August 27, 2004

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

SUBJECT: SAFETY EVALUATION OF REQUEST FOR RELIEF 1-RR-05 ON THE USE OF CODE CASE N-597-1 TO EVALUATE PIPE WALL THINNING AT WATTS BAR NUCLEAR POWER PLANT, UNIT 1 (TAC NO. MC1580)

Dear Mr. Singer:

By letter to the U.S. Nuclear Regulatory Commission dated December 17, 2003 (ADAMS Accession No. ML040070165), as supplemented by letter dated July 5, 2004 (ML041960388), Tennessee Valley Authority (TVA) submitted Relief Request 1-RR-05, Application of Code Case N-597-1 Requirements for Analytical Evaluation of Pipe Wall Thinning for the Watts Bar Nuclear Plant (WBN), Unit 1. The submittal, in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.55a(a)(3)(i), requested relief from the American Society of Mechanical Engineers (ASME) Section XI requirements to repair or replace an ASME Class 2 carbon steel piping elbow associated with the main feedwater system at its WBN, Unit 1. Instead, the licensee proposed to use the provisions of ASME Code N-597-1 to analytically evaluate the potential pipe wall thinning projected to take place by using WBN computer software program CHECWORKS.

Based on our review of your submittal, we have concluded that the proposed alternative is authorized, pursuant to 10 CFR 50.55a(a)(3)(i), for the duration of the current operating Cycle 6 for the WBN, Unit 1.

For continued operation until the end of Cycle 7, additional relief will be required. If such a relief request is submitted, the licensee must demonstrate that the structural integrity and safety of the degraded elbow will be ensured by performing a stress analysis, using the set of Ultrasonic Testing data recorded during the Cycle 6 Refueling Outage and projected to the end of Cycle 7. The stress analysis should be based on the licensing basis methodology that was approved by the staff in the resolution of Watts Bar Licencing Issue 20(a), and documented in Supplement No. 16 of NUREG-0847, “Watts Bar Safety Evaluation Report,” in accordance with the provisions of Code Case N-597-1 for piping stress analysis.

All other ASME Code Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

Sincerely,

/RA/

Michael L. Marshall, Jr., Acting Chief, Section 2
Project Directorate ll
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-390

Enclosure: Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

REQUEST FOR RELIEF 1-RR-05

USE OF CODE CASE N-597-1 TO EVALUATE FEEDWATER PIPING

TENNESSEE VALLEY AUTHORITY

WATTS BAR NUCLEAR PLANT, UNIT 1

DOCKET NO. 50-390

1.0 INTRODUCTION

By letter dated December 17, 2003 (ADAMS Accession No. ML040070165), Tennessee Valley Authority (TVA, the licensee) requested, pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 50.55a(a)(3)(i), relief from the American Society of Mechanical Engineers (ASME), Boiler and Pressure Vessel Code (Code), Section XI, requirements to repair or replace an ASME Class 2 carbon steel piping elbow associated with the main feedwater system at its Watts Bar Nuclear Power Plant (WBN), Unit 1. Instead, the licensee proposed to use the provisions of ASME Code N-597-1, "Requirements for Analytical Evaluation of Pipe Wall Thinning," to analytically evaluate the potential pipe wall thinning that was projected to take place with its Watts Bar computer software program CHECWORKS. The staff reviewed TVA's request for relief and requested additional information (RAI) from TVA. TVA responded to the staff's RAI in its letter dated July 9, 2004 (ADAMS Accession No. ML041960388). In addition, the staff conducted several telephone conferences to clarify issues associated with TVA's piping calculations.

