August 14, 2000

Mr. J. A. Scalice
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and Executive Vice President
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SUBJECT: BROWNS FERRY NUCLEAR PLANT UNIT 2, RELIEF REQUEST 2-ISI-9, ALTERNATIVES FOR EXAMINATION OF REACTOR PRESSURE VESSEL SHELL WELDS (TAC NO. MA8424)

Dear Mr. Scalice:

By letter dated March 24, 2000, the Tennessee Valley Authority (TVA) requested relief from the inservice inspection requirements of 10 CFR 50.55a(g) for the volumetric examination of circumferential reactor pressure vessel (RPV) shell welds at Browns Ferry Nuclear Plant, Unit 2. This request was pursuant to 10 CFR 50.55a(a)(3)(i) and consistent with the guidance of NRC Generic Letter 98-05, "Boiling Water Reactor Licensees Use of the BWRVIP-05 Report to Request Relief From Augmented Examination Requirements on Reactor Pressure Vessel Circumferential Shell Welds." The relief request was for permanent deferral (for the existing term of the current operating license) of examinations of the circumferential shell welds of the RPV.

The NRC staff has reviewed the request and concluded that the alternative proposal provides an acceptable level of quality and safety. Therefore, pursuant to 10 CFR 50.55a(a)(3)(i), the inspection of the circumferential welds may be permanently deferred for the remaining term of operation under the existing, initial operating license. The staff's safety evaluation is enclosed.

This completes the staff's activities related to your relief request of March 24, 2000. If you have any questions, please contact the Browns Ferry project manager at 301-415-3026.

Sincerely,

/RA/

Richard P. Correia, Chief, Section 2
Project Directorate II
Division of Licensing Project Management
Office of Nuclear Reactor Regulation

Docket No. 50-260

Enclosure: Safety Evaluation

cc w/encl: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ALTERNATIVES FOR EXAMINATION OF REACTOR PRESSURE VESSEL SHELL WELDS

BROWNS FERRY NUCLEAR PLANT, UNIT 2

TENNESSEE VALLEY AUTHORITY

DOCKET NO. 50-260

1.0 INTRODUCTION

By letter dated March 24, 2000, the Tennessee Valley Authority (TVA), licensee for the Browns Ferry Nuclear Plant, Unit 2 (BFN2), requested that the U.S. Nuclear Regulatory Commission (NRC) approve an alternative to performing examinations on the reactor pressure vessel (RPV) circumferential shell welds at BFN2. These examinations are required by Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code), and by the augmented examination requirements of Title 10, Code of Federal Regulations (10 CFR), Section 50.55a(g)(6)(ii)(A)(2). The alternative was proposed pursuant to the provisions of 10 CFR 50.55a(a)(3)(i) and is consistent with the guidance provided in Generic Letter (GL) 98-05, "Boiling Water Reactor Licensees Use of the Boiling Water Reactor Vessel and Internals Project (BWRVIP-05) Report to Request Relief From Augmented Examination Requirements on Reactor Pressure Vessel Circumferential Shell Welds," dated November 10, 1998, and the NRC staff safety evaluation (SE) of the BWRVIP-05 report dated July 28, 1998.

BFN2 is a boiling water reactor located near Athens, Alabama. The Code of Record for BFN2's Second 10-Year Inspection Interval is the ASME Code 1986 Edition, no addenda. TVA is scheduled to perform Code-required and augmented RPV weld examinations in the third period (Spring 2001) of the Second Inspection Interval.

The staff granted relief for Unit 3 on November 18, 1999.

1.1 Regulatory Requirements

Pursuant to the requirements of 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components are to meet the requirements, except the design and access provisions and the preservice examination requirements, set forth in the ASME Code, Section XI, "Rules for Inservice Inspection of Nuclear Power Plant Components," to the extent practical within the limitations of design, geometry and materials of construction of the components. The regulations require that inservice examination of components and system pressure tests conducted during the first 10-year interval and subsequent intervals comply with the requirements in the latest edition and addenda of the ASME Code, Section XI, incorporated by reference in 10 CFR 50.55a(b) on the date 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein.

As stated in 10 CFR 50.55a(g)(6)(ii)(A) licensees are required to perform an augmented RPV shell weld examination as specified in the 1989 Edition of Section XI of the ASME Code. The final Rule was published in the *Federal Register* on August 6, 1992 (57 FR 34666). By incorporating into the regulations the 1989 Edition of the ASME Code, the NRC staff required that licensees perform volumetric examinations of "essentially 100 percent" of the RPV pressure-retaining shell weld, during all inspection intervals. It is stated in 10 CFR 50.55a(a)(3) that 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. 10CFR 50.55(a)(3)(vi)(5) permit the use of an alternative to required examinations if they provide an acceptable level of quality and safety.

