February 12, 2007

Mr. Karl W. Singer
Chief Nuclear Officer and
Executive Vice President
Tennessee Valley Authority
6A Lookout Place
1101 Market Street
Chattanooga, TN 37402-2801

SUBJECT: BROWNS FERRY NUCLEAR PLANT, UNIT 3 - RELIEF REQUEST FROM AMERICAN SOCIETY OF MECHANICAL ENGINEERS, SECTION XI REQUIREMENTS FOR RISK-INFORMED INSERVICE INSPECTION OF PIPING WELDS (TAC NO. MC8795)

Dear Mr. Singer:

By a letter dated October 19, 2005, as supplemented by letters dated October 11, and November 20, 2006, the Tennessee Valley Authority (TVA, the licensee) submitted Relief Request 3-ISI-21 requesting authorization to extend the risk-informed (RI) inservice inspection (ISI) program for American Society of Mechanical Engineers Class 1 and Class 2 piping welds for the remainder of the third 10-year ISI interval.

The U.S. Nuclear Regulatory Commission staff has reviewed and evaluated the information provided in support of TVA's relief request. Based on the conclusions contained in the enclosed safety evaluation, the staff authorizes the extension of Browns Ferry Nuclear Plant's (BFN's) RI-ISI program pursuant to Title 10 of the *Code of Federal Regulations,* Part 50, Section 55a(a)(3)(i) on the basis that the alternative provides an acceptable level of quality and safety.

This relief is authorized for the third 10-year ISI interval at BFN Unit 3, which began November 19, 2005, and ends November 18, 2015.

Sincerely,

***/RA by Brenda Mozafari for/***

L. Raghavan, Chief
Project Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-296

Enclosure: Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RISK-INFORMED INSERVICE INSPECTION FOR THE THIRD 10-YEAR INTERVAL

RELIEF REQUEST 3-ISI-21

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT, UNIT 3

DOCKET NO. 50-296

## 1.0 INTRODUCTION

By letter dated October 19, 2005, as supplemented by letters dated October 11, 2006, and November 20, 2006, the Tennessee Valley Authority (TVA, the licensee) submitted a request to extend the risk-informed inservice inspection (RI-ISI) program plan for Browns Ferry Nuclear Plant (BFN), Unit 3, to the third 10-year inservice inspection (ISI) interval. The RI-ISI program was initially submitted to the U.S. Nuclear Regulatory Commission (NRC) staff in a letter dated April 23, 1999, as supplemented by letters dated October 25 and November 10, 1999, and January 18, 2000. Also, a meeting was held on September 20, 1999, and a site audit visit conducted December 1-2, 1999. The RI-ISI program was reviewed and approved by the NRC for use in the second 10-year ISI interval in a letter dated February 11, 2000.

The licensee considered relevant information collected since the development of the original program, and has reviewed and updated the RI-ISI program. The licensee's current submittal proposed to extend the updated RI-ISI program to the third 10-year ISI interval.

## 2.0 REGULATORY EVALUATION

Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.55a(g) specifies that ISI of nuclear power plant components shall be performed in accordance with the requirements of the American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code (ASME Code), Section XI, except where specific written relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i). Paragraph (a)(3) of 10 CFR 50.55a states that alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if the proposed alternatives would provide an acceptable level of quality and safety.

The licensee's RI-ISI program was, in general, developed in accordance with the methodology contained in the Westinghouse Owners Group (WOG) report WCAP-14572, Revision 1-NP-A, (the WCAP topical) which was reviewed and approved by the NRC staff on December 15, 1998. The RI-ISI program is an alternative pursuant to 10 CFR 50.55a(a)(3)(i). In the licensee's October 19, 2005, submittal, the licensee requested NRC authorization to extend its RI-ISI

program, previously approved for use in the second interval, for use in the third ISI interval. The scope of the RI-ISI program, however, was changed. The licensee stated in the submittal that an RI-ISI program has been developed for Browns Ferry Nuclear Plant, Unit 1 as part of its Restart Project, and based on precedents in the rest of the industry and at the other TVA nuclear facilities, the licensee decided to limit the scope of the BFN Unit 1 RI-ISI program to ASME Class 1 and Class 2 welds only. The licensee indicated that, for consistency, it revised its Unit 3 program to this same scope. The WCAP topical provides that this revision from a full-scope to a partial-scope program is acceptable as long as the partial scope is well-defined and the change in risk due to the implementation of the RI-ISI program meets the guidelines in NRC Regulatory Guide (RG) 1.174, Rev. 1. These criteria are evaluated in the next section of this safety evaluation (SE). The applicable ASME code of record for the third 10-year ISI interval at BFN Unit 3 is the 2001 Edition through 2003 Addenda.

