UNITED STATES
NUCLEAR REGULATORY COMMISSION
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ENCLOSURE

SAFETY EVALUATION BY THE OFFICE OF SPECIAL PROJECTS

RESPONSE TO GENERIC LETTERS 84-11 AND 88-01

TENNESSEE VALLEY AUTHORITY

BROWNS FERRY NUCLEAR PLANT, UNIT 2

DOCKET NO. 50-260

1.0 INTRODUCTION

This evaluation addresses the responses by the licensee, Tennessee Valley Authority (TVA), to Generic Letters (GL) 84-11, "Inspections of BWR Stainless Steel Piping," and 88-01, "NRC Position on IGSCC (intergranular stress corrosion cracking) in BWR Austenitic Stainless Steel Piping." With the extended outage at Browns Ferry for all units, the superseding of GL 84-11 by GL 88-01 resulted in the TVA work on the stainless steel piping being a continuing effort.

The NRC in its letter of March 26, 1986 found that TVA's inspection plans as presented in its June 7, 1984 letter with supplements dated February 13, and May 3 and 22, 1985 for the upcoming fuel outages acceptable, but requested information on TVA's three exceptions to GL 84-11 prior to restart. The three exceptions were: (1) after treatment with induction heating stress improvement (IHSI), inspections were to be performed on only 25 percent of welds IHSI treated versus the 100% recommended in the GL 84-11; (2) reactor coolant leakage monitoring where the Browns Ferry Technical Specifications (TS) did not meet the recommendations in GL 84-11; and (3) weld overlay design wherein TVA contended that one layer would be satisfactory and the NRC's position that a minimum of two layers was necessary. For the exception of post-IHSI inspection, the TVA approach was found acceptable provided TVA completed the examination of the remaining IHSI treated welds during the next refueling outage. However, TVA was to expand the sampling if crack indications were reported in any of the IHSI treated welds.

2.0 EVALUATION

In TVA's November 10, 1986 response to the NRC March 26, 1986 letter, TVA committed to complete the post-IHSI examination of any remaining welds during the next (Cycle 6) refueling outage and submit TS changes to meet the GL 84-11 recommendations on reactor coolant leakage monitoring. In addition, TVA stated that the two welds repaired with overlay weld and treated with IHSI have more than two layers of weld metal.

Technical Specifications changes were proposed by TVA, in its letter of December 15, 1986, to address the more restrictive reactor coolant leakage monitoring limits recommended in GL 84-11. The NRC issued amendments to the Facility Operating Licenses incorporating the TS changes in its letter of August 26, 1987.

TVA, in its March 11, 1986 submittal, described the GL 84-11 inspections and the results, IGSCC mitigation efforts, and the jet pump instrumentation nozzle safe end inspections and repairs. The June 1986 inspections of the recirculation nozzle safe ends and other inspections showed that IGSCC was prevalent. TVA decided to extend the outage to replace these safe ends and some of the associated piping, and IHSI treat the remaining welds susceptible to IGSCC and which were capable of being IHSI treated. The March 11, 1986 submittal was superseded by the December 31, 1987 submittal. This submittal reflected all of the work performed by TVA during the extended outage to meet GL 84-11.

A. GL 84-11 INSPECTIONS

In the fall of 1984, during the early part of the Browns Ferry Nuclear Plant, Unit 2 (BFN 2), Cycle 5 outage, a total of 172 IGSCC susceptible welds were ultrasonically inspected. The licensee indicated that 100% of the accessible stainless steel welds, susceptible to IGSCC, in piping systems equal to or greater than 4 inches in diameter and operating at temperatures over 200°F, which are part of or connected to the reactor coolant boundary, up to the second isolation valve, with the exception of the head spray piping, were ultrasonically inspected for IGSCC. The head spray system is not a required safety system, has never been used, and was removed from service during this outage. The 172 welds were identified as follows:

1. 98 welds in the recirculation piping system,

2. 34 welds in the residual heat-removal (RHR) system,

3. 14 welds in the reactor water cleanup (RWCU) system, and

4. 26 welds in the core spray system.

