UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

ALTERNATIVES FOR EXAMINATION OF REACTOR PRESSURE VESSEL SHELL WELDS

BROWNS FERRY NUCLEAR PLANT UNIT 3

TENNESSEE VALLEY AUTHORITY

DOCKET NO. 50-296

1.0 INTRODUCTION

By letter dated June 25, 1999, as modified by letter dated October 22, 1999, the Tennessee Valley Authority (TVA), licensee for the Browns Ferry Nuclear Plant Unit 3 (BFN3), requested that the U.S. Nuclear Regulatory Commission (NRC) approve an alternative to performing circumferential shell weld examinations on the reactor pressure vessel (RPV) welds at BFN3. 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 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 evaluation of the Boiling Water Reactor Vessel and Internals Project (BWRVIP)-05 report dated July 28, 1998.

TVA also requested elimination of the successive examination requirements specified in ASME Code paragraph IWB-2420(b) for the volumetric examination of fifteen, previously-identified, sub-surface, "nonthreatening" flaws. This proposed alternative was requested pursuant to 10 CFR 50.55a(a)(3)(i). These fifteen flaws, located in four vessel-shell welds and one vessel-to-flange weld, were identified during fall 1993 "expedited basis" examinations required by 10 CFR 50.55a(g)(6)(ii)(A). Proprietary report BWRVIP-05, "BWR Vessel and Internals Project, BWR Reactor Vessel Shell Weld Inspection Recommendations" dated September 28, 1995, proposes conditions to be met for elimination of successive examinations. The BWRVIP recommendations for successive examinations in this report were found acceptable by staff.

BFN3 is a boiling water reactor located near Athens, Alabama. The Code of Record for BFN3's Second 10-Year Inspection Interval is the ASME Code. TVA is scheduled to perform all Code-required and augmented RPV weld examinations in the third period (spring 2000) of the Second Inspection Interval.

1.1 Regulatory Requirements

Pursuant to the requirements of 10 CFR 50.55a(g)(4), ASME Code Class I, 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.

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 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. In addition, the report provided proposals to revise ASME Code requirements for successive and additional examinations of circumferential welds, provided in paragraph IWB-2420(b) of Section XI of the ASME Code.

The NRC staff issued a safety evaluation (SE) of the BWRVIP-05 report dated 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. In addition, the evaluation concluded that the BWRVIP proposals on successive and additional examinations of circumferential welds were acceptable. The evaluation 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 longitudinal 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 safety evaluation. The failure frequency for a reactor pressure vessel 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 longitudinal 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 evaluation (Ref. 3) identifies the conditional failure probabilities for the plant-specific conditions with the highest projected reference temperature (for that fabricator) after the initial 40-year license period.

For B&W-fabricated RPVs (such as the BFN3 RPV), 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 RT_{NDT} less than 99.8°F 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 describes the Code requirements and the 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:

(1) ASME Section XI, 1989 Edition (no addenda), Table IWB-2500-1, Examination Category B-A, Item No. B1.11, volumetric examination of reactor pressure vessel circumferential welds. Permanent relief (i.e., for the remaining term of operation under the existing license) is requested.

(2) ASME Section XI, 1989 Edition (no addenda), Subarticle IWB-2420(b) "If flaw indications or relevant conditions are evaluated in accordance with IWB-3132.4 or IWB-3142.4, respectively, and the component qualifies as acceptable for continued service, the areas containing such flaw indications or relevant conditions shall be reexamined during the next three inspection periods listed in the schedule of the inspection program for IWB-2410." Relief 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. The relief from successive examination requirements in ASME Code Subarticle IWB-2420(b) applies to the welds and flaws identified in Table 1.

Table 1: BFN3 Welds Requiring Successive Examination in Accordance with ASME Code IWB-2420(b)

WELD	NUMBER OF FLAWS
Vessel to Flange Weld C-5-FLG, Circumferential Vessel Closure Head Flange to Vessel Weld, (GE Designation VFW)	5
Vessel Shell Weld C-2-3, Circumferential Vessel Shell Weld (GE Designation H23)	2
Vessel Shell Weld C-3-4, Circumferential Vessel Shell Weld (GE Designation H34)	6**
Vessel Shell Weld C-4-5, Circumferential Vessel Shell Weld (GE Designation H45)	2
Vessel Shell Weld V-4-B Longitudinal Vessel Shell Weld (GE Designation V4)	1**

** One flaw is located in the circumferential shell weld (C-3-4) within an overlapping region with the examination boundary of the longitudinal shell weld (V-4-B).

Note that one flaw is reported for both circumferential weld C-3-4 and also longitudinal weld V-4-B since this flaw is located in the circumferential shell weld area within the overlapping region of the longitudinal shell weld boundary.

2.2 Licensee's Basis for Relief

The licensee's request is based upon provisions in the NRC 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 well as elimination of successive examinations of areas containing flaw indications.

As described previously, GL 98-05 provides two criteria that relief request applicants must demonstrate, based upon the limiting conditional failure probability of the applicant's circumferential welds and implementation of 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 safety evaluation.