## 3.0 TECHNICAL EVALUATION

The licensee requested relief to use the proposed RI-ISI program plan in the third 10-year ISI interval instead of the ASME Section XI program for piping. An acceptable RI-ISI program plan is expected to meet the five key principles of risk-informed decision making discussed in RG 1.178, Standard Review Plan 3.9.8, and the WCAP topical, as stated below.

1. The proposed change meets the current regulations unless it is explicitly related to a requested exemption or rule change.
2. The proposed change is consistent with the defense-in-depth philosophy.
3. The proposed change maintains sufficient safety margins.
4. When proposed changes result in an increase in core damage frequency (CDF) or risk, the increases should be small and consistent with the intent of the NRC's Safety Goal Policy Statement.
5. The impact of the proposed change should be monitored by using performance measurement strategies.

The first principle has been met in this relief request, because an alternative ISI program may be authorized pursuant to 10 CFR 50.55a(a)(3)(i), and, therefore, an exemption request is not required.

The second and third principles require assurance that the alternative program is consistent with the defense-in-depth philosophy and that sufficient safety margins are maintained, respectively. Assurance that the second and third principles are met is based on the application of the approved methodology and not on the particular inspection locations selected.

In a letter dated October 11, 2006, the licensee stated that the process used to develop the proposed RI-ISI program for the third ISI interval is the same as that outlined in TVA's original submittal of April 23, 1999, and follow-up letters dated October 25 and November 10, 1999, and January 18, 2000, which was then approved by NRC staff on February 11, 2000. In Attachment B of the October 2006, letter, with additional clarification in a letter dated November 20, 2006, the licensee noted that the processes used to develop its RI-ISI program were consistent with the methodology described in ASME Section XI, Code Case N-577, and the WCAP topical, with exception of four documented deviations. These four deviations involved the processes of:

- Failure Assessment - two deviations: 1) using a different structural analysis code than approved in the WCAP topical, and 2) applying the highest individual element failure probability as the segment's failure probability for segment risk-ranking purposes, in lieu of applying the "limiting" or "worst-case" element concept specified in the approved methodology,

- Risk Evaluation - treating all segments with risk reduction worth (RRW) $\geq$ 1.001 as high safety significant (HSS) in lieu of performing a sensitivity study and/or a RRW uncertainty analysis for assigning segments with 1.001 $\leq$ RRW $\leq$ 1.005 as HSS or low safety significant (LSS), and

- Element Selection - selecting each individual element in an HSS segment with RRW $\geq$ 1.001 for nondestructive examination (NDE) instead of using the approved statistical selection process. In segments where the structural analysis code calculates an RRW $\leq$ 1.001 for all elements, but where qualitative consideration results in the segment being placed in HSS, the traditional ASME criterion of selecting 25 percent of Class 1 elements for NDE is applied.

In addition to the licensee-identified deviations, the staff, in a letter dated February 11, 2000, to TVA, identified and documented five additional deviations in the licensee's original proposed RI-ISI program from the approved methodology of the WCAP topical, as follows:

- Segment Definition - Some segments contained normally closed reactor coolant system isolation valves. Because, during risk characterization, the licensee used that part of the segment with the highest pipe failure-related CDF or large early release frequency (LERF) to represent the segment, the February 11, 2000, letter documented this deviation as acceptable.

- Consequence Evaluation - Evaluating only one leak size (i.e., large leak), for system impact. However, all possible spatial impacts were applied in the evaluation, and the February 11, 2000, letter documented this deviation as acceptable.

