October 7, 2002

Mr. J. A. Scalice
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and Executive Vice President
Tennessee Valley Authority
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SUBJECT: SAFETY EVALUATION FOR BROWNS FERRY UNIT 2 — RELIEF REQUESTS (2-ISI-16 AND 2-ISI-17) CONCERNING INSERVICE INSPECTION REQUIREMENTS FOR THE CLASS 1 REACTOR VESSEL NOZZLES (TAC NO. MB4880)

Dear Mr. Scalice:

By a letter dated April 23, 2002, as supplemented by a letter dated September 5, 2002, the Tennessee Valley Authority (TVA) submitted two requests for relief from the inservice inspection (ISI) requirements specified in American Society of Mechanical Engineers Boiler and Pressure Vessel Code, Section XI, for the Class 1 Reactor Pressure Vessel (RPV) nozzle inner radius sections for the RPV and the RPV head, with the exception of the six (N4) Feedwater nozzles. Pursuant to Title 10 *Code of Federal Regulations* (10 CFR) Section 50.55a(a)(3)(i), your request, 2-ISI-16, proposes an enhanced remote visual examination capable of a 1-mil (0.001 inch) wire resolution as an alternative to the required volumetric examination for nozzles where plant configuration is such that visual examination may be performed on essentially 100 percent of the inner radius. Pursuant to 10 CFR 50.55a(a)(3)(ii), 2-ISI-17 requested relief, based on hardship, to perform an enhanced direct visual examination capable of 1-mil wire resolution for the identified nozzles where visual examination of the inner radius is limited by physical obstructions.

Based on our review of your submittal, we have concluded that the proposed alternative in 2-ISI-16 provides an acceptable level of quality and safety and, therefore, it is authorized pursuant to 10 CFR 50.55a(3)(i) for the remainder of the third 10-year ISI interval at Browns Ferry Unit 2, which began May 25, 2001, and ends May 24, 2011. For Relief Request 2-ISI-17, we have concluded that complying with the specified requirements would result in hardship without a compensating increase in the level of quality and safety, and the proposed alternative examination provides reasonable assurance of structural integrity of the subject components.

Therefore, 2-ISI-17 is authorized pursuant to 10 CFR 50.55a(a)(3)(ii) for the remainder of the third 10-year interval at Browns Ferry Unit 2. Our conclusions are based on the enclosed safety evaluation.

Sincerely,

/***RA***/

Allen G. Howe, 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/enclosure: See next page

Therefore, 2-ISI-17 is authorized pursuant to 10 CFR 50.55a(a)(3)(ii) for the remainder of the third 10-year interval at Browns Ferry Unit 2. Our conclusions are based on the enclosed safety evaluation.

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Allen G. Howe, Chief, Section 2
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Docket No. 50-260

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cc w/enclosure: See next page

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SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

INSERVICE INSPECTION PROGRAM

RELIEF REQUESTS (2-ISI-16 AND 2-ISI-17)

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT UNIT 2

DOCKET NO. 50-260

1.0 INTRODUCTION

By a letter dated April 23, 2002, as supplemented by a letter dated September 5, 2002, the Tennessee Valley Authority (TVA) submitted two requests for relief from the inservice inspection (ISI) requirements specified in American Society of Mechanical Engineers (ASME) Code, Section XI, for the Class 1 Reactor Pressure Vessel (RPV) nozzle inner radius sections for the RPV and the RPV head, with the exception of the six (N4) Feedwater nozzles. In accordance with Title 10 to the *Code of Federal Regulations* (10 CFR) Section 50.55a(a)(3)(i), your request 2-ISI-16 proposes an enhanced remote visual examination capable of a 1-mil (0.001 inch) wire resolution as an alternative to the required volumetric examination for nozzles where plant configuration is such that visual examination may be performed on essentially 100 percent of the inner radius. In accordance with 10 CFR 50.55a(a)(3)(ii), 2-ISI-17 requested relief based on hardship to perform an enhanced direct visual examination capable of 1-mil wire resolution for the identified nozzles where visual examination of the inner radius is limited by physical obstructions. The subject relief requests are for the third 10-year interval at Browns Ferry Nuclear Plant (BFN), Unit 2, which began May 25, 2001 and ends May 24, 2011.

