January 19, 2001

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

SUBJECT: BROWNS FERRY UNIT 2, ASME CODE RELIEF FOR RISK-INFORMED INSERVICE INSPECTION OF PIPING (TAC NO. MA8873)

Dear Mr. Scalice;

By letter dated June 1, 2000, Mr. T. E. Abney, Tennessee Valley Authority (TVA), requested approval of an alternative risk-informed inservice inspection (RI-ISI) program for Browns Ferry Unit 2 (BFN2). The letter included a description of the proposed program. Additional clarifying information was provided in TVA's letters dated October 16, 2000, and December 13, 2000.

The BFN2 RI-ISI program is similar to the program approved for BFN3 on February 11, 2000. As such, it was developed in general accordance with Westinghouse Owners Group Topical Report WCAP-14572, Revision 1-NP-A, using the Nuclear Energy Institute template methodology. The results of our review indicate that your proposal is an acceptable alternative to the requirements of the American Society of Mechanical Engineers Code Section XI, and that implementation of the RI-ISI program will result in a reduction in piping weld examinations, with an associated reduction in occupational radiation exposure, with little or no change in risk to the public due to piping failures. However, the recent event at the V.C. Summer facility in which through-wall cracking was discovered in a 34-inch main coolant loop hot leg to reactor pressure vessel nozzle weld may call into question the conclusions that have been made regarding the frequency of large-bore piping examination. The U.S. Nuclear Regulatory Commission (NRC) staff will evaluate the results of the V.C. Summer root cause analysis to determine whether any generic conclusions apply to this evaluation, for example to the frequency of large-bore piping examination. If generic implications are found, the NRC staff will take actions, as appropriate.

Your request for relief is authorized pursuant to Title 10, Code of Federal Regulations (10 CFR), Section 50.55(a)(3)(i). Our safety evaluation is enclosed. If you have any questions regarding this matter, please contact Bill Long at 301-415-3026.

Sincerely,

/RA by R. Martin Acting For/
Richard P. Correia, Chief, Section 2
Project Directorate II
Division of Licensing Project Management

Docket No. 50-260

Enclosure: Safety Evaluation

cc: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RISK-INFORMED INSERVICE INSPECTION PROGRAM

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT, UNIT 2

DOCKET NO. 50-296

1.0 INTRODUCTION

Current inservice inspection (ISI) requirements for the Browns Ferry Nuclear Plant Unit 2 (BFN2) are contained in the 1989 Edition of Section XI, Division 1 of the American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code, entitled *Rules for Inservice Inspection of Nuclear Power Plant Components* (hereinafter called Code). In a submittal dated June 1, 2000, the licensee, Tennessee Valley Authority (TVA), proposed a new ISI program entitled "*Browns Ferry Nuclear Plant (BFN) - Unit 2 - Request for Approval of the BFN American Society of Mechanical Engineers (ASME) Section XI Alternative Inspection Program - Risk Informed Inservice Inspection (RI-ISI) Program TAC No. MA8873* (Ref. 1)." The program was developed in general accordance with the Westinghouse Owners Group (WOG) Topical Report WCAP-14572, Revision 1-NP-A (WCAP) (Ref. 2), which has been approved by the Nuclear Regulatory Commission (NRC, Commission) staff. Additional clarifying information was provided in revised submittals dated October 16, 2000 (Ref. 3) and December 13, 2000 (Ref. 4).

In the proposed RI-ISI program, piping failure potential estimates were determined using the computer code WinPRAISE which utilizes industry piping failure history, plant-specific piping failure history, and other relevant information. Using the failure potential and supporting insights on piping failure consequences from the licensee's probabilistic risk assessment (PRA), safety ranking of piping segments was established for determination of new inspection locations. The proposed program maintains the fundamental requirements of ASME Code Section XI, such as the examination technology, examination frequency and acceptance criteria. However, the proposed program reduces the required examination locations significantly and is able to demonstrate that an acceptable level of quality and safety is maintained. Thus, the proposed alternative approach is based on the conclusion that it provides an acceptable level of quality and safety and, therefore, is in conformance with Title 10, *Code of Federal Regulations* (10 CFR), Section 50.55a(a)(3)(i).

The NRC staff reviewed the licensee's proposed alternative of the ISI program for BFN2, and applicable portions of the WOG risk-informed topical report WCAP-14572, based on guidance stated in NRC documents (Refs. 5, 6 and 7). The staff evaluation is provided below.

2.0 SUMMARY OF PROPOSED APPROACH

The licensee is required to perform ISI of ASME Code Category B-F, B-J and C-F piping welds during successive 120-month (ten-year) intervals. Excluding piping exempted from volumetric and surface examination, currently all B-F welds, 25% of Category B-J welds, and 7.5% of C-F welds are selected for volumetric and/or surface examination based on existing stress analyses and cumulative usage factors.

The licensee submitted the application as an RI-ISI “template” application. Template applications are short overview submittals intended to expedite preparation and review of RI-ISI submittals that comply with a pre-approved methodology. The licensee proposed to implement the staff approved RI-ISI methodology delineated in WCAP-14572, Revision 1-NP-A with the following six deviations.