- Failure Assessment - The licensee declined to credit augmented inspection program-related NDEs in the calculation of "without inspection" failure potential for intergranular stress-corrosion cracking (IGSCC) Category "A" elements previously selected for NDE under this augmented inspection program. This treatment was due to the WCAP topical's subsuming of the IGSCC augmented inspection program for Category "A" elements. Hence, these inspections would not necessarily be continued on each of these previously inspected elements, under RI-ISI. The licensee took the conservative approach to give no credit for these inspections in calculating failure potential. As a result, the February 11, 2000, letter documented this deviation as acceptable.

- There were no calculations of segment Risk Achievement Worth performed for the Expert Panel. Because the licensee's Expert Panel had invoked a qualitative criterion that all segments whose rupture would initiate a large loss-of-coolant accident (LOCA) would be classified as HSS, the February 11, 2000, letter documented the staff's assessment that this would provide equivalent sensitivity to ruptures of truly high consequence, and hence, this deviation was found acceptable.

- An uncertainty analysis of the delta CDF/LERF calculations was not performed. The February 11, 2000, letter documented the staff's finding of this deviation's acceptability on the basis of the similarity between the licensee's processes and the approved methodology.

The staff concluded that the licensee's original proposed RI-ISI program reasonably conformed to the WCAP topical, with exception of the above nine deviations. In the February 11, 2000, letter, the NRC staff concluded that these nine deviations, as used by the licensee to develop its original RI-ISI program, were acceptable.

In the submittal, the licensee provided Attachment 1, a table that compares the existing RI-ISI program (i.e., the number of NDEs within each system in scope) for the second interval with the proposed RI-ISI program for the third interval. The licensee proposed to reduce the number of NDEs from 100 in the second interval to 71 in the third interval. The licensee explained in the submittal that this reduction is "entirely attributable to the implementation of the hydrogen water chemistry/noble metal injection program, with the corresponding impact on IGSCC." In a letter dated October 11, 2006, the licensee provided additional justification on how they reduced the number of NDEs. The licensee noted that the entire RI-ISI evaluation process was repeated using new failure rates from the implementation of the hydrogen water chemistry/noble metal injection program, which resulted in revised pipe segment CDF and LERF values, as well as RRW values. This re-evaluation resulted in many RRW values dropping below the 1.001 threshold between LSS and HSS designation. However, due to the licensee's qualitative criterion that any segment causing the initiation of a large LOCA upon rupture will be considered HSS, these segments remained categorized as HSS (termed Defense-in-Depth HSS segments) even when the RRW values decreased. The licensee confirmed in a November 20, 2006, letter that, as a result of repeating the RI-ISI evaluation process for the third ISI interval, no pipe segment's safety significance was reduced from HSS to LSS. Hence, this significant reduction in proposed NDEs is not the result of a re-categorization of pipe segments.

Given the same number of HSS segments for the third interval as for the second interval, the reduction in NDEs was a result of the application of the element selection process to the revised results. The licensee stated, in the October 11, 2006, letter, that RRW was calculated for each weld (element) using the weld's failure rate, conditional core damage probability, and conditional large early release probability as inputs. Using the above-noted element selection criterion, the licensee then indicated that the impact of the recent implementation of its hydrogen water chemistry/noble metal injection program was to drive the failure rates of affected elements to zero. The licensee noted in this discussion that the significant reduction in element selection for NDE resulted from two factors associated with its hydrogen water chemistry/noble metal injection program:

- The RRW of some of the previously selected elements in HSS segments that still contain at least one other element with RRW $\geq$ 1.001 (termed RRW HSS segments) dropped below 1.001, resulting in the direct deletion of that element's selection for NDE.

- Some segments that previously had a number of elements with an RRW $\geq$ 1.001 no longer have any elements with an RRW $\geq$ 1.001, but were retained as Defense-in-Depth HSS segments. Application of the traditional ASME selection criteria resulted in fewer elements within the segment being selected for NDE.