2.0 REGULATORY EVALUATION

Inservice inspection of the ASME Code Class 1, 2, and 3 components is to be performed in accordance with Section XI of the ASME *Boiler and Pressure Vessel Code* (B&PV Code), and applicable addenda, as required by 10 CFR 50.55a(g), except where specific relief has been granted by the Commission pursuant to 10 CFR 50.55a(g)(6)(i). The regulation at 10 CFR 50.55a(a)(3) states that alternatives to the requirements of paragraph (g) may be used, when authorized by the U.S. Nuclear Regulatory Commission (NRC), if the licensee demonstrates that (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.

Pursuant to 10 CFR 50.55a(g)(4), ASME Code Class 1, 2, and 3 components (including supports) shall 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 (ISI) 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 Section XI of the ASME Code, which was incorporated by reference in 10 CFR 50.55a(b) 12 months prior to the start of the 120-month interval, subject to the limitations and modifications listed therein. The Code of record for the Browns Ferry Unit 2 third 10-year ISI interval is the 1995 edition with the 1996 Addenda of the ASME B&PV Code.

3.0 RELIEF REQUEST 2-ISI-16

3.1 Component Function/Description

This request covers the RPV and RPV head nozzles inner radius, specifically the:

- Reactor recirculation suction loop nozzles (2)
- Main steam nozzles (4)
- RPV head nozzles (3)
- Control rod drive (CRD) return line - capped (1)

3.2 Code Requirements for Which Relief is Requested

The 1995 Edition with Addenda 1996 (95A96), ASME Section XI, Table IWB-2500-1, Examination Category B-D, Item B3.100, requires a volumetric examination of the RPV and RPV head nozzles inner radius section. Relief is requested from the requirements to perform the volumetric examination of the inner nozzle radii for the nozzles listed in Section 3.1 above.

3.3 Licensee's Proposed Alternative (as submitted)

In accordance with 10 CFR 50.55a(a)(3)(i) TVA will perform the following alternate examinations:

TVA will perform an enhanced direct visual (VT-1) examination, capable of a 1-mil wire resolution, of the reactor pressure vessel (RPV) head nozzles (Nozzles N6A, N6B, and N7) inner radius sections, in accordance with ASME Section XI, VT-1 requirements. Essentially 100 percent Code coverage will be attained.

For the Reactor pressure vessel nozzles inner radius sections, (N1A, N1B, N3A, N3B, N3C, N3D, and N9), TVA will perform an enhanced remote visual examination (VT-1), capable of a 1-mil wire resolution, in accordance with ASME Section XI, VT-1 requirements. This examination will be a remote visual exam utilizing cameras. Essentially 100 percent Code coverage will be attained.

Crack-like surface flaws exceeding the acceptance criteria of Table IWB-3512-1 are unacceptable for continued service unless the reactor vessel meets the requirements of IWB-3142.2, IWB-3142.3 or IWB-3142.4.

3.4 Licensee's Bases for Alternative (as submitted)

The RPV nozzles were nondestructively examined during fabrication and have previously been examined using inservice ultrasonic techniques specific to the nozzle configuration. No indication of fabrication defects or service related cracking has been detected by these examinations.

The RPV and RPV head nozzles inner radius sections are the only non-welded areas (excluding the RPV head bolts) requiring examination on the reactor vessel. This requirement was deterministically made early in the development of ASME Section XI. For all nozzles, other than Feedwater, there is no significant thermal cycling during operation. From a risk perspective, there is no need to perform a volumetric examination on any nozzle other than the Feedwater and CRD return nozzles. No service related cracking has ever been discovered in any of the BWR fleet nozzles other than on Feedwater or CRD return lines.