In addition, eight welds in the jet pump instrumentation nozzle to safe end and reducer weldments were also inspected.

The following welds were not ultrasonically inspected for reasons provided. However, these welds were liquid penetrant inspected.

1. Two pipe-to-pipe welds in the RHR (DRHR-2-13B and DRHR-2-3B) which are in containment penetrations and therefore inaccessible.

2. The RWCU system has one weldment with two welds (DRWC-2-1A and DSRWC-2-1B) which overlap to such an extent that it should be considered/counted as one weld and an undesignated pipe-to-pipe weld (DRWC-?) located in a containment penetration and therefore inaccessible.

3. The core spray system had two pipe-to-pipe welds (DCS-2-4A and DCS-2-12A) that are inaccessible because they are within containment penetrations.

The ultrasonic testing (UT) was performed by personnel from TVA. The licensee indicated that all UT personnel (Level I, II, and III) were qualified and their capabilities demonstrated in accordance with Generic Letter 84-11. Region II of the NRC determined that TVA's UT procedures, calibration standards, equipment, personnel and IGSCC detection capabilities were satisfactorily demonstrated in accordance with IE Bulletin 83-02, and that the same procedures and techniques were used in TVA's UT examinations. Region II also indicated that all of TVA's UT personnel conducting these examinations have received appropriate training in IGSCC inspections using service-induced IGSCC cracked thick wall pipe specimens. Region II personnel also performed confirmation UT examinations of IGSCC indications for sizing and their results confirmed TVA's inspection results (see NRC Inspection Report 50-260/84-51).

B. INSPECTION RESULTS AND FLAW DISPOSITIONS

The inspections performed on BFN 2 during the Cycle 4 outage in compliance with IE Bulletin 82-03 revealed indications in two sweepolet to recirculation manifold welds (KR-2-14 and KR-2-36). The inspections performed under GL 84-11 reconfirmed the existence of these indications. Small indications were also detected in another sweepolet to recirculation manifold weld (KR-2-41) and in one end cap to recirculation manifold weld (KR-2-37). The indications in each of these four welds were found to be relatively short and shallow, the deepest detected indication being 26 percent through wall and the longest detected indication being four inches. These four welds were IHSI treated in the first of two lots to be so treated and fracture mechanics evaluations were performed to justify further operation with these flaws without further mitigation measures.

A large indication was found in RWCU pipe to elbow weld DRWC-2-4. The weld was repaired by removing the elbow and using the heat sink welding process for the six welds which reinstalled the elbow using 304 stainless steel.

In this time frame, the jet pump instrumentation nozzle safe ends and reducers were inspected and found to have extensive cracking in the safe ends and reducers near weld JP-2-1A and JP-2-1B. These components were replaced with a new design using 316 NG stainless steel.

C. IGSCC MITIGATION - FIRST LOT OF IHSI TREATED WELDS

The General Electric (GE) Company IHSI treated the first lot of welds (149 of 156 selected welds) from January to March of 1985. The 156 selected welds were distributed as follows:

1. 103 in the recirculation system,
2. 15 in the RWCU,
3. 9 in the core spray, and
4. 29 in the RHR system.

Seven of the 156 welds were not IHSI treated for the following reasons:

1. GE was unsuccessful in the IHSI treatment of four weldolets to pipe welds (KR2-4, KR-2-1, KR-2-23 and KR-2-26 in the recirculation system) and one flued head to pipe weld (DRWC-2-5A in the RWCU system).

2. Two welds (DSRWC-2-7 and DRWC-2-4) were to be cut out and replaced after the IHSI contractor finished. This was a repair of an IGSCC crack detected during the 100% inspection in weld DRWC-2-4 of the RWCU.