The evaluation of the licensee's methodology to determine the safety significance of the segments and to select elements for NDE, as described in the February 11, 2000, letter, remains valid. The licensee indicated in the October 11, 2006, letter, that it re-performed all necessary calculations, starting from inputting the impact of this new chemistry program into its structural reliability code, WINPRAISE, in order to calculate revised element failure rates. In Attachment E, the licensee lists all Defense-in-Depth HSS segments, both those designated as such during the second 10-year interval as well as those in which no contained element has an RRW $\geq$ 1.001 for the first time in the third 10-year interval. The staff observed that for these Defense-in-Depth HSS segments listed in Attachment E, the licensee had appropriately applied the traditional ASME selection criteria, indicating that 21 of the 84 elements associated with these segments were selected for NDE. The NRC staff's February 2000 letter discussed the observation that very few of the initially proposed locations were not already part of the licensee's existing flow-accelerated corrosion or IGSCC augmented inspection programs. The licensee responded by adding 14 NDEs to the proposed second 10-year interval program to provide for monitoring against other degradation mechanisms, such as thermal fatigue. NRC staff review of Attachment 1 to the licensee's submittal indicated that the licensee had not only maintained this "balance," but had, in fact, modestly increased the number of NDEs for thermal fatigue.

The NRC staff has concluded that the licensee's methodology for evaluating and developing the previous RI-ISI program (which derived from the methodology in the topical, but includes a number of acceptable deviations) has been appropriately re-applied in updating this program for the third 10-year interval. Hence, the staff concludes that the second and third key principles have been met.

The fourth principle (any increase in CDF or risk should be small and consistent with the intent of the Commission's Safety Goal Policy Statement) requires an estimate of the change in risk, and the change in risk is dependent on the location of inspections in the proposed ISI program compared to the location of inspections that would be inspected using the requirements of ASME Section XI. The WCAP topical requires that a change in risk measurement must consider the discontinuance of ASME code required inspections, as well as any new inspections resulting from the application of its methodology. TVA letter dated April 23, 1999, indicated that, for the second interval, the ASME Section XI code of record was the 1989 edition with no addenda. As previously mentioned, the licensee plans to update to the 2001 Edition through 2003 Addenda. It is possible that, if a revised ASME inspection program for the third interval were to be developed for this updated code of record, the number and/or locations of inspections mandated by the updated code of record could increase or otherwise change. This is due to potential new scoping requirements, possible changes in code sampling percentage requirements, or for other reasons, all of which could potentially impact the change of risk analysis. However, development of an acceptable RI-ISI program is primarily achieved through the risk-ranking and the inspection location selection processes. When applied as part of an integrated decision-making process, subsequent change in risk estimates provide reasonable assurance that the change in the ISI program would result in a total plant risk neutrality, risk decrease, or a small risk increase that will be consistent with staff guidelines found in RG 1.174. Although the ASME Section XI inspection program may change slightly when developed from the updated code of record, the accuracy of the change in risk calculations does not warrant developing a new ASME program for the new code of record simply to be used as a new baseline for the change of risk

analysis. Therefore, the NRC staff has determined that the licensee's approach in estimating the change of risk between the RI-ISI program proposed in the submittal and the ASME program based on the code of record, from which relief was granted in the February 11, 2000, letter, is acceptable.

In the November 20, 2006, letter, the licensee indicated that Baseline model U3011702, dated January 17, 2002, was used to perform the probabilistic risk assessment (PRA) calculations for the submittal. As part of the NRC staff's review of the licensee's application for Extended Power Uprate, an audit of the licensee's PRAs for Units 1, 2, and 3 was conducted during the period January 23-26, 2006. During this audit, the NRC staff reviewed the package containing the Level A and B Facts and Observations (F&Os) from the Boiling-Water Reactors Owners Group (BWROG) Peer Review of the licensee's PRA and noted that, in some cases, the new Unit 1 model contained the same issues previously identified for the Units 2 and 3 PRA model. The auditors identified several additional findings with respect to the licensee's PRAs. As a result, the NRC staff reviewed the BWROG Peer Review Report again and concluded that the documented Level A and B F&Os involving a needed change to the Units 2 and 3 PRA model were either reasonably resolved or do not have a significant impact on this application for the third 10-year ISI interval. The licensee briefly discussed the major findings from the above-noted staff audit, indicated that they are being addressed as part of corrective action program, and demonstrated that they do not have a significant impact on this application. On the basis of the results of the NRC staff review of the evolution of the PRA, since the initial RI-ISI program submittal, the staff concluded that use of Baseline model U3011702, dated January 17, 2002, is reasonable and sufficient for developing the proposed RI-ISI program for the third 10-year ISI interval. This is consistent with Section 4.5.2 of the WCAP topical, which notes that the PRA used in the development of any RI-ISI program is a state of knowledge at the time of implementation and takes credit for the existence of the monitoring and feedback program discussed below.