1.2 BWRVIP-05 Report

By letter dated September 28, 1995, as modified and supplemented by letters dated June 24 and October 29, 1996, May 16, June 4, June 13 and December 18, 1997, the BWRVIP submitted proprietary report BWRVIP-05. As modified, the BWRVIP-05 report proposed to reduce the scope of inspection of boiling-water reactor (BWR) RPV welds from essentially 100 percent of all RPV shell welds to examination of essentially 100 percent of the axial (i.e., longitudinal) welds and essentially zero percent of the circumferential RPV shell welds, except at the intersection of the axial and circumferential welds, thereby including approximately 2-3 percent of the circumferential welds.

The NRC staff issued a SE of the BWRVIP-05 report on July 28, 1998. This evaluation concluded that the failure frequency of RPV circumferential welds in BWRs was sufficiently low to justify elimination of inservice inspection of these welds. The SE indicated that examination of the circumferential welds shall be performed if axial weld examinations reveal an active, mechanistic mode of degradation.

In the BWRVIP-05 report, the BWRVIP concluded that the conditional probabilities of failure for BWR RPV circumferential welds are orders of magnitude lower than those of the axial welds. As part of its review of the report, the NRC conducted an independent risk-informed, probabilistic fracture mechanics assessment of the results presented in the BWRVIP-05 report. The staff assessment conservatively calculated the conditional probability of failure from RPV axial and circumferential welds during the (current) initial 40-year license period and at conditions approximating an 80-year vessel lifetime for a BWR nuclear plant, as indicated in Tables 2.6-4 and 2.6-5, respectively, of the staff's SE. The failure frequency for a RPV is calculated as the product of the frequency for the critical (limiting) transient event and the conditional probability of failure for the weld.

The staff determined the conditional probability of failure for axial and circumferential welds in BWR vessels fabricated by Chicago Bridge and Iron, Combustion Engineering, and Babcock and Wilcox (B&W). The analysis identified a cold over-pressure event in a foreign reactor as the limiting event for BWR RPVs, with the pressure and temperature from this event used in the probabilistic fracture mechanics calculations. The staff estimated that the probability for the occurrence of the limiting over pressurization transient was 1×10^{-3} per reactor year. For each of the vessel fabricators, Table 2.6-4 of the staff's SE identifies the conditional failure probabilities for the plant-specific conditions with the highest projected mean reference temperature (for that fabricator) after the initial 40-year license period.

For B&W-fabricated RPVs, the highest or limiting mean RT_{NDT} value was found to be 99.8°F. Using this data, the staff calculated the conditional failure probability for B&W-fabricated circumferential welds to be 8.17×10^{-5} per reactor year, with a failure frequency of 8.17×10^{-8} per reactor year. B&W-fabricated vessels with a limiting mean RT_{NDT} less than 99.8°F have failure frequencies which are bounded by the results from the staff's evaluation.

For the BFN2 RPV, all of the beltline circumferential welds were fabricated by Ishikawajima-Harima Heavy Industries Co. (IHI) using the automatic submerged arc weld process, in a manner similar to that used by B&W. Hence, the failure frequency of these welds fabricated by IHI should be similar to that for welds fabricated by B&W, such that welds with a mean RT_{NDT} less than 99.8°F should have failure frequencies which are bounded by the results from the staff's calculations.

1.3 Generic Letter 98-05

On November 10, 1998, the NRC issued GL 98-05, "Boiling Water Reactor Licensees Use of the BWRVIP-05 Report to Request Relief From Augmented Examination Requirements on Reactor Pressure Vessel Shell Welds." GL 98-05 stated that BWR licensees may request permanent (i.e., for the remaining term of operation under the existing, initial, license) relief from the inservice inspection requirements of 10 CFR 50.55a(g) for the volumetric examination of circumferential reactor pressure vessel welds (ASME Code Section XI, Table IWB-2500-I, Examination Category B-A, Item 1.11, "Circumferential Shell Welds"), upon demonstrating that:

(1) at the expiration of the license, the circumferential welds will continue to satisfy the limiting conditional failure probability for circumferential welds in the NRC staff's July 28, 1998, safety evaluation, and

(2) licensees have implemented operator training and established procedures that limit the frequency of cold over-pressure events to the amount specified in the NRC staff's July 28, 1998, safety evaluation.

Licensees would still need to perform the required inspections of "essentially 100 percent" of all axial welds.

2.0 INFORMATION PROVIDED BY LICENSEE

This section identifies the specific Code requirements and components for which the licensee is seeking relief, the basis for the relief request, and a demonstration by the licensee that the criteria for relief are satisfied.