The recirculation nozzle to safe end welds, the core spray nozzle to safe end welds, and welds DCS-2-12, DCS-2-3, DRHR2-12 and DRHR-2-3 were excluded because they were not treatable by the IHSI methods generally available at the time.

D. INSPECTION OF THE FIRST LOT OF WELDS IHSI TREATED

For the first lot of IHSI treated welds, 25 percent of the original inspection workscope welds were reinspected. The 25 percent sample was selected from those welds which required recording and evaluation of an indication. Additional welds needed to complete the sample were chosen from weld locations shown to have a high propensity for IGSCC.

After the IHSI treatment was applied to GR-2-15, a weld in the recirculation piping which joins a 28-inch by 12-inch reducer, a through wall leak (an IGSCC crack indication) was discovered. The area of crack indication or flaw was not inspectable by UT methods because of configuration geometry. No sample expansion inspections were conducted as stipulated in the NRC letter of March 26, 1986. This weld was repaired by the application of a full structural weld overlay. An analysis was performed in accordance with the recommendations of GL 84-11. The effect of weld shrinkage due to this overlay was also considered for those adjacent welds with cracks whose mitigation measures consisted only of IHSI.

Two more small indications were found in weld KR-2-36 which were evaluated in accordance with the recommendations of GL 84-11. However, no sample inspection expansion of other welds was performed as had been stipulated in the NRC letter of March 26, 1986.

E. RECIRCULATION INLET NOZZLES

The recirculation inlet nozzle safe ends and core spray safe ends were inspected in June 1986. All ten of the recirculation inlet safe ends were found to have indications of crevice cracking in the thermal sleeve attachment area. To correct this, TVA has replaced a portion of the recirculation piping, from the safe ends and attached piping upstream to an intermediate point on the risers. The interface joint on the existing piping was corrosion resistant cladded (CRC). All replacement joints were IHSI treated. Baseline ultrasonic and radiographic inspections were performed on the new welds resulting from replacement.

During October 1986, ASME Section XI inservice inspections were performed, and one pipe to elbow weld in the RWCU (DSRWC-2-5) was found to have IGSCC. This weld had been inspected during the original 100 percent inspection and was included in the 25 percent post-IHSI inspections. In both of these inspections, this weld was found satisfactory. Finding IGSCC in this joint resulted in a sample expansion inspection of all RWCU welds which had not previously received post-IHSI inspections in the 25 percent sample of the first lot of IHSI treated welds.

F. IGSCC MITIGATION - SECOND LOT OF IHSI TREATED WELDS

In May 1987, as a result of the extended outage length due to safe end replacements, a second lot of welds were IHSI treated. The treatment was applied to the new welds in the recirculation riser and safe end replacements and most of the welds which were not treated in the first lot of IHSI treatments. Nutech Engineers was contracted to perform the IHSI treatment on this second lot of welds. The licensee indicated that 41 welds were in this second lot of IHSI treatments. This included 30 new recirculation system welds which replaced 40 welds in the safe ends and risers. The remaining 11 original fabrication welds were core spray, RWCU or recirculation welds which had not been treated in the first lot. The six welds which replaced DRWC-2-4 and DSRWC-2-7 and which were heat sink welded (HSW) were not IHSI treated.

G. INSPECTION OF SECOND LOT OF WELDS IHSI TREATED

Post-IHSI inspections were performed on all welds treated in this second lot of IHSI treatments. With the 25 percent inspection sample of the first lot of welds post-IHSI treated, the limited sample expansion inspection of the RWCU system, and the Section III fabrication inspections and Section XI preservice inspections, a total of 109 welds of 180 welds within the scope of GL 88-01 have been inspected. The inspections included radiography, partial ultrasonic, and liquid penetrant examinations because of geometric configuration limitations. The 30 new replacement welds in resistant material were also IHSI treated and post-IHSI inspected. There are 71 welds of the 131 IHSI treated

original fabrication welds that remain to be post-IHSI inspected. The only welds which have not received IHSI treatments are the five RHR, core spray, and RCWU penetration welds, six other welds in the core spray where stainless steel piping was replaced with carbon steel for one side of the welded joint (dissimilar metal welds), the six HSW joints, and two jet pump instrumentation welds where 316 NG material was used. The six welds in the core spray with dissimilar metal welds are to be IHSI treated in the future.