The licensee stated in the submittal that a new delta risk evaluation was performed, and the proposed program for the third interval continued to represent a risk reduction when compared to the last deterministic ASME Section XI inspection program. The licensee also noted that the risk reduction is smaller, and is attributable to a smaller piping-related base CDF and LERF to begin with, mostly due to the implementation of the hydrogen water chemistry/noble metal injection program. As a result, and because no deviation from the risk acceptance criteria of the WCAP topical was identified above, the NRC staff has determined that the fourth key principle is met.

With regard to the fifth key principle, Section 4.5.2 of the WCAP topical states that RI-ISI programs are living programs and should be monitored continuously, and that monitoring of these programs encompasses many facets of feedback or corrective action, which includes periodic updates. The licensee reported in the submittal that reviews and updates have been performed on an ASME periodic basis. Specifically, the licensee updated the PRA and initiated a new hydrogen water chemistry/noble metals injection program prior to the end of the second period of inspection interval 2. Considering these changes, the licensee performed a review and program update in March 2002 prior to the end of the second period, which was on November 19, 2002. The licensee stated that another review and update was completed in December 2002. The licensee noted that the final outage of the third period of the second interval took place in March 2004 and that the periodic review was completed in June 2005.

This is consistent with Section 4.5.2 of the WCAP topical, which notes that the PRA used in the development of any RI-ISI program is a state of knowledge at the time of implementation. Hence, any significant changes in the parameters that affect CDF or LERF by a critical factor should be considered as expeditiously as possible.

As discussed in Section 2.0 of this SE, one of the changes being made in the licensee's RI-ISI program for the third interval is to reduce the scope of the RI-ISI program from HSS piping segments regardless of ASME Class to just ASME Class 1 and 2 piping. The NRC approval of the WCAP topical letter dated December 15, 1998, states that such a partial scope program is acceptable as long as the partial scope is well-defined, and the change in risk due to the implementation of the RI-ISI program meets the guidelines in RG 1.174. The first requirement is met on the basis that ASME Section XI Class 1 and 2 components are formally defined by all licensees to comply with 10 CFR 50.55a. The second provision was shown to be met as previously discussed in this SE. In addition, the licensee noted in the submittal that the same segments were determined to be significant (i.e., HSS) regardless of scope. The NRC staff reviewed the licensee's data for both the second and third intervals, and noted that none of the tables of HSS segments for either of the ISI intervals included any segments from ASME Class 3 or non-Class systems, nor are any of the ASME Class 3 or non-ASME Class systems' elements selected for NDE. Hence, the staff concurs that this proposed reduction in scope will have no effect on the implementation of the third 10-year interval RI-ISI program. The licensee is expected to conform to ASME Section XI requirements for its ASME Class 3 systems. Based on the above considerations, the NRC staff concludes that the licensee's RI-ISI program is consistent with the living-program concept, and therefore, the fifth key principle is met.

Based on the above discussion, the staff finds that the five key principles of risk-informed decision making are ensured by the licensee's proposed third 10-year RI-ISI interval program plan, and therefore the proposed program for the third 10-year ISI interval is acceptable.

## 4.0 CONCLUSION

Based upon the information provided by the licensee, and upon the above evaluations, the NRC staff has determined that the licensee's RI-ISI program, which is based on the methodology of the NRC-approved WCAP topical with a number of deviations previously considered and approved in the licensee's initial implementation of this program and is currently assessed by the staff as continuing to be consistently applied in the evaluation of this program for the third ISI interval, provides an acceptable level of quality and safety, and therefore, it is authorized for ASME Class 1 and 2 piping welds pursuant to 10 CFR 50.55a(a)(3)(i) for the third 10-year ISI interval, which began on November 19, 2005, and ends November 18, 2015.

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