1. Calculation of Failure Rate: The WCAP methodology uses the Westinghouse Structural Reliability and Risk Assessment (SRRA) computer code to calculate failure rates. TVA uses the computer code WinPRAISE to calculate failure rates. The original version of this code (pc-PRAISE), a probabilistic fracture mechanics computer code for piping reliability analysis, was developed for the NRC. WinPRAISE is a Windows version of pc-PRAISE.

2. Definition of a segment: The WCAP process defines a segment as a length of pipe where the consequences of failure are the same for the entire length of pipe. TVA occasionally combines lengths of pipe with different consequences into a single segment.

3. Determination of Failure Rate for a Segment: In the WCAP process, the most susceptible failure mechanisms were postulated for each segment, and a failure probability was calculated using the most limiting condition for the segment. At TVA, failure rates are quantified for the individual elements in a segment, and the highest individual failure rate is used to determine segment risk.

4. Uncertainty Analysis: The WCAP advocates using a simplified uncertainty analysis to ensure that no low safety significant (LSS) segments could move into the high safety significance category when reasonable variations are considered. The TVA expert panel considered not only segments with a risk reduction worth (RRW)>1.005 as recommended in the WCAP as high safety significant (HSS), but also those in the range 1.005>RRW>1.001 as HSS, in lieu of performing any limited uncertainty analyses.

5. Inclusion of IGSCC [intergranular stress-corrosion cracking] Category “A” welds in the RI-ISI program: The WCAP methodology excludes changes to all augmented program inspections due to implementation of the RI-ISI program. The TVA includes changes to inspections of IGSCC Category “A” welds due to implementation of the RI-ISI program.

6. Structural Element Selection: In the WCAP methodology, selection of elements of low failure potential in Regions 1 and 2 of the Structural Element Selection Matrix is determined by a statistical evaluation process. At TVA, two methods are used to select the elements. For those elements with a quantified failure potential, the risk of the individual element was utilized in selecting examination locations. For those elements with no quantified failure potential, the existing examination requirements of Section XI were used.

Discussions and analyses addressing the deviations allowed the staff to conclude that the deviations were acceptable. All the deviations between the TVA methodology and the approved WCAP methodology are discussed in this safety evaluation (SE).
The licensee requested approval of this alternative for implementation during the spring 2001, Unit 2 refueling outage. According to the information provided in Refs. 2 and 3, BFN2 is currently in the second 10-year interval that started on May 24, 1992, and ends on May 24, 2001. The current period (third period of the interval) started on May 24, 1998, and ends on May 24, 2001.

The implementation of an RI-ISI program for piping would ideally be initiated at the start of a plant's 10-year inservice inspection interval consistent with the requirements of the ASME Code Section XI, Edition and Addenda committed to by the Owner in accordance with 10 CFR 50.55a. However, the implementation may begin at any point in an existing interval as long as the examinations are scheduled and distributed to be consistent with ASME XI requirements, e.g., the minimum examinations completed at the end of the three inspection periods under ASME Code, Section XI, Program B should be 16%, 50%, and 100%, respectively, and the maximum examinations credited at the end of the respective periods should be 34%, 67%, and 100%. In Ref. 3, the licensee stated that the ASME Code minimum and maximum inspection requirements will be met.

It is also the staff's view that the programs for the RI-ISI inspections (RI-ISIs) and for the balance of the inspections should be on the same interval start and end dates. This can be accomplished by either implementing the RI-ISI at the beginning of the interval or merging RI-ISIs into the program for the balance of the inspections if the RI-ISIs are to begin during an existing ISI interval. One reason for this view is that it eliminates the problem of having different Codes of record for the RI-ISIs and for the balance of the inspections. A potential problem with using two different interval start dates and hence two different Codes of record would be having two sets of repair/replacement rules depending upon which program identified the need for repair (e.g., a weld inspection versus a pressure test). In Ref. 3, the licensee stated that the RI-ISI inspections and the balance of the inspections will be on the same interval start and end dates.

Ref. 3 stated that the RI-ISI program for piping will be updated and resubmitted in conjunction with the update to existing ISI program at the expiration of the current 10 year interval and during periodic 10 year updates. Ref. 3 also stated that:

> ......*The BFN Unit 2 RI-ISI program would be resubmitted to the NRC for approval, before the end of the 10-year inspection interval, if the RI-ISI methodology and/or inspection program is changed as a result of new information such as:*
>
> *industry initiatives to change augmented inspection programs (including IGSCC)*
>
> *significant changes to the PRA*
>
> *significant inspection results*
>
> *new failure modes experienced by the industry*
>
> *major replacement activities resulting from materials degradation or failure*
>
> *significant plant design or operational changes*

> *The above is consistent with the requirements imposed by the NRC's SER for BFN Unit 3, dated February 11, 2000*.....

The staff finds that the BFN2 RI-ISI program meets the ASME XI requirements for minimum and maximum inspections during inspection periods and intervals.

