TVA

Tennessee Valley Authority, Post Office Box 2000, Decatur, Alabama 35609

May 6, 1996

U.S. Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, D.C. 20555

Gentlemen:

| | | |
|---|---|---|
| In the Matter of | ) | Docket No. 50-296 |
| Tennessee Valley Authority | ) | |

**BROWNS FERRY NUCLEAR PLANT (BFN) - UNIT 3 - REPLY TO NRC REQUEST FOR ADDITIONAL INFORMATION (RAI) REGARDING AUGMENTED REACTOR VESSEL WELD EXAMINATION (TAC NO. M91786)**

This letter provides TVA's reply to NRC's February 5, 1996, RAI regarding the Unit 3 augmented reactor pressure vessel (RPV) weld examinations. Specifically, NRC requested information regarding the design limitations for the General Electric System 2000 ultrasonic examination equipment and the location of BFN Unit 3 RPV weld C-BH-1 with respect to adjacent interferences. Also, NRC requested that TVA provide additional justification to demonstrate that the proposed inspection alternatives provide an acceptable level of quality and safety.

The enclosure contains specific details regarding the information requested by NRC. In summary, the BFN Unit 3 augmented RPV examination was conducted in a technical manner conducive with the requirements of Appendix VIII of ASME Section XI, "Performance Demonstration for Ultrasonic Examination Systems," and therefore, was performed with current industry state-of-the-art techniques. The weld examinations performed provide reasonable assurance that inservice flaws unacceptable for continued operation have not developed when 100 percent of total weld coverage is considered.

030029



D030

There are no commitments contained in this letter. If you have any questions, please contact me at (205) 729-2636.

Sincerely,

Pedro Salas
Manager of Site Licensing

Enclosure
cc (Enclosure):
Mr. Mark S. Lesser, Branch Chief
U.S. Nuclear Regulatory Commission
Region II
101 Marietta Street, NW, Suite 2900
Atlanta, Georgia 30323

NRC Resident Inspector
Browns Ferry Nuclear Plant
10833 Shaw Road
Athens, Alabama 35611

Mr. J. F. Williams, Project Manager
U.S. Nuclear Regulatory Commission
One White Flint, North
11555 Rockville Pike
Rockville, Maryland 20852

ENCLOSURE

TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNIT 3

TVA REPLY TO NRC REQUEST FOR ADDITIONAL INFORMATION
REGARDING AUGMENTED REACTOR VESSEL WELD EXAMINATION

---

**PURPOSE/BACKGROUND**

This enclosure provides TVA's reply to NRC request for additional information dated February 5, 1996.

10 CFR 50.55a(g)(6)(ii)(A) requires an augmented examination of essentially 100 percent of the weld length of all reactor pressure vessel (RPV) circumferential and longitudinal shell welds. Additionally, 10 CFR 50.55a(g)(5) states that licensees that determine they are unable to completely satisfy the requirements for augmented reactor vessel shell weld examinations specified in 10 CFR 50.55a(g)(6)(ii)(A) shall submit information to the commission to support the determination and shall propose an alternative to the examination requirements that would provide an acceptable level of quality and safety. Due to the location of Unit 3 RPV circumferential weld C-BH-1 (i.e., on the bottom of the vessel and surrounded by jet pumps and jet pump sensing lines) and limitations in the General Electric (GE) System 2000 ultrasonic examination equipment (i.e., length of inspection mast and width of the examination probe), TVA was able to examine only 28 percent of this weld. TVA requested relief from the 100 percent inspection requirement in relief request 3-ISI-17 on March 6, 1995. In a letter to TVA dated February 5, 1996, NRC requested additional information regarding the inspection coverage for weld C-BH-1.

The following is a restatement of the requested information followed by TVA's reply.