TVA stated that during implementation of WBN, Unit 1, Cycle 5 Refueling Outage (RFO) Flow Accelerated Corrosion (FAC) Program, ultrasonic testing (UT) detected a thin location in an ASME Code Class 2 main feedwater piping elbow at the steam generator Loop 2 inlet nozzle. As a result, a map of the thin areas was made using UT thickness measurements. The UT data was evaluated by the Watts Bar CHECWORKS program and by analytical methods. Based on the UT thickness measurements, predicted wear rate, and analytical analysis, it was determined that the predicted wall thickness (t_p) will fall below the required minimum wall thickness (t_{min}) 11 months after startup from the Cycle 5 RFO. However, the analysis demonstrated that the elbow meets the alternative evaluation criteria of ASME Code Case N-597-1, Section-3600. This condition was documented on a Problem Evaluation Report (PER) in Watts Bar's Corrective Action Program. Specifically, the Cycle 5 RFO UT measurements of the elbow found the current wall thickness (t_{meas}) to be 0.639 inches. Using an estimated wall

ENCLOSURE

thinning rate of 0.025 inches/year (0.0375 inches/18 month cycle) (plus a 10 percent safety factor), the predicted wall thickness t_p at the Cycle 6 RFO was calculated to be 0.598 inches.

The allowable minimum wall thickness t_{min} as calculated by the equation specified in Code Case N-597-1 Paragraph -3622.1(a)(1) is 0.613 inches. The remaining three steam generator elbows to the inlet nozzles were ultrasonically examined and were found acceptable.

2.0 REGULATORY EVALUATION

It specifies in 10 CFR 50.55a(g) that inservice inspection (ISI) of nuclear power plant components shall be performed in accordance with the requirements of the ASME Code, Section XI, except where specific written relief has been granted by the Nuclear Regulatory Commission (NRC) pursuant to 10 CFR 50.55a(g)(6)(i). As stated in 10 CFR 50.55a(a)(3), alternatives to the requirements of paragraph (g) may be used, when authorized by the NRC, if (i) the proposed alternatives would provide an acceptable level of quality and safety or (ii) compliance with the specified requirements would result in hardship or unusual difficulty without a compensating increase in the level of quality and safety. WBN, Unit 1, is currently in the first 10-year ISI interval and the1989 Edition of ASME Code, Section XI governs the current repair and replacement activities at WBN, Unit 1.

It states in 10 CFR 50.55a(g)(5)(iii) that if the licensee has determined that conformance with certain code requirements is impractical for its facility, the licensee shall notify the Commission and submit a report, as specified in Section 50.4, to support the determination.

2.1 Code Requirement for Which Relief is Requested

ASME Section XI, 1989 Edition, IWA-4300 provides a process for assessing a component for continued service after a defect has been removed. This provision stipulates that where the section thickness has been reduced below the minimum design thickness, the component shall be repaired. As an alternative, the component may be evaluated and accepted in accordance with the design rules of either the Construction Code or Section III.

2.2 Component Identification

FAC Grid 103BE252, Class 2, 16-inch nominal pipe size feedwater pipe mitered 45-degree elbow at the inlet to Loop 2 Steam Generator, located in main feedwater system piping at WBN, Unit 1.

2.3 Basis for Relief and Proposed Alternative:

Regulatory Guide (RG) 1.147, Revision 13, conditionally accepted the use of Code Case N-597-1 subject to five conditions. Some of these conditions require prior NRC review and approval to continue to use the Code Case N-597-1. As an alternative to the requirements of ASME Section XI, 1989 Edition, IWA-4300, TVA proposes to use the provisions of the ASME Code Case N-597-1 for analytical evaluation of the main feedwater piping, FAC grid 103BE252, subject to the conditions incorporated into the acceptance of the Code Case in RG 1.147, Revision 13.

3.0 TECHNICAL EVALUATION

3.1 Licensee's Evaluation

Summary:

During implementation of WBN, Unit 1, Cycle 5 RFO FAC Program, UT detected a thin location in an ASME Code Class 2 main feedwater piping elbow at the steam generator Loop 2 inlet nozzle. A "topography map" of the thin areas was made using UT thickness measurements and the UT data was evaluated both by CHECWORKS and analytical methods. Based on the UT thickness measurements, predicted wear rate, and analytical analysis, it was determined that the predicted wall thickness (t_p) will fall below the required minimum wall thickness (t_{min}) 11 months after startup from the Cycle 5 RFO. However, analysis demonstrates the elbow meets the alternative evaluation criteria of ASME Code Case N-597-1, Section -3600. This condition was documented on a PER in Watts Bar's Corrective Action Program. The remaining three steam generator elbows to the inlet nozzles were ultrasonically examined and found acceptable.