Development of Code Case N-648 was coordinated with the Westinghouse Owners Group (WOG), ASME, and the NRC. On May 9, 2000, the WOG met with NRC to discuss issues related to the proposed inspection elimination for reactor pressure vessel inner radius regions. Although justification was presented to eliminate any examination of RPV nozzle inner radius sections (excluding BWR [boiling-water reactor] Feedwater and CRD nozzles), a consensus was reached between the WOG and the NRC, to replace the volumetric examination of the other RPV nozzles (non Feedwater or CRD) with a visual (VT-1) examination.

3.5 Evaluation

In the mid 1970s, fatigue-initiated cracking was discovered in the nozzle inner radius section of feedwater nozzles at 18 BWRs. The cracks were found using visual examination. Ultrasonic testing or UT failed to reveal the presence of these cracks, which prompted the NRC to prepare NUREG-0619, which modified inspection requirements for these components.

In NUREG-0619, the NRC staff concluded that UT of the vessel nozzle inner radius section involves complex geometries, long examination metal paths, and inherent UT beam spread, scatter, and attenuation. During the intervening years, improvements in UT technologies were introduced (e.g., computer modeling, tip diffraction, and phased array scanning), which improved the quality of the examination for this component. However, the area remains difficult to examine completely.

The NRC staff finds that even with vessel examinations using improved nondestructive examination (NDE) technology from the outside surface, the complex geometry of the RPV head nozzle inner radius sections prevents complete UT coverage. For the RPV head nozzles, the licensee proposed to perform what the licensee has identified as an enhanced direct VT-1 (EVT) visual examination with 'essentially 100-percent coverage' in lieu of the UT. Enhanced in this case refers to the 1-mil standard at 2 feet that is to be demonstrated by the examiners to assure acceptable resolution sensitivity. The estimated coverage for each nozzle is provided in the licensee's September 5, 2002, submittal. The licensee indicated that measures will be taken to assure that examination conditions, including adequacy of lighting, will be consistent with the conditions used to demonstrate examiner competency.

The primary degradation mode in RPV nozzles is fatigue, which produces hairline surface indications along the circumference of the nozzle at the inner radius section. Given the 1-mil resolution capability of the EVT, it is highly unlikely that the licensee would not detect such flaws using high magnification cameras that can examine 100 percent of the nozzle inner radius section surface area. The staff has determined that the high resolution image from the camera may be used in lieu of UT of the inner nozzle radius to provide adequate assurance of structural integrity. The staff notes that the licensee has indicated their intention to use examination equipment with a demonstrated capability of a 1-mil wire resolution for this examination.

The licensee indicated in their April 23, 2002, submittal, that their alternative examination "is consistent with the alternative proposed in ASME Code Case N-648-1." The staff recognizes that for crack-like surface flaws exceeding the criteria of Table IWB-3510-3, Allowable Linear Flaws, the use of Table IWB-3512-2, Component Thickness vs. Flaw Location, for calculating the component thickness value is done in accordance with the provisions of Table IWB-3510-3 as stated in ASME Code Case N-648-1. The staff notes that the allowable linear flaw acceptance criteria in Table IWB-3510-3 does not contain provisions for the inner radius. The licensee acknowledged this discrepancy in its supplement dated September 5, 2002, to the original submittal, and indicated TVA's intention to use an aspect ratio of 0.50 and surface flaw depth of 2.5 percent for calculating the flaw acceptance criteria as specified in Table IWB-3512-1. The conservatism in the allowable flaw length specified provides for an extension of the crack that is not visible using the alternative method, but would be if the licensee was using the UT method.

Based on the licensee's ability to demonstrate equipment and operator qualification to a 1-mil resolution at 2 feet during the examinations and a reasonable flaw acceptance criteria based on Table IWB-3512-1, the NRC staff has determined that there is reasonable assurance that the licensee's proposal to use enhanced direct visual examination of the RPV head nozzles (N6A, N6B, and N7) and enhanced remote visual examination for the RPV nozzle inner radius sections (N1A, N1B, N3A, N3B, N3C, N3D, and N9) will result in an acceptable level of quality and safety.