H. GL-88-01 RESPONSE

TVA's response to GL 88-01 was submitted in an August 1, 1988 letter. The TVA positions pertaining to materials, processes, water chemistry, weld overlay, partial replacement, stress improvement of cracked weldments, clamping devices, crack evaluation and repair criteria, inspection methods and personnel, and leak detection had been defined in the previous submittals. Inspection schedules, additional changes to leak detection, and plans for notifying NRC of flaws are discussed in the August 1, 1988 submittal. These aspects meet the requirements of GL 88-01. It is noted that Table 1 of the August 1, 1988 submittal lists the five inaccessible welds in penetrations as "A" NUREG category welds. These welds should be listed in the "G" category. These five welds appear to be listed correctly in Appendix 1 of the submittal. These TVA positions meet the requirements of GL 88-01. TVA did not address the NRC staff position on sample expansion inspections when IGSCC crack indications are found and the inclusion of Surveillance Requirements in the Technical Specifications as recommended in GL 88-01. However, it is the staff's understanding that Technical Specifications changes outlined by GL 88-01 are scheduled to be sent to the NRC by December 30, 1988. Table 1 summarizes the TVA positions regarding NRC staff positions. This table also provides references to the specific TVA submittal in which the TVA position is provided.

I. SUMMARY OF WELD CLASSIFICATIONS AND MITIGATION TREATMENTS

A summary of classification of welds by NRC IGSCC categories and of previous action taken by TVA to mitigate IGSCC for Browns Ferry, Unit 2 is provided in Table 2. This table was generated from the TVA August 1, 1988 submittal.

J. CURRENT PLANS FOR MITIGATING ACTIONS

Current plans for future actions to mitigate IGSCC include:

1. Installation of hydrogen water chemistry during or before the Cycle 6 refueling outage on Unit 2.

2. Application of inspections as outlined in the August 1, 1988 submittal.

3. Application of additional mitigating actions to welds that develop indications that are revealed by the inspection program or to existing indications that propagate beyond acceptable limits.

4. Application of other mitigation actions on those welds which were not IHSI treatable because they were in penetrations (5 welds) before or during the next refueling outage (Cycle 6 refueling outage).

K. EVALUATION OF CONFORMANCE TO STAFF POSITIONS AND RECOMMENDATIONS

The mitigating actions previously applied and those planned for future implementation satisfy the requirements of GL 88-01. However, the expansion of sample inspections when IGSCC is found, and the incorporation of the Surveillance Requirements in the Technical Specifications as specified in GL 88-01 have not been addressed by TVA.

L. CURRENT INSPECTION SCHEDULE

An inspection schedule was provided by TVA in the August 1, 1988 submittal. The schedule presented reflects the status of inspecting only about half of the welds IHSI treated, and the treated IHSI welds which have not been post-IHSI inspected and are now Category G will be inspected during the next refueling outage (Cycle 6). This is in accordance with TVA's submittal dated June 7, 1984, their response to GL 84-11, which was accepted by NRC letter dated March 26, 1986. However, the acceptance was contingent upon the requirement that the sample inspections would be expanded if crack indications were reported in any of the IHSI treated welds. There were three instances of IGSCC found after IHSI treatment of the first lot of IHSI treated welds. Two more small indications were found in weld KR-2-36 by the post-IHSI inspection and no sample inspection expansion of other welds was performed. After IHSI, weld GR-2-15 developed a through wall leak. The staff's concern is that the IHSI might have caused an existing crack to grow, for a variety of reasons, in this weld and potentially others. For this reason, the staff requires that the inspection sample be expanded whenever new crack indications are found as specified in GL 84-11 and 88-01.