2.1 Code Requirements for Which Relief Is Sought

The licensee identifies the following Code requirements from which relief is sought:

> ASME Section XI, Table IWB-2500-1, Examination Category B-A, Item No. B1.11, Circumferential Shell Welds, and the (expedited) augmented examination requirements of 10 CFR 50.55a(g)(6)(ii)(A). Permanent relief (i.e., for the remaining term of operation under the existing license) is requested.

2.1.1 Components for Which Relief Is Sought

The requested permanent relief from the Table IWB-2500-1 requirements applies to all of the reactor pressure vessel circumferential welds. Table 1 lists the BFN2 RPV circumferential welds for which TVA is requesting permanent relief from volumetric examination. The proposed relief is for the remaining term of operation under the existing, initial license.

TABLE 1: BFN2 WELDS FOR WHICH TVA IS REQUESTING RELIEF FROM VOLUMETRIC EXAMINATION REQUIREMENTS

WELD DESCRIPTION	CATEGORY AND EXAM METHOD	TABLE IWB-2500-1 ITEM NUMBER
Vessel Shell to Flange Weld No. C-5-FLG	B-A, Volumetric	B1.11
Vessel Shell to Shell Weld No.C-4-5	B-A, Volumetric	B1.11
Vessel Shell to Shell Weld No. C-3-4	B-A, Volumetric	B1.11
Vessel Shell to Shell Weld No. C-2-3	B-A, Volumetric	B1.11
Vessel Shell to Shell Weld No. C-1-2 (Belt-line Weld)	B-A, Volumetric	B1.11
Vessel Shell to Bottom Head Weld No. C-BH-1	B-A, Volumetric	B1.11

2.2. Licensee's Basis for Relief

The licensee's request is based upon provisions in the NRC staff's SE for the BWRVIP-05 report and the guidance outlined in GL 98-05. These documents provide the basis for the elimination of inservice inspections of BWR RPV circumferential shell welds.

As described previously, GL 98-05 provides two criteria that relief request applicants must demonstrate: (1) the circumferential welds will continue to satisfy the limiting conditional failure probability of the staff's safety evaluation, and (2) they have implemented operator training and established procedures to limit the frequency of cold over-pressure events. These criteria are intended to demonstrate that the conditions at the applicant's plant are bounded by those in the NRC staff's SE.

The NRC staff's SE for the BWRVIP-05 report evaluated the conditional failure probability of circumferential welds for the limiting plant-specific case of BWR RPVs manufactured by different vendors, including B&W, using the highest mean irradiated RT_{NDT} to determine the limiting case. The relief request compared the mean irradiated RT_{NDT} for BFN2 (determined using fluence values from the power uprate 32 effective-full-power-years operating curves) to

that for the limiting B&W case described in Table 2.6-4 of the NRC staff's SE. As illustrated in Table 2, the RT_{NDT} for BFN2 is much lower than that for the limiting B&W case, and the licensee concluded that the conditional failure probability for the BFN2 circumferential welds is bounded by the conditional failure probabilities in the staff's SE through the end of the current license period.

Table 2: Comparison of BFN2 Circumferential Weld and the Limiting B&W Weld from Table 2.6-4

PARAMETER	BFN2 (Weld C-1-2)	LIMITING B&W RPV
Fluence (10^{19} n/cm^2)	0.11	0.095
Initial RT_{NDT} (°F)	-40	20
Chemistry Factor (°F)	116.8	196.7
Cu (Wt. %)	0.09	0.31
Ni (Wt. %)	0.65	0.59
ΔRT_{NDT} (°F)	50.9	79.8
Mean RT_{NDT} (°F) [Initial RT_{NDT} + ΔRT_{NDT}]	10.9	99.8

The licensee indicated that examination of the circumferential welds shall be performed if examinations of the axial welds reveal an active, mechanistic mode of degradation. This is consistent with provisions in the NRC staff's SE for the BWRVIP-05 report.

In the submittal, the licensee has assessed the systems that could lead to a cold over-pressurization of the BFN2 RPV. In addition, the relief request described operator training and plant-specific administrative procedures that reduce the likelihood of a cold over-pressure transient. On the basis of the evaluation of high pressure injection sources, operator training and established plant-specific procedures, the licensee determined that the probability of occurrence of a cold over-pressure event is less than or equal to the probability used in the NRC staff's SE for the BWRVIP-05 report.