3.0 EVALUATION

The licensee's submittal was reviewed with respect to the methodology and criteria contained in WOG Topical Report WCAP-14572, Revision 1-NP-A. Further guidance in defining acceptable methods for implementing an RI-ISI program is also provided in Regulatory Guide (RG) 1.174 (Ref. 5), RG 1.178 (Ref. 6), and Standard Review Plan (SRP) Chapter 3.9.8 (Ref. 7).

3.1 Proposed Changes to ISI Program

Pursuant to 10 CFR 50.55a(a)(3)(i), the licensee has proposed to implement Code Case N-577, *Risk-Informed Requirements for Class 1, 2, and 3 Piping, Method A*, with the more detailed provisions provided in WCAP-14572, Revision 1-NP-A, as an alternative to the Code examination requirements for piping systems for the BFN2. A general description of the proposed changes to the ISI program was provided in Section 3 of the licensee's submittal.

3.2 Engineering Analysis

In accordance with the guidance provided in RGs 1.174 and 1.178, an engineering analysis of the proposed changes is required using a combination of traditional engineering analysis and supporting insights from the PRA. As noted in the June 1, 2000, submittal, the licensee confirmed that their expert panel considered traditional engineering concerns during the worksheet review of the risk-based information for each pipe segment. In the submittal, the licensee provided a discussion on how traditional engineering analysis is used to ensure that the impact of the proposed ISI changes are consistent with the principles of defense-in-depth. In addition, TVA reviewed the program from a defense-in-depth perspective and decided that all segments that could result in a large loss-of-coolant accident (LOCA), regardless of actual risk value, would be selected for inspection. TVA stated in its submittal of June 1, 2000, that TVA's further review of the program from a defense-in-depth perspective included reconsideration of various degradation mechanisms and ASME Section XI, Code Class 2 welds, including welds in segments determined to be LSS. As a result of this review, a total of 12 welds was added to the proposed RI-ISI program.

The scope of the piping systems considered in the licensee's RI-ISI program was based upon guidance in the WCAP topical report which states that the scope should include:

(1) Class 1, 2, and 3 systems currently within the ASME Section XI program,
(2) Piping systems modeled in the Individual Plant Examination (IPE) for the plant, and
(3) Various balance of plant fluid systems determined to be of importance for the Maintenance Rule.

Systems in the scope of the current Section XI program were determined from Surveillance Instruction 2-SI-4.6.G, *Inservice Inspection Program* (Ref. 8), and current isometric drawings.

Systems modeled in the plant PRA were determined from the Browns Ferry IPE. Maintenance Rule system significance was determined from Browns Ferry Technical Instruction 0-TI-346, *Maintenance Rule Performance Indicator Monitoring, Trending, and Reporting* (Ref. 9). Table 3.1-1 of the submittal lists the various systems that were identified from the above determinations for inclusion in the RI-ISI scope, and the number of RI-ISI segments which were considered for each of these systems.

In the approved WOG topical report, WCAP-14572, Revision 1-NP-A, piping systems are divided into segments, with the segment boundaries selected according to failure consequences. Section 3 of the submittal states that some segments contain normally closed reactor coolant system isolation valves within a segment. The consequence of failures upstream or downstream of the valves during normal operation would have different local and plant-level consequences. This represents a deviation from the approved methodology. However, the licensee stated that, for these segments, the segment part with the highest consequences was used to represent the segment in all calculations. Characterizing the risk significance of a combined segment with the risk of the most risk significant segment is a simplification that introduces some conservatism into the analysis. The conservatism will not prevent the identification of any risk significant segment and is, therefore, acceptable.

In accordance with the WCAP methodology, the licensee reviewed the failure history of piping systems at BFN2 and industry experience to analyze each system for parameters indicative of particular degradation mechanisms. The licensee noted that their submittal deviated from the approved WCAP methodology in two areas related to the determination of failure probabilities for the pipe segments:

The WCAP process postulates the worst-case parameters (e.g., most susceptible failure mechanisms and stress levels) within the segment and then calculates a failure probability using the most limiting condition for the segment. At TVA, failure rates are quantified for each individual element in a segment, and the highest individual failure rate is used to determine segment risk. This represents a deviation from the approved methodology. Studies performed for BFN3 RI-ISI program (Ref. 10) indicated that the TVA method produced results equivalent to those of the approved WCAP methodology. BFN3 is a boiling-water reactor similar to BFN2 and the risk at both units is dominated by IGSCC with few other damage mechanisms identified. Therefore, it is reasonable to assume that results equivalent to the approved WCAP methodology would also be obtained for BFN2 and it is not necessary to repeat the sensitivity study for BFN2.

The WCAP methodology uses the Westinghouse SRRA computer code to calculate failure rates. TVA used the WinPRAISE computer code to calculate failure rates where applicable; if not applicable, deterministic methods were used. The use of the WinPRAISE computer code represents a deviation from the approved methodology. During the review of the BFN3 RI-ISI program (Ref. 10), the staff and its consultant reviewed the documentation and calculations related to the determination of failure frequencies for piping segments using the WinPRAISE code. The staff found that on the whole the methods used to estimate failure frequencies were consistent with those described in the WOG Topical Report. The WinPRAISE and SRRA codes are based on similar methods and have been shown in past studies to predict similar values of failure probabilities if input parameters are assigned the same values for each code.