The UT of the elbow during Cycle 5 RFO found the current wall thickness (t_{meas}) to be 0.639 inches. Using an estimated wall thinning rate of 0.025 inches/year (0.0375 inches/18-month cycle) (plus a 10 percent safety factor), the predicted wall thickness t_p at the Cycle 6 RFO is calculated to be 0.598 inches.

The allowable minimum wall thickness t_{min} as calculated by the equation specified in Code Case N-597-1, paragraph 3622.1(a)(1), is 0.613 inches. As noted, the predicted wall thickness t_p of 0.598 inches will fall below the allowable minimum wall thickness t_{min} of 0.613 inches. The minimum wall thickness is greater than ninety percent of the minimum wall thickness t_{min} as allowed by the provision of the Code Case. Thus, TVA is requesting review and approval for application of the Code Case N-597-1 as allowed by the conditions of RG 1.147, "Inservice Inspection Code Case Acceptability, ASME Section XI, Division 1, Revision 13."

Application of the Code Case provides an acceptable level of quality and safety for this application. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), TVA is requesting approval of this request for relief (1-RR-05) to use the Code Case N-597-1.

Justification for Granting Relief:

A copy of the UT data obtained during the Cycle 5 RFO as printed from the CHECWORKS program is shown in Enclosure 1, Attachment 2 of TVA submittal dated December 17, 2003. The blank locations are either obstructions or places where the UT examiner was unable to properly place the transducer due to obstructions in confined access space. In addition to performing the normal FAC UT for thickness on the grid, a 100 percent UT scan at the toe of the weld (TOW scan) was performed. The lowest thickness reading and its location were recorded. The location of the "A1" (grid origin) is approximately at the top of the horizontal portion of the elbow on the upstream end (end opposite that viewed in Enclosure 1, Photo 3 of TVA submittal dated December 17, 2003). This places Row "E" at the intrados and Row "N" at the extrados. With the configuration of this portion of the pipe loop, it would be expected that wear would occur in the extrados portion of the subject elbow and would be elongated in the direction of flow.

The UT data evaluator determined the wear for the elbow should be evaluated by the blanket method since the elbow was fabricated from bent pipe which could be expected to cause thickness variations in a circumferential direction. Also, it was decided bands showing evidence of being countered-bored (Bands 1, 2, 3, 9, and 10), would not be used to determine the wear of the grid. Enclosure 1, Attachment 3 of TVA submittal dated December 17, 2003, shows the results of wear determination.

The UT data and the wear data obtained as described above were next entered into a spreadsheet. Enclosure 1, Attachment 4 of TVA submittal dated December 17, 2003, shows a copy of the data as entered into cells P16 (wear) and cells W16, X16, and Y16 for the UT data. The wear and the limiting thickness (the lowest UT reading) were used to calculate the remaining service life (L_{rem}) shown in cell T16. The L_{rem} was calculated to be a time less than the 1.5 years required to operate until Cycle 6 RFO, in fact a negative number.

The UT data and the physical configuration of the pipe in question indicates there was an extra long counterbore applied to the upstream end of the elbow during construction and that Band 3 is a transition area between counterbore and non-counterbore. The thickness required after counterbore is a nominal 0.758 inches with a tolerance of plus 0.005 inches and minus zero inches. This thickness is only 0.037 inches thicker than the T_{accpt} value of 0.721 inches. Also, during construction the weld was prepared manually on the outside diameter surfaces for nondestructive examination. As seen in Enclosure 1, Attachment 1 of TVA submittal dated December 17, 2003, the location and orientation of the "thin" areas are not typical of FAC wear.

The following additional information is based upon suggested content in an NRC memorandum, dated August 6, 2003, for relief requests where the wall thickness is less than t_{min}.