The NRC 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 Babcock and Wilcox (B&W), using the highest mean irradiated RT_{NDT} to determine the limiting case. The relief request compared the mean irradiated RT_{NDT} for BFN3 to that for the limiting B&W case described in Table 2.6-4 of Ref. 3. As illustrated in Table 2, the RT_{NDT} for BFN3 is much lower than that for the limiting B&W case, and the licensee concluded that the conditional failure probability for the BFN3 circumferential welds is bounded by the conditional failure probabilities in the staff's safety evaluation report through the end of the current license period.

Table 2: Comparison of BFN3 Circumferential Weld and the Limiting B&W Weld from Table 2.6-4

PARAMETER	BFN3	LIMITING B&W RPV
Fluence (10^{19} n/cm^2)	0.11	0.095
Initial RT_{NDT} (°F)	-40	20
Chemistry Factor (°F)	117.5	196.7
Cu (Wt. %)	0.09	0.31
Ni (Wt. %)	0.67	0.59
ΔRT_{NDT} (°F)	51.2	79.8
Mean RT_{NDT} (°F) [Initial RT_{NDT} + ΔRT_{NDT}]	11.2	99.8

The applicant indicated that examination of the circumferential welds shall be performed if examination of the axial welds reveals an active, mechanistic mode of degradation. This is consistent with provisions in the SE for the BWRVIP-05 report.

The licensee has assessed the systems that could lead to a cold over-pressurization of the BFN3 reactor pressure vessel (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 likelihood of a cold over-pressure transient event placing the plant in nondesign conditions is very low.

The basis for relief from performing successive examinations of the BFN3 RPV circumferential shell weld flaw areas is outlined in the three conditions of Section 2.8.1 of the BWRVIP-05 SE. The criteria outlined in Section 2.8.1 permits elimination of examinations for "nonthreatening" flaws (e.g., such as embedded flaws from material manufacturing or vessel fabrication which experience negligible or no growth during the design life of the vessel) provided the conditions below are satisfied:

- The flaw is characterized as subsurface.
- The nondestructive examination (NDE) technique and evaluation that detected and characterized the flaw as originating from material manufacture or vessel fabrication is documented in a flaw evaluation report.
- The vessel containing the flaw is acceptable for continued service in accordance with IWB-3600 and the flaw is demonstrated acceptable for the intended service life of the vessel.

Justification not to perform the successive examinations required by the ASME Code IWB-2420(b) is based upon TVA's compliance with the conditions specified above as described in section 2.8.1 of the NRC SE for the BWRVIP-05 report. The licensee stated that:

- The flaws have been characterized as subsurface. NRC concluded the flaws were subsurface in Section 4.0 of its SE dated August 17, 1998, for BFN Request for Relief 3-ISI-1, Revision 0.
- Each of the flaws has a flaw evaluation report which describes the NDE technique and the conclusion that the flaws were pre-existing.
- The GE flaw evaluation shows that the maximum indication depths (2a) will not exceed the ASME Code allowable flaw depths during the intended service life of the vessel.

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 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 SE to the BWRVIP-05 report and GL 98-05 are satisfied.

3.1 Relaxation From Circumferential Weld Examination Requirements

3.1.1 Circumferential Weld Conditional Failure Probability

The 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 (RVID) with that submitted in the relief request, the staff has confirmed that the mean RT_{NDT} of the circumferential welds at BFN3 is projected to be 11.2°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 BFN3 is significantly lower than that for the limiting plant-specific case for B&W-fabricated RPVs, indicating that the conditional failure probability of the BFN3 circumferential welds is much less than 8.17×10^{-5} per reactor year. From Figure B-1 of the staff's SE and using a transient temperature of 88°F (such that T - RT is 77°F), the conditional failure probability for the BFN3 circumferential welds is actually found to be much less than 10^{-7}.

3.1.2 Cold Overpressure Transient Probability

During review of the BWRVIP-05 report, the staff identified nondesign 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 BFN3 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 the Technical Specification 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 transient event placing the plant in nondesign conditions is very low. The staff agrees with the licensee that the information provided regarding the BFN3 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 nondesign basis cold over-pressure transient is unlikely to occur at BFN3.

3.2 Relaxation from Successive Flaw Examination Requirements

The SE for the BWRVIP-05 report concluded that the BWRVIP recommendations for successive examinations are acceptable for circumferential welds. In response to a request for one-cycle relief from performing the first successive examination of the weld flaws, the staff issued a detailed evaluation of the weld flaws in a safety evaluation dated August 17, 1998. This evaluation concluded that:

1. The flaws are subsurface.

2. A flaw evaluation shows that the maximum indication depths (2a) will not exceed the ASME Code-allowable flaw depths during the intended service life of the vessel.

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:

- Permanent relief (i.e., for the remaining term of operation under the initial, existing 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, Item No. B1.11.

- Relief from requirements for successive examinations of flaws in Subarticle IWB-2420(b) of ASME Code Section XI.

The NRC staff concludes that authorization of TVA's alternative examinations would provide assurance of structural integrity and, therefore, an acceptable level of quality and safety. Accordingly, pursuant to 10 CFR 50.55a(g)(6)(ii)(A)(5) and 10 CFR 50.55a(a)(3)(i), the licensee's proposed alternative examination is authorized and effective from the date of this SE until the expiration of the operating license at midnight on July 2, 2016.

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Date: November 18, 1999

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