Probabilistic fracture mechanics calculations do not give exact values of failure probabilities, but rather are subject to many uncertainties associated with uncertain inputs to the calculations as well as uncertainties in the fracture mechanics models themselves. However, the frequencies developed from the application of WinPRAISE have similar characteristics to those developed from SRRA. The staff has found that the frequencies developed from SRRA are adequate for use in RI-ISI methodology. The output of the WinPRAISE code is best described as a quantitative estimate illustrating the susceptibility of a pipe segment to failure as determined by the weld material and environmental conditions within the segment. In light of the magnitude of uncertainties, the staff believes that the output of the WinPRAISE code may better be recognized as providing relative values of susceptibility of piping segments to failure. The staff finds that the licensee's definition of susceptibility of piping segments to failure is an appropriate characterization of the WinPRAISE output. The estimate of failure probability is a reasonable indication of the relative material and environmental properties of each segment such that, subject to final review and approval of the weld selection process and results by an expert panel, the estimates are acceptable for use to support an RI-ISI change request.

The consequences of the postulated pipe segment failures considered include both direct and indirect effects of each segment's failure. Direct effects always include a diversion of flow large enough to disable a train, disable a system, trip the reactor, or any combination. The BFN2 application is a full scope application that covers much of the piping at the plant. In some cases, TVA screened out parts of some systems from the detailed consequence analysis. These include normally isolated and unused system parts, and some system parts whose failure would not result in the loss of function of important equipment.

Early in plant life, the Browns Ferry units were subjected to an extended shutdown. In preparation for restart, the licensee evaluated the spatial effects of high energy pipe ruptures (Ref. 11 and 12). The evaluations included walkdowns, listing of each target and each protective device, a description of the postulated interaction, and an evaluation and classification of indirect effects. The licensee stated that the corrective actions resulting from these studies reconciled all potential effects of high energy line break. Potential spatial effects from the failure of low pressure piping were evaluated through walkdowns to support the RI-ISI analysis.

The approved WCAP methodology requires that a range of piping failure modes be used, that is, leaks, disabling leak, or rupture. The WCAP methodology further defines which consequential failure effects can be expected for each failure mode. For example, spray effects from a small leak could cause consequential failure of nearby electrical equipment, but not the diversion of sufficient flow to disable the leaking pipe's function. The three failure sizes were used in the WCAP because unstable structural failure (causing a rupture) almost always requires an unusual loading and, therefore, limited structural failure (causing a small or large leak) is the most likely failure mode. The structural mechanical models in the WinPRAISE computer code reflect this property and ruptures are calculated to occur much less frequently than leaks.

The BFN2 RI-ISI methodology deviates from the WCAP methodology in that it only evaluates one leak size, i.e., large leak. However, all possible spatial effects are applied when determining the consequential failure effects of each leak. During the December 1-2, 1999, audit of the BFN3 submittal (Ref. 10), the staff found that large leak rates were assigned on the basis of a percentage of the full flow rates for the particular piping segment being addressed in each WinPRAISE calculation. The staff believes that the current state-of-the-art in both pipe failure modeling and in consequential failure effects determination, while sufficient to support RI-ISI applications, is not precise enough to clearly require the more detailed failure mode evaluation.

The staff recognized this lack of precision when it developed RG 1.178 and SRP 3.9.8, which allow for the use of a single pipe break size, as long as all possible spatial effects are included. The BFN2 evaluation is consistent with RG 1.178 and SRP 3.9.8 and is an acceptable deviation from the WCAP methodology.

3.3 Probabilistic Risk Assessment

The June 1, 2000, RI-ISI submittal reported a core damage frequency (CDF) of 5.39E-6/yr and a large early release frequency (LERF) of 1.83E-6/yr. The BFN2 IPE was docketed in September 1992. TVA docketed a multi-unit IPE in August 1995, and a Unit 3 IPE in June of 1996. The June 1996, Unit 3 IPE (BFNU3M) represented the site configuration for Unit 2 and Unit 3 operating and Unit 1 shutdown. The licensee reported that they used the Unit 2 model (BFNU2M) to support the June 1, 2000, submittal. The Unit 2 submittal discussed the Probabilistic Safety Analysis (PSA) Peer Review Certification Team review, administered under the auspices of the Boiling Water Reactor Owners Group Peer Certification Committee, that was also discussed in the Unit 3 Submittal (Ref. 10). The submittal also reported that the differences between the results of Unit 2 and the previous Unit 3 Submittal (Ref. 10) primarily reflect the ability of Unit 2 to cross connect residual heat removal system with both Unit 1 and Unit 3, while Unit 3 could only cross connect with Unit 2.

TVA has submitted an evaluation of external events in its IPE of external events in June 1995, June 1996, and August 1997. TVA stated in the RI-ISI submittal that the functions and the corresponding piping segments required to maintain the plant in a shutdown configuration were explicitly and systematically considered by the expert panel. The seismic stresses were included in the failure likelihood calculation for each segment. The staff finds the scope of the PRA acceptable because initiating events and operating modes outside the scope of the PRA were systematically included in the safety significance determination process.