1. Markup of piping isometric showing location where piping is less than t_{min}: Enclosure 1, Attachment 5 of TVA submittal dated December 17, 2003, shows the location of FAC grid 103BE252 on the main feedwater piping. The thin areas are located toward the upstream end of the elbow and are shown in Enclosure 1, Attachment 1 of TVA submittal dated December 17, 2003. Enclosure 1, Attachment 1, page E1A1-5 of TVA submittal dated December 17, 2003, shows the thin area of concern. The grid spacing is a 3-inch square. Enclosure 1, Photo 1, of TVA submittal dated December 17, 2003, shows an overall view of the nozzle, the elbow, pipe pup piece, and other elbows, plus pipe restraint devices and a hanger. Enclosure 1, Photo 2, of TVA submittal dated December 17, 2003, shows a close-up looking between the restraint devices which shows a portion of the pipe pup piece, a portion of the subject elbow, and a hanger. Enclosure 1, Photo 3, shows a close-up of the subject elbow and the inlet nozzle from the side opposite the view shown in Enclosure 1, Photo 1 and Photo 2, of TVA submittal dated December 17, 2003. Each attachment shows the pipe whip restraint devices around the elbow.

2. Affected System: Main Feedwater System

3. System normal operating temperature = 440 degrees Fahrenheit (F); Normal operation pressure = 1145 pounds per square inch (psi); Design Pressure = 1185 psi

4. Pipe size and nominal pipe wall thickness t_{nom}: 16-inch Schedule 80 (t_{nom} = 0.844 inches)

5. Code-allowable t_{min}: The allowable minimum wall thickness t_{min} as calculated by the equation specified in Code Case N-597-1 paragraph 3622.1(a)(1) is 0.613 inches. This equation is essentially the same equation for calculating the minimum wall thickness based upon the allowable hoop stresses.

6. Current thickness and date measured: t_{meas} = 0.639 inches measured on September 16, 2003

7. Estimated wall thinning wear rate: 0.025 inch/year (0.0375 inch/18-month cycle)

8. Predicted wall thickness (t_p) at RFO 6: 0.598 inches.

9. Discuss how pressure spikes associated with anticipated system transients are accounted for in establishing t_{min}: The identified pressure surges due to anticipated system design transients are considered and bounded in establishing t_{min}. For this piping the Feedwater Check Valve Slam Transient loadings have also been considered as input.

10. Provide licensee's basis for determining the wear thinning rate: The UT data evaluator determined the wear for the elbow should be evaluated by the blanket method since the elbow was fabricated from bent pipe which could be expected to cause thickness variations in a circumferential direction. Also, it was decided bands showing evidence of being counter-bored (Bands 1, 2, 3, 9, and 10) would not be used to determine the wear of the grid. Enclosure 1, Attachment 3 of TVA submittal dated December 17, 2003, shows the results of wear determination.

11. Provide licensee's criteria for repairing or replacing piping and the basis for the criteria: TVA's FAC Program allows three options if the predicted remaining service life is less than the amount of time until the next inspection. These options are:

    a) shorten the inspection interval;

    b) perform a more detailed stress analysis to obtain a more accurate value of the acceptable service life using the evaluation methods specified in TVA's Civil Design Standard, Structural Evaluation of Wall Thinning in Pipe Due to FAC; and,

    c) repair or replace the component.

    In addition, for piping and components with predicted wall thinning that satisfies the acceptance criteria for continued service, the Program requires monitoring areas containing FAC degradation during successive examinations, until repaired or replaced with a FAC resistance material, and the determination of the frequency of future examinations by the FAC wear rate or remaining service life calculated from examination data.

For this application, the current FAC Program requires this elbow to be inspected during the next refueling outage. The Program requires that when the predicted remaining service life is shorter than the time until the next outage, the appropriate corrective action document be initiated. A Watts Bar PER was initiated during the Cycle 5 RFO.

WBN, Unit 1, planned action regarding FAC grid 103BE252, pending approval of this request, is to:

a) continue operation until the Cycle 6 RFO;

b) during the Cycle 6 RFO, ultrasonically examine this elbow to obtain a new set of UT data, obtain a refined wear rate and perform a new analysis; and,

c) based on the Cycle 6 data, determine whether to replace the elbow or continue to implement Code Case N-597-1 using the revised (new) analysis.