1. **NRC Request**

   Explain the nature of the "inspection equipment extension restrictions" noted in the submittal in connection with the inspection of circumferential weld C-BH-1. Determine the additional inspection coverage for weld C-BH-1 and other welds, if applicable, that would have been obtained if the inspection equipment had not been limited by "equipment extension restrictions." Summarize the additional coverage and how it was determined.

**TVA Response**

Inspection of RPV's is required by Section XI of the ASME Boiler and Pressure Vessel Code. The GERIS 2000 Invessel Inspection System was designed to examine Boiling Water Reactors (BWR) from the inside diameter (ID) surfaces (NOTE: Examination from the ID surface is performed when outside access is not available due to bioshield design, insulation interferences, and when radiological considerations could present high exposure risks to examination personnel). The GERIS 2000 Invessel System design is a computer-controlled track-mounted manipulator. The major components of the manipulator are the upper and lower guide rings, mast assembly, circumferential car, boom extension, swivel guide, chain assembly, and horizontal travel mechanism (HTM). The HTM is mounted to the last link of the chain assembly and carries the lower search unit package.

The design parameters of the GERIS 2000 Invessel System are governed by the reactor pressure vessel and refuel floor layouts of the vessel intended to be inspected. The vessel design parameters affecting the invessel tooling included the vessel flange diameter, shroud flange diameter, the vertical separation of the vessel and shroud flanges, location and size of the installed jet pumps, location and size of internal attachments, and internal piping. Additional factors that limited the design of the invessel tooling are the refuel floor access, weight limits, and the maximum safe lift height. Scanning with the lower search unit package is limited by the upper scan limit of the HTM (approximately 10 inches below the shroud flange surface, i.e., vessel elevation 394"), the lower scan limit of the chain assembly (approximately 246 inches below the shroud flange surface, i.e. vessel elevation 158"), and by the proximity of internal attachments, jet pump diffusers, jet pump risers, and nozzles.

The GERIS 2000 invessel inspection of the Unit 3 RPV did not include examination of the Bottom Head to Shell Course 1 circumferential weld C-BH-1. The weld was inaccessible to the GERIS 2000 manipulator. The limitation that prevented access to C-BH-1 was the lower scan limit of the chain assembly. An evaluation was performed by GE to determine the coverage that could be achieved by modifying the manipulator as necessary to reach the shroud ledge and perform scanning along the C-BH-1 weld. This would initially require the addition of a minimum of 16 inches to the chain length.

No mechanical difficulties are presented by increasing the chain length. This could be accomplished by adding one or more link sections to the chain. However, the increase in chain length would require the manipulator mast to be extended to accommodate the additional links. The manipulator as configured requires the entire vertical lift capability available to the crane for installation in the vessel. Increasing the length of the manipulator may require unconventional rigging over the vessel or modification of the crane. Modifications to the HTM (reducing the depth of the search unit package and HTM) were also considered. Due to mechanical considerations related to the telescoping sections of the HTM, and the clearances required for the stepping motors and resolvers contained in the HTM, the HTM was already at its minimum practical dimension. Therefore, modification of the HTM was not feasible.

An evaluation of the coverage for weld C-BH-1 obtainable by modifying the GERIS 2000 manipulator was performed. The evaluation assumed that the manipulator chain was lengthened and the mast was extended to accommodate the increase chain length. Several invessel obstructions limited the achievable coverage. These items included the jet pump riser brackets, jet pump instrumentation piping, and the jet pump diffuser tail pipe to vessel wall clearances. With the ID tool modified as described above and conducting the examination solely from the inside surface, the maximum possible coverage of weld C-BH-1 is calculated to be approximately nine percent of the required examination volume. The 1993 examination of the C-BH-1 performed from the outside diameter (OD) surface resulted in approximately 28 percent of the required examination volume achieved. The majority of the accessible area from the inside surface that could be obtained with a modified ID tool is located in the same areas that were scanned in 1993 from the outside surface. Therefore, performing an ID only examination of this weld would result in significantly less examination coverage than was obtained from the outside surface in 1993. Performing a combination of inside and outside examinations would result in an increase in examination coverage of approximately one percent above what was achieved in 1993 from the outside surface.