The staff did not review the PRA to assess the accuracy of the quantitative results. Quantitative results of the PRA are used, in combination with a quantitative characterization of the pipe segment failure likelihood, to support the development of broad safety significance categories reflecting the relative impact of pipe segment failures on CDF and LERF. The safety significance categories determined from the PRA are considered, together with the individual weld or element failure likelihood, to support the determination of the number of elements to inspect in each segment. Inaccuracies in the PRA models, or assumptions large enough to invalidate the broad categorizations developed to support RI-ISI, should have been identified in the licensee or the staff reviews. As discussed in Ref. 10, the staff found that the quality of the BFN3 PRA is adequate to support the submittal because any minor errors or inappropriate assumptions which might remain in the models would only affect the consequence calculations of a few segments and should not invalidate the general results or conclusions. The staff finds that the quality of the BFN2 PRA model (BFNU2M) appears to be consistent with the quality of the BFN3 PRA model (BFNU3M) and is, therefore, adequate to support this RI-ISI submittal.

The approved WCAP methodology does not change augmented examination requirements. In the WCAP methodology, the reduction in a segment's failure potential caused by augmented program inspections of locations within the segment is included in the "without credit for inservice inspection" calculations. The failure potential and the safety significance of segments with locations inspected under the current augmented programs are lower when the inspections are credited. TVA will change the location and frequency of inspections of IGSCC Category "A" welds upon implementation of this RI-ISI program. Therefore, reduction in failure potential caused by IGSCC Category “A” inspection of locations within a segment is not included in TVA’s “without credit for inservice inspection” calculations. This is a deviation from the approved methodology that leads to higher failure potential and, thus, higher risk significance for segments with locations currently inspected within the IGSCC Category “A” program. This deviation from the WCAP methodology is necessary to properly characterize the safety significance of segments with Category “A” locations so that the inspections can be targeted at higher safety significant locations and is acceptable. All other IGSCC inspections are credited in the “without credit for inservice inspection” as required in the WCAP methodology.

Each segment has a total of four RRW values. The WCAP states that segments with any one of the four RRW values greater than1.005 are deemed HSS, and that segments with any RRW value between 1.001 and 1.004 are placed in a medium category and deemed worthy of special consideration by the expert panel. TVA deviated from the RRW guidelines in the WCAP. They did not use the medium category, but used the RRW guideline of 1.001 as the lower boundary for the HSS category. That is, segments with any RRW>1.001 are deemed HSS for consideration by the expert panel.

Use of the RRW guideline of 1.001 as the lower boundary for HSS segments instead of the 1.005 used by the WCAP means that TVA will classify a larger number of segments as HSS from a given population. Two related deviations from the WCAP methodology are that (1) TVA did not perform a sensitivity study required by the WCAP and (2) they did not calculate the Risk Achievement Worth (RAW) and provide it to the expert panel. These deviations are discussed below.

The approved WCAP methodology requires that a sensitivity study be done where uncertainty distributions are assigned to the segment failure likelihoods and the PRA results. The aim of the study is to investigate the potential movement of segments from low to high based on variation in the quantitative inputs and the guideline values defining the high, medium, and low RRW ranges. Experience with the pilot study indicated that no segments moved from low (RRW<1.001) to high (RRW>1.005) safety significance due to the sensitivity study. Therefore, TVA’s use of the lower RRW guideline of 1.001 should identify all segments that might have moved from medium to high safety significant during the sensitivity study.

The WCAP states that the RAW should be calculated and provided to the expert panel, but there are no guidelines in the WCAP on what value of RAW constitutes an HSS segment. The TVA submittal stated that the expert panel classified any segment that would result in a large LOCA if failed as an HSS segment, regardless of the RRW. The staff finds that this is sufficient evidence that the expert panel was sensitive to the potential consequences of segment failure, and sensitivity to the consequences was the reason the WCAP includes the RAW estimate for consideration by the expert panel.

The staff finds that the conservatism in the use of the lower RRW value provides reasonable assurance that, even with these two deviations from the approved WCAP method, the TVA methodology will tend to select the same, or almost the same, set of HSS segments from a given population as would the application of the WCAP methodology and the deviations are, therefore, acceptable.

Operator actions to isolate a break and mitigate the spatial consequences of the break are included in the RI-ISI analysis. For example, an operator closing a motor-operated valve (MOV) will stop the loss of water from a break downstream of the MOV. The WCAP method requires that the change in CDF and change in LERF calculations be performed twice; once assuming all such actions are successful (failure probability of 0.0), and once assuming that all such actions fail (failure probability of 1.0). These estimated changes in risk are used as described in Section 4.4.2 of the WCAP to illustrate the acceptability of the proposed change in the ISI program. TVA estimated the change in risk calculation assuming that all such operator actions fail. However, TVA did not estimate the change in risk assuming that all actions are successful but, instead, calculated a best estimate CDF and LERF. The best estimate CDF and LERF value for each segment includes or excludes the impact of operator actions depending on the judgment of the expert panel. That is, each potential operator action was evaluated by the expert panel and it decided if the success or the failure of the operator action was the most appropriate assumption. The intent of the change in risk calculations assuming that all operator actions are successful is to illustrate the change in risk that includes the potential impact of the plant personnel's attempts to control and mitigate the rupture. The staff finds that the best estimate CDF and LERF, as defined in the submittal, also illustrates the change in risk reflecting the potential impact of actions by the plant personnel and is, therefore, an acceptable alternative.