12. Discuss what evaluation methods and criteria the licensee plans to use for performing analytical evaluations of pipe wall thinning in Class 1 carbon steel piping subjected to FAC. WBN, Unit 1, has no Class 1 carbon steel piping within the FAC Program.

13. Discuss what evaluation methods and criteria the licensee plans to use for performing analytical evaluations of pipe wall thinning in non-Code Class 1 carbon steel piping subjected to FAC:

Analytical structural evaluation of piping that is subjected to FAC and is within the scope of WBN, Unit 1, ASME Section XI Program is based upon satisfying design basis stress criteria per the Code of Record for the piping (i.e., ASME Class 2 or Class 3). Specifically, this requires the determination of the minimum piping component wall thickness that satisfies all pertinent stress requirements including hoop stress due to pressure and longitudinal stress due to pressure and moment loading for all applicable load combinations. In addition, the minimum required wall thickness to satisfy design basis stress criteria is screened against a limiting thickness of 30 percent of the pipe nominal thickness and the larger value is used to determine remaining life in the component. This overall approach is summarized in TVA Civil Design Standard DS-C1.2.5, "Structural Evaluation of Wall Thinning in Pipe Due to Flow Accelerated Corrosion," which was developed to provide a consistent evaluation process for determination of a required thickness that satisfies design basis stress criteria and, as such, it provides a rational basis for repair/replacement decisions.

Implementation Schedule:

The alternative to apply Code Case N-597-1 to FAC Grid 103BE252 is requested for the duration of time that the analytical evaluation can support the acceptability of the component or until it is repaired or replaced.

3.2 Staff Evaluation

By letter dated December 17, 2003, TVA requested pursuant to 10 CFR 50.55a(a)(3)(i), a request for relief from ASME Code, Section XI requirements to repair or replace one ASME Class 2 carbon steel piping elbow associated with the main feedwater system at WBN, Unit 1. TVA proposed to use the provisions of ASME Code Case N-597-1 to analytically evaluate the potential pipe wall thinning that was projected to take place by its Watts Bar CHECWORKS program. The staff reviewed TVA's request for relief and response to RAI in its letter dated July 9, 2004. In addition, the staff conducted several telephone conferences to discuss issues associated with the TVA's piping calculations. WBN, Unit 1, is currently in the first 10-year ISI interval and the 1989 Edition of ASME Code, Section XI with no Addenda governs the current repair and replacement activities.

The staff reviewed the information provided by TVA in support of its request for relief from ASME Section XI requirements to permanently repair or replace one ASME Class 2 carbon steel piping elbow at its WBN, Unit 1 (FAC Grid 103BE252). The staff evaluation of the request follows.

In Enclosure 2 of TVA letter dated December 17, 2003, to its Watts Bar Request for Relief, TVA addressed wall thinning by FAC in an ASME Section III Class 2 degraded elbow located in Loop 2 of WBN, Unit 1, Main Feedwater System. The elbow is fabricated from 16-inch, Schedule 80, SA-333 Grade 6 material. For this elbow the nominal thickness t_{nom}= 0.844 inches. The safety evaluation of the piping was based on the application of ASME Section XI Code Case N-597-1. This Code Case was conditionally accepted by the staff with conditions listed in Table 2 as documented in RG 1.147.

Condition (2) for this Code Case, as listed in RG 1.147, states that: "*Components affected by FAC to which this Code Case are applied must be repaired or replaced in accordance with the construction code of record and Owner's requirements or a later NRC approved edition of Section III of the ASME Code prior to the value of t_p (minimum projected wall thickness) reaching the Code required minimum wall thickness, t_{min}, as specified in -3622.1(a)(1) of this Code Case. Alternatively, the use of this Code Case is subject to NRC review and approval.*"

Based on measured wall-thickness data taken during the Cycle 5 RFO in September 2003, the minimum measured wall thickness was determined to be 0.613 inches. On the basis of wear rates computed using Watts Bar FAC Program methods (including a 10 percent safety factor), the minimum predicted wall thickness t_p at the end of current operating Cycle 6 (1.5 years later, or February 2005) was determined as t_p = 0.598 inches.