3.6 Conclusion

Based on the information provided in the licensee's submittal, the NRC staff has determined that the proposed alternative in 2-ISI-16, as described in Section 3.3 above, provides an acceptable level of quality and safety, and, therefore, it is authorized pursuant to 10 CFR 50.55a(a)(3)(i) for the remainder of the third 10-year ISI interval at Browns Ferry Unit 2, which began May 25, 2001, and ends May 24, 2011. This authorization is limited to those components described in Section 3.1 above.

4.0 RELIEF REQUEST 2-ISI-17

4.1 Component Function/Description

This request covers the reactor pressure vessel (RPV) and RPV head nozzle inner radius, specifically the:

- Reactor recirculation inlet loop nozzles (10)
- Core Spray nozzles (2)
- Jet Pump instrumentation (2)

4.2 Code Requirements for Which Relief is Requested

ASME Section XI,1995 Edition with 1996 Addenda, Table IWB-2500-1, Examination Category B-D, Item B3.100, requires a volumetric examination of all reactor pressure vessel nozzles inner radius section welded with full penetration welds as shown in Figures IWB-2500-7(a) through (d).

4.3 Licensee's Proposed Alternative (as submitted)

TVA will perform the following examination on the specified nozzles:

For the reactor pressure vessel nozzles inner radius sections, (N2A, N2B, N2C, N2D, N2E, N2F, N2G, N2H, N2J, N2K, N5A, N5B, N8A, and N8B), TVA will perform an enhanced remote visual examination (VT-1), capable of a 1-mil wire resolution, in accordance with ASME Section XI, VT-1 requirements. This examination will be a remote visual examination utilizing cameras. Visual examination of the inner radius section for the above nozzles is limited because the reactor internal piping configuration prevents placement of the camera in all positions necessary to examine the surface M-N [See Figures IWB-2500-7(a) through (d)] over the full circumference.

Crack-like surface flaws exceeding the acceptance criteria of Table IWB-3512-1 are unacceptable for continued service unless the reactor vessel meets the requirements of IWB-3142.2, IWB-3142.3 or IWB-3142.4. The specific limitations and estimated examination coverage for each nozzle are provided below.

NOZZLE TYPE/NO.	LIMITATION	ESTIMATED COVERAGE
Recirculation Inlet, N2 (10 nozzles)	Thermal Sleeve/ Jet-Pump Riser	50%
Core Spray, N5 (2 Nozzles)	Thermal Sleeve and Sparger	40%
Jet-Pump Instrumentation, N8 (2 Nozzles)	Instrumentation Lines	60%

4.4 Licensee's Bases for Relief (as submitted)

Pursuant to 10 CFR 50. 55a(a)(3)(i) TVA is requesting relief from ASME Section XI requirements to perform the volumetric examination described above. TVA is proposing to implement a visual examination alternative. This examination is consistent with the alternative proposed in ASME Code Case N-648-1. The visual examination will cover the same inspection surface as specified for the volumetric examination.

The volumetric examinations (ultrasonic) conducted from the outside surfaces are difficult and time consuming due to the asymmetrical configuration of both the nozzle outside surface (where the transducers are manipulated) and the

inner radius section of the nozzle being interrogated. Examination of the asymmetrical surfaces may require several different transducer/wedge angle combinations and these are applied at certain azimuths around the nozzle weld blend area of the vessel surface. Different size nozzles usually require a separate set of transducer/wedge angle combinations and calibrations. Several hours may be required for the calibrations and examination of one typical 6-inch diameter nozzle inner radius section.

An enhanced visual (VT-1) examination of the nozzle inner radius sections would provide assurance of the required coverage and indicate the presence of surface flaws. The option to perform an enhanced visual (VT-1) examination will provide an acceptable examination without compromising the level of quality and safety.

The proposed alternative will also provide a significant savings in examination resources and radiation exposure to examination and support personnel.

4.5 Evaluation

As stated in Section 3.5 above, the staff finds that even with vessel examinations using improved NDE technology from the outside surface, the complex geometry of the RPV nozzle inner radius regions prevents complete UT coverage. At the same time, performance of UT on these components requires the examiner to enter and remain inside the biological shield penetration area around the nozzle for the duration of the UT, which takes approximately 1 hour. The licensee stated that dose rates for the specified RPV nozzles are in the range of 500 to 1200 millirem per hour with shielding in place, which results in an estimated personnel exposure of about 4.5 rem per inspection interval. Performance of a visual examination using remote cameras essentially eliminates any personnel exposure.