The licensee reported that the change in risk associated with the implementation of the RI-ISI program is risk neutral because the estimated change in risk was in the third and forth significant digits for the estimated LERF and CDF, respectively, due to pipe failures. In Ref. 3 the licensee reported a maximum increase in CDF of about 2E-9/yr. In Ref. 4 the licensee reported a maximum increase in LERF of about 1E-9/yr. The staff believes that Refs. 3 and 4 illustrate that implementation of the RI-ISI program may be accompanied by a very slight increase in risk. Criterion 1 in Section 4.4.2 of the WCAP suggests that the total change in piping risk should be risk neutral or a risk reduction in moving from the current inspection program to an RI-ISI program. However, the change in risk estimate indicates that any risk increase is expected to be well below the guidelines in RG 1.174 and 1.176 and is, therefore, acceptable.

3.4 Integrated Decision Making

As described in the BFN2 submittal, an integrated approach is utilized in defining the proposed RI-ISI program by considering in concert the traditional engineering analysis, risk evaluation, and the implementation and performance monitoring of piping under the program. This is in compliance with the guidance of RG 1.178.

In the BFN2 RI-ISI program, integrated decision making is done, at the highest level, by the expert panel. It was the same panel that reviewed the BFN3 program which included personnel who had the expertise in the following fields; PSA, ISI, nondestructive examination, stress and material consideration, plant operations, system design and operation, plant and industry maintenance, repair, and failure history.

The expert panel assigned seven segments as LSS that would, according to TVA's RRW selection criteria, normally be HSS for the "without operator action" scenarios. TVA provided detailed information about the sequence of events following the rupture of any of these segments. TVA stated that the plant personnel would have at least 20 hours to detect and mitigate leaks in these segment before structures, systems, and components would be failed due to flooding and, therefore, the expert panel was justified in placing these segments in LSS. TVA also performed a defense-in-depth review of the BFN2 RI-ISI program. This review included consideration of various degradation mechanisms and ASME Section XI, Code Class 2 welds, including welds in segments determined to be LSS. As a result of this review, 12 welds were added to the proposed inspection program as shown in Table 3.8.1 of the submittal. Three of the proposed additional welds were selected for thermal fatigue in ASME Class 1 systems which consist of two in the feedwater system and one in the reactor water cleanup system. Nine of the 12 welds were added for ASME Class 2 systems.

The TVA method to select locations to inspect within segments deviates from the approved WCAP methodology. HSS piping segments are placed in Region 1 or 2 of Figure 3.7-1 in the WCAP topical report. Region 3 and 4 pipe segments are LSS, and are considered in “Owner Defined Program” outside of the scope of the RI-ISI program. As illustrated in Figure 3.7-1 of the WCAP, HSS locations in segments in Region 1 are further subdivided into regions 1A and 1B based on exposure to a degradation mechanism (region 1A) or no exposure to any degradation mechanism (region 1B). The WCAP requires that all locations placed in region 1A be inspected. If the location is already being inspected in an augmented program, such as flow-accelerated corrosion (FAC), that inspection is sufficient. Finally, the WCAP specifies that a statistical sampling technique may be used to determine how many locations should be inspected in Region 1B and within all segments in Region 2.

Instead of the methods described in the WCAP, TVA calculates the RRW value for each location in each HSS segment in Regions 1A, 1B, and 2. Any individual location in each HSS segment with a RRW>1.001 is considered for inspection. Locations within HSS segments with calculated failure rates of 0.0 are grouped, and the ASME selection criteria is applied to the group. That is, if the locations are ASME Class 1, 25% of this group is selected. Locations in LSS segments that could cause a large LOCA are selected by the expert panel. Locations exposed to degradation mechanisms in LSS segments that were chosen to provide coverage of all degradation mechanisms are also selected by the expert panel.

The staff believes this is a reasonable alternative to the WCAP selection process. All segments with RRW>1.001 will be placed in HSS and there is no further subdivision of these segments into two regions. The highest location’s failure probability is used to represent the segment failure rate so that location, at least, will have an RRW>1.001. This is consistent with the statistical method’s result that at least one weld is inspected in each segment. Furthermore, locations exposed to degradation mechanisms within the segment tend to have relatively high failure rates and, thus, relatively high RRW’s. The submitted results show that most HSS segments had multiple inspection locations. This is consistent with the WCAP’s recommendation to inspect all locations in Region 1A subjected to a degradation mechanism. The staff finds the location selection process consistent with the process approved for the WCAP and, therefore, acceptable.

