUATION FOR EMF-2310, REVISION 1,

"SRP CHAPTER 15 NON-LOCA METHODOLOGY FOR

PRESSURIZED WATER REACTORS"

By letter dated April 1, 2004, Framatome ANP (FANP) provided comments on the draft safety evaluation (SE) for EMF-2310, Revision1, "SRP Chapter 15 Non-LOCA Methodology for Pressurized Water Reactors." A call was held with FANP on May 3, 2004, to discuss the staff's disposition of the comments. The following is the staff's resolution of those comments.

1. FANP Comment: Delete the last two sentences of the last paragraph of Section 3.3, and replace with Insert 1.

   NRC Action: This comment was partially adopted into the final SE, as agreed upon during the May 3, 2004, call between FANP and NRC. The last sentence was deleted. The second to last sentence was left as modified by inserting "FANP" as the first word.

2. FANP Comment: Delete Section 4.0, and replace with Insert 2. The boron dilution event analysis does not use the code S-RELAP5. FANP requests that the conditions in Section 4.0 of the SE be deleted since they are primarily related to the presumed use of S-RELAP5 for the analysis of the boron dilution event.

   NRC Action: The comment was partially adopted into the final SE, as agreed upon during the May 3, 2004, call between FANP and NRC. The first paragraph and conditions 1, 2, and 3, were deleted. The second paragraph was reworded to state "The parameters and assumptions used in the analysis should be suitably conservative. The following values and assumptions, as delineated in SRP Section 15.4.6, are considered acceptable, and should be used if appropriate."

   The 9 parameters were not deleted, because they are assumptions in SRP Section 15.4.6. The rewording of the second paragraph meets the intent of FANP's comment to delete the parameters.

3. FANP Comment: FANP considered that sufficient information was provided in the submittal to justify the use of the complete mixing model under asymmetric conditions, and requests that the NRC specifically approve the use of the complete mixing model for this situation by replacing the conclusion paragraph of Section 5.0 with Insert 3.

   NRC Action: The comment was partially adopted into the SE, as agreed upon during the May 3, 2004, call between FANP and NRC. The conclusion paragraph of Section 5.0 now states: "The NRC staff concludes that the FANP methodology described in this TR is capable of addressing the thermal-hydraulic response of the boron dilution event in a conservative manner and is, therefore, approved for reference in licensing actions."

4. FANP Comment: FANP proposes (for the purpose of clarity) to modify the first sentence in Topical Report EMF-2310(P), Revision 1, Section 5.6 to read: "The analysis of the boron dilution event does not use the system code S-RELAP5." This modification will be made in the approved version of the topical report.

   NRC Action: This modification is acceptable to the NRC.