The Code required minimum wall thickness t_{min} was determined to be 0.613 inches. Since this value falls between the minimum measured wall thickness at the end of Cycle 5 RFO and the predicted minimum wall thickness at the end of current operating Cycle 6, the licensee determined that, based on the computed wear rate, the wall thickness will reach the Code required minimum wall thickness t_{min} 11 months into the current operating cycle (i.e., sometime in August 2004). This would potentially constitute a deviation from the licensing basis of the plant and, thus, require plant shutdown to repair or replace the degraded elbow. Because of that, TVA requested relief from the ASME Code requirements so that plant operation can continue until the end of current operating Cycle 6.

In the application of this Code Case, Section -3221, "Acceptance by Examination," states that piping items whose examination and evaluation results reveal that t_p meets the acceptance standards of Section -3500 or the Construction Code, these items are acceptable for continued service. Paragraph -3500(a)(1) of Section -3500, "Wall Thickness Acceptance Standards," states that for straight pipe and elbows purchased to a nominal pipe specification with an allowable wall thickness under tolerance of 12 percent t_p shall not be less than $0.875t_{nom}$. For this elbow, $0.875t_{nom}$ = 0.739 inches, which is greater than both the current measured minimum wall thickness and the predicted minimum wall thickness t_p. The acceptance criterion by examination was therefore not met. When this criterion cannot be met, Section -3221 states that alternative acceptance standards stated in Sections -3222, -3223, and -3224 may be used.

Section -3223, "Acceptance by Engineering Evaluation," states that for Class 2 and 3 piping, an acceptable evaluation method and criteria are provided in Section -3600, "Analytical Evaluation for Class 2 and Class 3 Piping Items." Paragraph -3610, "General Requirements," states that: *(a) analytical evaluations shall be conducted in accordance with the Construction Code. Later Code Editions and Addenda may be used. Use of later Code Editions and Addenda shall be reviewed for acceptability to the regulatory and enforcement authorities having jurisdiction at the plant site, (b) analytical evaluations shall be conducted using the predicted wall thickness t_p at the next examination of the piping item, (c) a piping item is acceptable for continued service if the minimum pipe wall thickness, branch reinforcement requirements, and piping stress criteria of the Construction Code used in the evaluation are met for all specified loading conditions, and (d) as an alternative to item (c), butt welded pipe, elbow, branch connection, and reducer piping items may be evaluated in accordance with Section -3620, "Evaluation of Pipe, Elbows, Branch Connections and Reducers."*

The general requirements stated in Subsection -3621 of Section -3620 state the following: *(a) the evaluation shall meet the requirements of Sections -3622 and -3622, (b) for a branch connection or tee, the region within the limits of reinforcement defined in the Construction Code shall meet the requirements of -3624, and (c) evaluations shall be conducted using the appropriate piping equations, loadings, load combinations, allowable material properties, and other acceptance standards from the Construction Code used in the evaluation, except as specifically modified by this Case.* Paragraph -3622.1(a), "Evaluation for Minimum Wall Thickness," of Section -3622, "Thickness Evaluation," also states that, *". . . except as provided in paragraph -3622.1(b), the value of t_p shall not be less than 90% of the minimum wall thickness of the piping item, t_{min}, required for design pressure, defined in the Construction Code used in the evaluation, exclusive of any additional corrosion allowance."* Based on the Code required minimum wall thickness t_{min} for this elbow of 0.613 inches, the licensee determined that 90 percent of t_{min} is 0.552 inches. The staff finds that TVA has shown that predicted minimum wall thickness is less than t_{min} but greater than $0.9t_{min}$, and therefore meets the criterion in this section.