The examination conducted on the BFN Unit 3 Bottom Head to Shell Course 1 circumferential weld C-BH-1 in 1993 represents the maximum examination coverage achievable considering the BFN RPV design and current technology.

Modification of the GERIS 2000 invessel tooling would not significantly increase the examination coverage for weld C-BH-1 since the weld would remain essentially inaccessible to the GERIS 2000 Invessel system. The maximum achievable examination of weld C-BH-1 permitted by the proximity of the shielding from the outside surface was obtained during the 1993 examination.

2. **NRC Request**

In a telephone conversation on January 11, 1996, TVA and General Electric representatives indicated that inspection coverage for weld C-BH-1 is limited by the size of the inspection transducer (reported to be two inches wide). Provide the basis for the dimensions of the transducer used. Describe changes in inspection coverage of the shell welds, inspections effectiveness, and inspection methodology that would result from the use of a more compact transducer.

**TVA Response**

In the answer to question one above, justification is provided that modification of the HTM is not feasible due to mechanical considerations related to the telescoping sections of the HTM and the clearances required for the stepping motors and resolvers contained in the HTM. Since the HTM is already at its minimum practical dimension, a smaller search unit package would not increase examination coverage. Therefore, no benefit is obtained from the use of a more compact transducer.

3. **NRC Request**

Provide justification as to why TVA was unable to complete the augmented examination, giving consideration to the above questions on inspection equipment design limitations. TVA should explicitly address the requirements of 10 CFR 50.55a(g)(6)(ii)(A)(5) to demonstrate that the proposed alternative provides an acceptable level of quality and safety.

**TVA Response**

TVA was unable to meet the "essentially 100%" coverage requirement specified in 10 CFR 50.55a(g)(6)(ii)(A) due to a number of plant design factors which restricted access of the GERIS 2000 ID ultrasonic inspection tool. These factors are summarized as follows:

- Jet pump riser brackets limited ID access at all jet pump locations (a total of 20).
- Jet pump instrumentation piping at the 0 and 180 degree locations limited ID access.
- Jet pump diffuser tail pipe to vessel wall clearance (1.68 inches between the jet pump tail pipe and the vessel pipe limited ID access).
- OD access was limited due to non-removable insulation and the close proximity of the biological shield wall.

As a result of the above physical limitations, the following weld examination coverage was obtained:
Circumferential RPV Shell Welds (See Attachment 1)

C-2-3: 80 percent
C-1-2: 90 percent
C-BH-1: 28 percent

Longitudinal RPV Shell Welds (See Attachment 1)

V-1-A: 82 percent
V-1-B: 83 percent
V-1-C: 88 percent
V-2-A: 85 percent
V-2-B: 90 percent
V-3-C: 70 percent
V-4-B: 83 percent

The remaining ten RPV shell welds received "essentially 100%" examinations ranging from 91 percent to 100 percent coverage:

C-4-5: 93 percent
C-3-4: 97 percent
V-2-C: 91 percent
V-3-A: 99 percent
V-3-B: 99 percent
V-4-A: 100 percent

V-4-C: 100 percent
V-5-A: 100 percent
V-5-B: 99 percent
V-5-C: 100 percent

Although greater than 90 percent coverage required under 10 CFR 50.55a(g)(6)(ii)(A) is not achieved for all welds, an acceptable level of quality and safety has been achieved based on the following:

The Boiling Water Reactor Owners Group Vessel and Internals Project (BWRVIP) has issued report BWRVIP-05 entitled "BWR Reactor Pressure Vessel Shell Weld Inspection Recommendations" that provides the technical and economic basis for the examination of BWR Vessel Shell Welds. This report, which has been submitted for NRC review by the BWR Owners Group, provides recommendations for inspections to ensure that quality and safety are maintained without placing undue burden on the industry. The BWRVIP-05 report provides a recommendation, with technical justification, that BWR vessel inspections be limited to 50 percent of the vessel vertical (longitudinal) welds and that inspection of the circumferential welds be eliminated. This recommendation is acceptable since weld orientation has been found to have a very significant effect on probability of failure (POF) results, fundamentally because of differences in pressure stresses in the two directions. Since there are no thermal stresses in the governing (pressure test) loading condition for BWR vessel shell welds, and since weld residual and cladding stresses are both small compared to the pressure stresses, weld orientation has a dominant effect in the analysis. Also, the stress intensity factor multipliers are significantly higher for axially oriented cracks. The combination of these two effects produces essentially zero probability of fracture for circumferentially oriented BWR vessel shell welds, regardless of material, irradiation embrittlement, or crack growth rate assumptions.

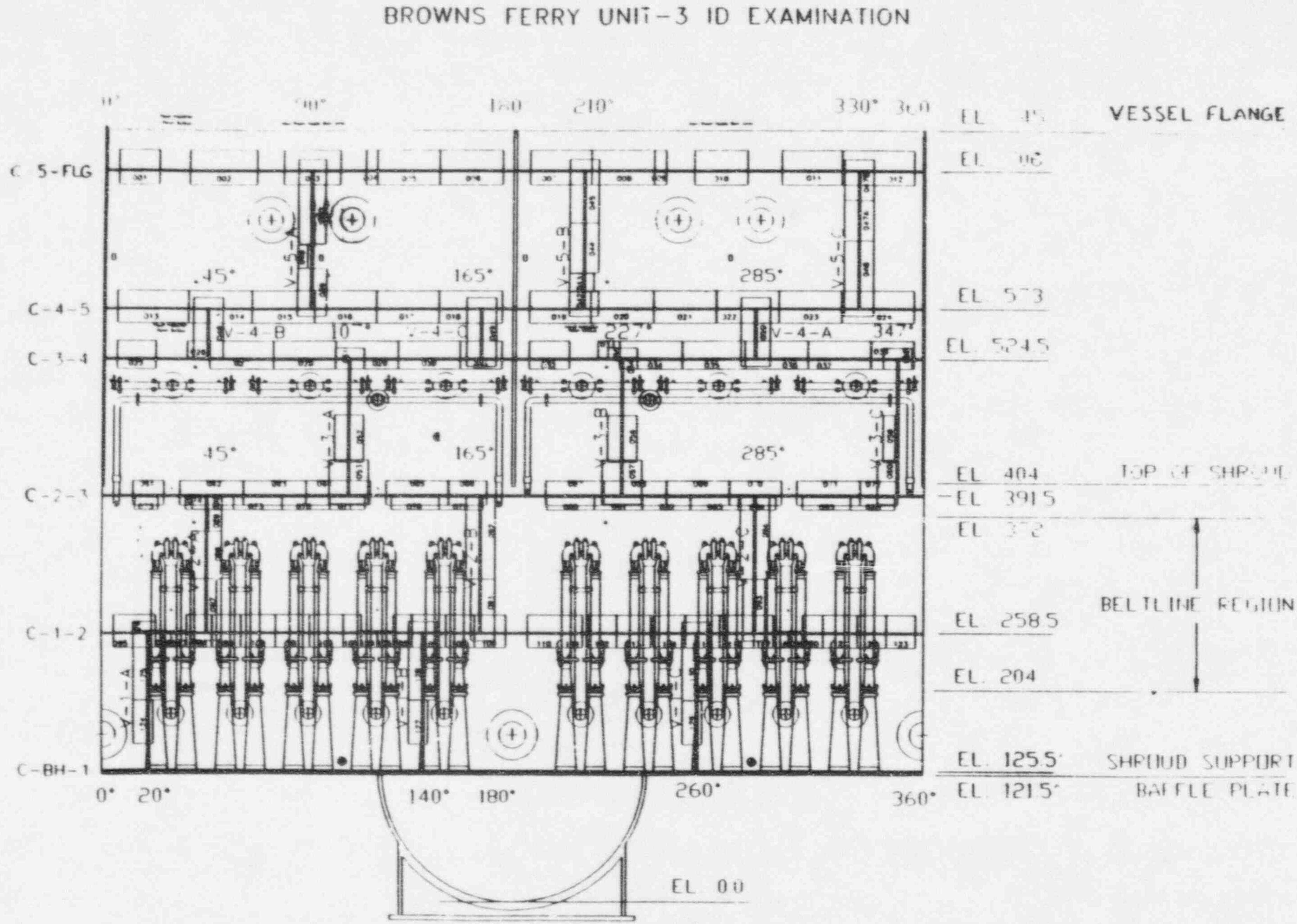
A review of construction practices and associated preservice inspection methods documented in BWRVIP-05 establish that vessels like BFN Unit 3 were constructed to very high standards. This is further supported by the fact that inspections performed both within the industry and most recently on Unit 3 have not identified service-related conditions. Indications were found during the Unit 3 exam which were not identified during preservice exams; however, these indications were evaluated not to be service-related and are attributed to improved sensitivity of the ultrasonic testing (UT) techniques employed. The qualification of the UT techniques performed on Unit 3 demonstrate that the techniques are highly reliable in detecting flaws.