All four regions continue to receive ASME Code-required system pressure testing and visual examination as part of the current ASME Section XI program. For the 393 piping segments that were evaluated in the BFN2 RI-ISI program, Region 1 contains 31 segments, Region 2 contains five segments, Region 3 contains 92 segments, and Region 4 contains 265 segments. The examinations determined originally for the BFN2 RI-ISI Program included few non-augmented ASME Section XI welds. The reason for this result is the relatively high failure rates associated with IGSCC and FAC which causes segments exposed to these degradation mechanisms to dominate the estimated risk.

Based on the rationale discussed in the submittal, it is concluded that the licensee has provided adequate justification for element selection and sample sizes. The staff finds the location selection process to be acceptable since it is consistent with the process approved for the WCAP, takes into account defense-in-depth, and includes coverage of systems subjected to degradation mechanisms in addition to those covered by augmented inspection programs.

The WCAP provides that the HSS piping structural elements should be examined in accordance with the requirements as taken directly out of ASME Code Case N-577 for the areas and/or volumes of concern at each location. The examination methods selected by the licensee are based on Code Case N-577, Table 1. Table 1 of Code Case N-577 provides the specific requirements for Category R-A, Risk-Informed Piping Examinations. This category is subdivided into Item Numbers R1.11 through R1.18, based on degradation modes and specific examination requirements for each mode. The licensee has determined that the degradation mechanisms applicable to the RI-ISI program are: R1.11 - Elements Subject to Thermal Fatigue, R1.16 - Elements Subject to IGSCC and R1.18 - Elements Subject to FAC.

Based on review of the cited portion of Code Case N-577 and the examination methods specified in the licensee's Inspection Plan, the staff concludes that the examination methods are appropriate since they are selected based on specific degradation mechanisms, pipe sizes and materials of concern. This evaluation does not endorse the use of Code Case N-577 in its entirety.

3.5 Implementation and Monitoring

Implementation and performance monitoring strategies require careful consideration by the licensee, and are addressed in Element 3 of RG 1.178 and SRP 3.9.8. The objective of Element 3 is to assess performance of the affected piping systems under the proposed RI-ISI program by implementing monitoring strategies that confirm the assumptions and analyses used in the development of the RI-ISI program. To approve an alternative pursuant to 10 CFR 50.55a(a)(3)(i), implementation of the RI-ISI Program, including inspection scope, examination methods, and methods of evaluation of examination results, must provide an adequate level of quality and safety.

The WCAP recommends that implementation of an RI-ISI program for piping be initiated at the start of a plant’s 10-year ISI interval but allows that implementation can begin at any point in an existing interval as long as the examinations are scheduled consistent with the requirements of the ASME Code Section XI, Edition and Addenda committed to by an Owner in accordance with 10 CFR 50.55a. The WCAP topical report indicates that examinations and system pressure tests may be performed during either system operation or plant outages, such as refueling outages or maintenance outages. The licensee has stated that the frequency of examinations will be scheduled per the existing augmented programs to satisfy the requirements of Table 1 of Code Case N-577. The proposed examination frequency is provided in Table 3.8-2 of the submittal.

The licensee stated in Section 4 of the submittal that a proposed revision to TVA BFN2 Surveillance Instruction 2-SI-4.6.G has been written to implement and monitor the RI-ISI program. Upon approval, the new program would be integrated into the existing ASME ISI program. The licensee also stated that the proposed monitoring and corrective action program will include periodic updates as well as consideration of any plant changes, plant-specific feedback, or NRC requirements that may require more frequent adjustment of the RI-ISI program. The staff concludes that the licensee has incorporated the results of its RI-ISI evaluation into a plant-specific program procedure that is consistent with the performance-based implementation and monitoring strategies specified in RG 1.178 and ASME Code Section XI.

The licensee stated in Section 4 of the submittal that the RI-ISI program is a living program and its implementation will require feedback of new relevant information to ensure the appropriate identification of HSS piping locations. The submittal also states that, as a minimum, risk ranking of piping segments will be reviewed and adjusted on an ASME-period basis and that significant changes may require more frequent adjustment as directed by NRC requirements or plant specific feedback.

The proposed periodic reporting requirements meet existing ASME Code requirements and applicable regulations and, therefore, are considered acceptable. The proposed process for RI-ISI program updates meets the guidelines of RG 1.174 that provide that risk-informed applications must include performance monitoring and feedback provisions; therefore, the process for program updates is considered acceptable.

4.0 CONCLUSIONS

In accordance with 10 CFR 50.55a(a)(3)(i), proposed alternatives to regulatory requirements may be used when authorized by the NRC when the applicant demonstrates that the alternative provides an acceptable level of quality and safety. In this case, the licensee's proposed alternative is to use risk-informed process described in the NRC-approved Westinghouse Owners Group Report WCAP-14572, Revision 1-NP-A, with some deviations. The impact of the identified deviations from the WCAP methodology on the licensee’s results and conclusions have been evaluated by TVA and the staff. The staff concludes that the TVA’s proposed RI-ISI program as described in WCAP-14572, Revision 1-NP-A, with the deviations identified in this SE will provide an acceptable level of quality and safety pursuant to 10 CFR 50.55a for the proposed alternative to the piping ISI requirements with regard to the number of inspections, locations of inspections, and methods of inspection.