In response to a staff RAI, the licensee stated that all ASME Code Class 1, 2 and 3 piping at Watts Bar is designed to the Code, Section III, Division 1, 1971 Edition up to and including the Summer 1973 Addenda. Later Code Editions, Addenda and Code Cases were incorporated in accordance with the provisions of ASME Section III, NA-1140. This represents the Code of Record for piping design at Watts Bar for all loading conditions, except for the faulted condition load combination which includes Safe Shutdown Earthquake (SSE) plus dynamic loading resulting from a Check Valve Slam (CVS) event. This event was not part of the licensing Design Basis for WBN, Unit 1.

The feedwater system was initially designed and qualified to ASME Code Class 2 piping. As a result of the discovery for potential CVS loading, following a postulated pipe rupture at the main header in the Turbine Building, the NRC staff identified Licensing Issue 20(a), "Feedwater Check Valve Slam," in NUREG-0847, Watts Bar Safety Evaluation Report, Supplement dated April 1991. The issue was the qualification of the feedwater piping system inside containment, from the check valves to the steam generator nozzles, to Level D service limits when subjected to the faulted condition load combination of CVS waterhammer and SSE loading.

To qualify the Class 2 system for licensing under combined CVS and SSE loading, the licensee performed a dynamic, elastic-plastic analysis, using the computer program ANSYS. The as-built nominal wall thickness (t_{nom} = 0.844 inches) and as-built support configuration values were used as input. In conjunction with this analysis, the licensee also invoked the Level D Service (faulted condition) stress limits for pressure boundary integrity stated in ASME Section III Appendix F (1980 Edition through Winter 1982 Addenda, or a later Edition) for plastic analysis. Although the limits of Appendix F specified in the 1980 Edition were valid only for qualification of ASME Class 1 piping, the staff approved the application of these limits for qualification of this Class 2 system. These limits are significantly higher than the faulted conditions limits specified for Class 2 piping. During the initial licensing review for Watts Bar, the NRC staff reviewed the ANSYS analysis and found it acceptable. The staff also approved the application of Class 1 limits for the qualification of Class 2 piping. These findings and the resolution of Licensing Issue 20(a) are documented in NUREG-0847, "Watts Bar Safety Evaluation Report," Supplement No. 16, dated April 1994.

In support of its relief request, TVA performed a stress analysis, in accordance with ASME Code Case 597-1, Section -3623, to support the acceptability of the degraded elbow with the wall thinning predicted to occur by the end of the current operating Cycle 6. The licensee's analysis was a simplified elastic estimation of the largest stress intensity in the elbow, subject to the stress limits stated in paragraph F-1331 of Appendix F, "Criteria for Components." The analysis used the actual thickness measurements of the highest degraded cross-section in the elbow. Based on this analysis, the licensee concluded that the primary membrane and membrane-plus-bending stress intensities will meet the Appendix F stress limits at the end of current operating Cycle 6. However, this analysis did not meet the evaluation requirements stated in Subsection -3623.1, "Evaluation Requirements," which require that the stress evaluation be performed using the equations required by the Code of Construction. In this case, the analysis should have been performed using the methodology accepted by the staff in NUREG-0847, Supplement No. 16. Therefore, the staff finds that the licensee's stress analysis associated with the relief request may not reflect the highest stress intensity in the elbow for the predicted wall thinning at the end of the current operating Cycle 6.

Based on the information provided by the licensee, the staff performed a bounding elastic analysis using the average degraded wall thickness value which was predicted to occur by the end of the current operating Cycle 6. The analysis showed that the largest primary membrane-plus-bending stress intensity (as calculated using Equation 9 of NC-3653) will exceed the corresponding Appendix F stress limit for faulted conditions, stated in the relief request and accepted by the staff as the licensing basis for this system. Based on this bounding analysis, the staff finds that it is probable that there may be little or no margin to accommodate any additional wall degradation beyond the current operating Cycle 6.