The probabilistic fracture mechanics analysis (PFMA) results provided in BWRVIP-05 demonstrate that the probability of vessel rupture or brittle fracture is several orders of magnitude below NRC guidelines even for the case of no inspection. The 15 flaws found during the Unit 3 examination are bound by the PFMA, since the PFMA conservatively assumes a total of 30 surface-connected flaws. By comparison, BFN Unit 3 had a total of 15 subsurface weld flaws in approximately 82 percent of total weld coverage. This figure includes the fact that no flaws were found in beltline circumferential weld C-1-2 (where 90 percent coverage was obtained) and no flaws were found in the six beltline vertical welds V-1-A,-B,-C and V-2-A,-B,-C (where an average of 86.5 percent coverage was obtained). The evaluation of the 15 subsurface weld flaws identified during the Unit 3 augmented RPV evaluation is documented by TVA calculation MD-Q3001-940005, "Vessel Weld Flaw Evaluation for Browns Ferry Nuclear Plant (BFN) Unit 3." This calculation was previously submitted to NRC by TVA letter dated October 4, 1995. BWRVIP-05 states that lab results demonstrate that subsurface flaws located one inch from the surface are 1000 times less likely to cause a vessel failure than a comparable surface flaw.

BFN Unit 3 has achieved a significant amount of exam coverage for both the circumferential and vertical welds. The only weld with less than 50 percent coverage was circumferential weld C-BH-1. This is not considered adverse to quality or safety since the weld is not located in the vessel Beltline Region, where the highest radiation levels exist (see Attachment 1). The exam coverage, coupled with the inspection results and the technical basis established in BWRVIP-05, provide a high degree of confidence that safety and quality are maintained.

**Conclusion**

The BFN Unit 3 augmented RPV examination was conducted in a technical manner conducive with the requirements of Appendix VIII of ASME Section XI, "Performance Demonstration for Ultrasonic Examination Systems," and therefore, was performed with current industry state-of-the-art techniques. The weld examinations performed provide reasonable assurance that inservice flaws unacceptable for continued operation have not developed when 100 percent of total weld coverage is considered. An acceptable level of quality and safety has been achieved based on the results of the current ultrasonic examinations performed on the accessible portions of the circumferential and longitudinal RPV shell welds.




Attachment 1

| | | | | |
|---|---|---|---|---|
| GE NUCLEAR ENERGY | BROWNS FERRY UNIT 3 | VESSEL ROLLOUT & AS SCANNED PATCH LOCATIONS | BF3-RPS | REV. 0 |