The primary degradation mode in RPV nozzles is fatigue, which produces hairline surface indications along the circumference of the nozzle at the inner radius section. Given the resolution capacities of the enhanced remote VT-1 (ERVT), it is highly unlikely that the licensee would not detect such flaws using high magnification cameras that can examine the accessible portions of the nozzle inner radius section surface area. As stated in Section 3.5 above, the staff has determined that the high resolution image from the camera may be used in lieu of UT of the inner nozzle radius that is difficult to perform, and provides adequate assurance of structural integrity. For the components listed in Section 4.1 above, the licensee proposed to perform an ERVT examination on the accessible portion of the nozzle inner radius regions in lieu of UT. The licensee stated that the estimated coverage for some nozzles will be in the range of 40-60 percent. The resolution sensitivity for this remote in-vessel exam will be established using a 1-mil diameter wire.

The licensee indicated in their April 23, 2002, submittal that their alternative examination “is consistent with the alternative proposed in ASME Code Case N-648-1.” The staff recognizes that for crack-like surface flaws exceeding the criteria of Table IWB-3510-3, Allowable Linear Flaws, the use of Table IWB-3512-2, Component Thickness vs. Flaw Location, for calculating the component thickness value is done in accordance with the provisions of Table IWB-3510-3 as stated in ASME Code Case N-648-1. The staff notes that the allowable linear flaw acceptance criteria in Table IWB-3510-3 does not contain provisions for the inner radius. The licensee acknowledged this discrepancy in its supplement dated September 5, 2002, to the original submittal, and indicated TVA’s intention to use an aspect ratio of 0.50 and surface flaw depth of 2.5 percent for calculating the flaw acceptance criteria as specified in Table

IWB-3512-1. The conservatism in the allowable flaw length specified provides for an extension of the crack that is not visible using the alternative method, but would be if the licensee was using the UT method.

While the proposed visual examination on these components will be limited to about 40-60 percent estimated coverage, the NRC staff believes it still provides reasonable assurance that flaws of significant size will be detected. When flaws are initiated by the fatigue mechanism, they typically are encountered over a significant portion of the nozzle circumference, as was the case for cracking of feedwater nozzles addressed in NUREG-0619. The NRC staff also recognizes that the industry has stated that they have experienced no reported cracking in the subject nozzle inner radius regions, and that the subject nozzles are not subjected to significant thermal cycling. In addition, the staff notes that at least ten nozzles in the RPV nozzle population will receive a complete visual nozzle inner radius examination (either UT or ERVT in accordance with 2-ISI-16).

Based on the licensee's ability to demonstrate high magnification equipment qualification to a 1-mil standard at two ft. during the examinations and a reasonable flaw acceptance criteria based on Table IWB-3512-1, the NRC staff has determined that there is reasonable assurance that the licensee's proposal to use enhanced remote visual examination for the RPV nozzle inner radius sections (N2A, N2B, N2C, N2D, N2E, N2F, N2G, N2H, N2J, N2K, N5A, N5B, N8A, and N8B) will result in reasonable assurance of structural integrity of the subject components.

4.6 Conclusion

Based on the information provided in the licensee's submittal, the NRC staff has concluded that complying with the specified requirements would result in hardship without a compensating increase in the level of quality and safety, and the proposed alternative provides reasonable assurance of structural integrity of the subject components. Therefore, Relief Request 2-ISI-17 is authorized pursuant to 10 CFR 50.55a(a)(3)(ii) for the remainder of the third 10-year ISI interval at Browns Ferry Unit 2, which began May 25, 2001, and ends May 24, 2011. This authorization is limited to these components described in Section 4.1 above.

Principal Contributors: E. Brown
D. Naujock

Date: October 7, 2002

Mr. J. A. Scalice
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BROWNS FERRY NUCLEAR PLANT

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