The staff also performed a bounding elastic analysis with an average wall thickness based on the wall thickness distribution as measured during the Cycle 5 RFO, with the smallest degraded wall thickness equal to the Code-required minimum wall thickness. The results indicate that the stress exceeds the Appendix F stress limit for membrane plus bending by about 1 percent. However, based on the inherent conservatism in the bounding analysis, the staff finds that there is reasonable assurance that the elbow structural integrity will not be compromised under the CVS and SSE loading when the wall thickness degrades to the Code-required minimum wall thickness.

TVA stated in its request for relief that WBN, Unit 1, has an action plan for addressing the FAC in this elbow. This plan consists of the following steps:

1. Continue operation until the Cycle 6 RFO.

2. During the Cycle 6 RFO, ultrasonically examine this elbow to obtain a new set of UT data, obtain a refined wear rate, and perform a new analysis.

3. Based on the Cycle 6 RFO data, determine whether to replace the elbow or continue to implement Code Case N-597-1 using the revised (new) analysis.

Based on the staff's evaluation, the staff finds the licensee's proposed action plan acceptable. This acceptance is based on the following: (a) the reduction of wall thickness to the Code required minimum wall thickness t_{min} of 0.613 inches is estimated to occur after 11 months of operation, (b) this time interval is based on predicting the reduced wall thickness using calculated wear rates which include a 10 percent safety factor, and (c) the staff's bounding elastic evaluation shows that the relevant Level D stress limits are met for this Code required minimum wall thickness. On this basis, the staff finds that it is unlikely that the integrity of the degraded elbow will be compromised during the remaining 7 months of operation, to the end of the current operating Cycle 6. In addition, the licensee has also used some of the provisions of Code Case N-597-1 to evaluate the suitability of the pipe elbow for service. Code Case N-597-1 has been conditionally endorsed by the staff in its RG 1.147.

However, the NRC staff notes that TVA in its letter dated December 17, 2003, page E1-7, Item c) of TVA's plan provides for evaluation of the pipe elbow to determine suitability for service beyond the Cycle 6 RFO. This is acceptable to the NRC staff provided TVA submits a renewed relief request before restart from Cycle 6 RFO. If such a relief request is submitted, the licensee must demonstrate that the structural integrity and safety of the degraded elbow will be ensured by performing a stress analysis, using the set of UT data recorded during the Cycle 6 RFO and projected to the end of Cycle 7. The stress analysis should be based on the licensing basis methodology that was approved by the staff for resolution of Licencing Issue 20(a), and documented in Supplement No. 16 of NUREG-0847, "Watts Bar Safety Evaluation Report," in accordance with the provisions of Code Case N-597-1 for piping stress analysis.

4.0 CONCLUSION

Based on the above evaluation, the NRC staff concludes the proposed alternative is authorized pursuant to 10 CFR 50.55a(a)(3)(i) for the duration of the current operating Cycle 6 for WBN, Unit 1, on the basis that the reduction of wall thickness to the Code required minimum wall thickness t_{min} of 0.613 inches is estimated to occur after 11 months of operation and the time

interval is based on predicting the reduced wall thickness using calculated wear rates which include a 10 percent safety factor, and the staff's bounding elastic evaluation shows that the relevant Level D stress limits are met for this Code required minimum wall thickness. On this basis, the staff finds that it is unlikely that the integrity of the degraded elbow will be compromised during the remaining 7 months of operation, to the end of the current operating Cycle 6. For continued operation until the end of Cycle 7, TVA must submit a renewed relief request before restart from Cycle 6 RFO. If such a relief request is submitted, the licensee must demonstrate that the structural integrity and safety of the degraded elbow will be ensured by performing a stress analysis, using the set of UT data recorded during the Cycle 6 RFO and projected to the end of Cycle 7. The stress analysis should be based on the licensing basis methodology that was approved by the staff in the resolution of Watts Bar Licensing Issue 20(a), and documented in Supplement No. 16 of NUREG-0847, "Watts Bar Safety Evaluation Report," in accordance with the provisions of Code Case N-597-1 for piping stress analysis.

All other ASME Code Section XI requirements for which relief was not specifically requested and approved in this relief request remain applicable, including third party review by the Authorized Nuclear Inservice Inspector.

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Date: August 27, 2004

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