2.3 License's Proposed Alternative Examination

As stated in 10 CFR 50a(a)(3), licensees are allowed to propose alternatives to the requirements of 10 CFR 50a(g). TVA proposed, as an alterative, to perform only the RPV axial (longitudinal) weld examinations during the Third Inspection Period (Spring 2004) of the second 10-year inservice inspection interval in conjunction with the scheduled ASME Section XI Code and augmented RPV examinations.

3.0 NRC STAFF'S EVALUATION

The staff's review focused on confirming that the licensee has adequately documented that the conditions for relief outlined in the NRC staff's SE to the BWRVIP-05 report and GL 98-05 are satisfied.

3.1 Circumferential Weld Conditional Failure Probability

The NRC staff's SE provides a limiting conditional failure probability of 8.17×10^{-5} per reactor year for a limiting plant-specific mean RT_{NDT} of 99.8°F for B&W-fabricated RPVs. Comparing the information in the NRC Reactor Vessel Integrity Database with that submitted in the relief request, the staff has confirmed that the mean RT_{NDT} of the circumferential welds at BFN2 is projected to be 10.9°F at the end of the current license. In this evaluation, the chemistry factor, ΔRT_{NDT}, and mean RT_{NDT} were calculated consistent with the guidelines of Regulatory Guide 1.99, Revision 2. The calculated value of mean RT_{NDT} for the circumferential welds at BFN2 is significantly lower than that for the limiting plant-specific case for B&W-fabricated RPVs, indicating that the conditional failure probability of the BFN2 circumferential welds is much less than 8.17×10^{-5} per reactor year. From Figure B-1 of the NRC staff's SE and using a transient temperature of 88°F (such that T - RT_{NDT} is 77°F), the conditional failure probability for the BFN2 circumferential welds is found to be much less than 10^{-7}.

3.2 Cold Overpressure Transient Probability

During review of the BWRVIP-05 report, the staff identified non-design basis events which should have been considered in the BWRVIP-05 report. In particular, the potential for and consequences of cold over-pressure transients should be considered. The licensee has assessed the systems that could lead to a cold over-pressurization of the BFN2 RPV. These include the high pressure core injection (HPCI), reactor core isolation cooling (RCIC), standby liquid control (SLC), control rod drive (CRD), and reactor water cleanup (RWCU) systems.

The HPCI and RCIC pumps are steam driven and do not function during cold shutdown. There are no automatic starts associated with the SLC system. The system is only initiated by manual operator action in accordance with the plant emergency operating procedures or during controlled test conditions; therefore, inadvertent manual initiation of SLC is an unlikely event. In addition, in the event of manual initiation during shutdown, the SLC injection rate of approximately 50 gpm would allow operators sufficient time to control reactor pressure.

During normal cold shutdown conditions, RPV level and pressure are controlled through a feed and bleed process using the CRD and RWCU systems. Plant procedures are in place to respond to any unexpected or unexplained rise in reactor water level.

In all cases, the operators are trained in methods of controlling water level within specified limits in addition to responding to abnormal water level conditions during shutdown. The licensee also stated that procedures and administrative controls for reactor coolant temperature, level, and pressure are in place to minimize the potential for RPV cold over-pressure events. Plant-specific procedures have been established to provide guidance to the operators regarding compliance with theTS pressure-temperature limits.

On the basis of the evaluation of high pressure injection sources, operator training and established plant-specific procedures, the licensee determined that the likelihood of a cold over-pressure event placing the plant in non-design conditions is very low. The staff agrees with the

licensee that the information provided regarding the BFN2 high pressure injection systems, operator training, and plant-specific procedures provides a sufficient basis to support approval of the alternative examination request. The staff concludes that a non-design basis cold over-pressure transient is unlikely to occur at BFN2.

4.0 CONCLUSIONS

The staff has reviewed TVA's submittal and finds that TVA has provided an acceptable demonstration that the appropriate criteria in GL 98-05 and the staff's evaluation of the BWRVIP-05 report have been satisfied regarding the licensee's request for permanent relief (i.e., for the remaining term of operation under the existing, initial license) from inservice inspection requirements for the volumetric examination of RPV circumferential welds, ASME Code Section XI, Table IWB-2500-1, Examination Category B-A, and Item No. B1.11.

The NRC staff concludes that authorization of TVA's alternative examinations for BFN2 would provide assurance of the structural integrity of the BFN2 RPV, and, therefore, an acceptable level of quality and safety. Accordingly, pursuant to 10 CFR 50.55a(a)(3)(i) and (g)(6)(ii)(A)(3)(vi)(5), the licensee's proposed alternative examination for BFN2 is authorized and effective from the date of this evaluation until the expiration of the operating license at midnight on June 28, 2014.

Principal contributor: A. Hiser

Date: August 14, 2000

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