The staff finds that the results of the different elements of the engineering analysis are considered in an integrated decision-making process. The impact of the proposed change in the ISI program is founded on the adequacy of the engineering analysis and acceptable change in plant risk in accordance with RG 1.174 and 1.178 guidelines.

The BFN2 methodology also considers implementation and performance monitoring strategies. Inspection strategies ensure that failure mechanisms of concern have been addressed and there is adequate assurance of detecting damage before structural integrity is affected. The risk significance of piping segments is taken into account in defining the inspection scope for the RI-ISI program.

System pressure tests and visual examination of piping structural elements will continue to be performed on all Class 1, 2, and 3 systems in accordance with the ASME Code Section XI program. The RI-ISI program applies the same performance measurement strategies as existing ASME Code requirements and, in addition, increases the inspection volumes at weld locations.

BFN2 methodology provides for conducting an engineering analysis of the proposed changes using a combination of engineering analysis with supporting insights from a PRA. Defense-in-depth and quality are not degraded in that the methodology provides reasonable confidence that any reduction in existing inspections will not lead to degraded piping performance when compared to existing performance levels. Inspections are focused on locations with active degradation mechanisms as well as selected locations that monitor the performance of system piping.

The licensee has stated that the ASME XI Code minimum and maximum inspection requirements for Program B will be met and that the RI-ISI inspections and the balance of the inspections will be on the same interval start and end dates. The licensee has also stated that BFN2 would continue to submit its 10-year interval ISI program including the RI-ISI program every 10 years. The licensee has also stated in Ref. 3 that BFN2 would submit the revised RI-ISI program prior to the end of the interval if relief requests are required from certain aspects or if there are program changes that require NRC approval similar to the practice under the current ASME XI program. The staff finds that the BFN2 RI-ISI program meets the ASME XI requirements for minimum and maximum inspections during inspection periods and intervals. The staff also finds that the BFN2 RI-ISI program meets the 10 CFR 50.55a requirements for submitting relief requests to the NRC.

5.0 <u>REFERENCES</u>

1. Letter, dated June 1, 2000, T. E. Abney (TVA Manager of Licensing and Industry Affairs), to U.S. Nuclear Regulatory Commission, containing *Browns Ferry Nuclear Plant (BFN) - Unit 2 - Request for Approval of the BFN American Society of Mechanical Engineers (ASME) Section XI Alternative Inspection Program - Risk Informed Inservice Inspection (RI-ISI) Program TAC No. MA8873*.

2. WCAP-14572, Revision 1-NP-A, *Westinghouse Owners Group Application of Risk-Informed Methods to Piping Inservice Inspection Topical Report*, February 1999.

3. Letter, dated October 16, 2000, T. E. Abney (TVA Manager of Licensing and Industry Affairs), to U.S. Nuclear Regulatory Commission, containing *Browns Ferry Nuclear Plant (BFN) - Unit 2 - Proposed Risk-Informed Inservice Inspection (RI-ISI) Program - Response to NRC Request for Additional Information.*

4. Letter, dated December 13, 2000, T. E. Abney (TVA Manager of Licensing and Industry Affairs), to U.S. Nuclear Regulatory Commission, containing *Browns Ferry Nuclear Plant (BFN) - Unit 2 - Proposed Risk-Informed Inservice Inspection (RI-ISI) Program - Supplemental Response to NRC Request for Additional Information.*

5. U.S. Nuclear Regulatory Commission, "An Approach for Using Probabilistic Risk Assessment in Risk-Informed Decisions on Plant-Specific Changes to the Licensing Basis," Regulatory Guide 1.174, July 1998.

6. NRC Regulatory Guide 1.178, *An Approach for Plant-Specific Risk-Informed Decision Making: Inservice Inspection of Piping*, September 1998.

7. Standard Review Plan (SRP) Chapter 3.9.8, *Standard Review Plan for Trial Use for the Review of Risk-Informed Inservice Inspection of Piping*, NUREG-0800, May 1998.

8. TVA Surveillance Instruction 2-SI-4.6.G, Inservice Inspection Program.

9. Browns Ferry Technical Instruction 0-TI-346, *Maintenance Rule Performance Indicator Monitoring , Trending, and Reporting*.

10. Letter, dated February 11, 2000, Richard P. Correia (U.S. Nuclear Regulatory Commission) to J. A. Scalice (TVA Chief Nuclear Officer and Executive Vice President) containing Safety Evaluation by NRR on the Risk Informed Inservice Inspection (RI-ISI) Program for the TVA Browns Ferry Nuclear Plant, Unit 3.

11. “Pipe Rupture Evaluation Program for Inside and Outside Primary Containment for the Browns Ferry Nuclear Plant Units 2 and 3,” Tennessee Valley Authority Office of Engineering, Civil Engineering Branch (CEB) Report Revision 4, February 19, 1998, Report Number: CEB 88-06-C

12. “Pipe Rupture Evaluation for The BFNP Unit 2 Restart,” Revision 3, BFN Civil Engineering Branch April 13, 1998.

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