There was one IGSCC crack found in the RWCU, weld DSRWC-2-5, during an ASME Section XI inservice inspection. As a result, all RWCU welds were inspected by TVA which had not received post-IHSI inspections earlier. The reason for the sample inspection expansion, whether required by the March 26, 1986 NRC letter or ASME Section XI requirements, was not specified in the December 31, 1987 TVA submittal.

M. ADDITIONAL EXAMINATIONS REQUIRED

ASME Section XI, Paragraph IWB-2430 of the applicable ASME Code (1977 Edition, Summer 1978 Addenda), requires that "examinations performed during any one inspection that reveal indications exceeding the allowable standards of Table IWB-2500, in a component of an examination category shall be extended to include an additional number (or areas) of components within the same category,

approximately equal to the number (or areas) initially examined during the inspection. In the event further indications in excess of the allowable standards are revealed, all of the remaining number (or areas) shall be examined to the extent specified in Table IWB-2500 for the inspection interval."

The applicable Table IWB-2500 examination category for these components is "B-J, Pressure-Retaining Welds in Piping." The extent and frequency of examinations for this examination category is as follows:

> "The examinations performed during each inspection interval shall cover all of the area of 25 percent of the circumferential joints including the adjoining 1 foot sections of longitudinal joints and 25 percent of the pipe branch connection joints."

There should have been a sample expansion inspection of another 25 percent of the first lot of IHSI treated welds because of the two indications found in KR-2-36. The 41 welds of the second IHSI treated lot which were post-IHSI inspected were not a sufficient number to satisfy the sample expansion. This is because 30 of the 41 welds which were part of the replacement piping should not be included in sample expansion inspection required under GL 84-11 because they had not been subjected to IGSCC conditions for a significant period of time. They also had no relation to previous inspections, and thus their use as a check for adequacy and accuracy of prior inspections is not valid.

In accordance with GL-84-11, TVA was required to perform a sample inspection of 25 percent or 40 welds after the leak (a crack indication) occurred in weld GR-2-15.

The staff requests the basis for the limited sample expansion inspections made due to the crack found in weld DSRWC-2-5. It is also noted that this particular weld had been inspected in the original 100 percent inspection of refueling outage Cycle 5, declared satisfactory, and after it was IHSI treated, was again inspected and again declared satisfactory. It appears that the original 100 percent inspections performed in response to GL-84-11 and the post-IHSI inspections of the first lot of IHSI treated welds were deficient in identifying welds with IGSCC.

Based on a comparison of the inspection plan with the requirements of GL 88-01, the staff finds that the provisions of GL 88-01 have not been satisfied in that there are IHSI treated welds which were not post-IHSI inspected. It is acknowledged that they will be inspected during the next refueling cycle (RFO Cycle 6). Footnote (1) to Table 1 of GL 88-01 recommends that: "All welds in non-resistant material should be inspected after a stress improvement process as part of the process. Schedules shown should be followed after this initial inspection."

In consideration of future ALARA exposures and the fact that these welds are now accessible, TVA should reassess the need for completing post-IHSI inspections for all remaining welds which have been IHSI treated prior to startup rather than during the next refueling outage (Cycle 6).

3.0 CONCLUSIONS

A. The plans presented by TVA in their August 1, 1988 submittal to mitigate IGSCC provide adequate assurance of continued long-term piping integrity and reliability.

B. The Inservice Inspection (ISI) program to be implemented at the next refueling outage for austenitic stainless steel piping covered under the scope of GL 88-01 conforms to the staff positions on inspection schedules, methods and personnel recommended in GL 88-01. However, sample expansion inspections had not been conducted in the past when required, and future commitments on this subject have not been made by TVA. Because of the indications of IGSCC after inspections, we do not have the assurance necessary to find that there are no unsatisfactory welds remaining in the austenitic piping system at BFN 2. Therefore, we conclude that the 71 welds which have not been post-IHSI inspected should be inspected prior to restart.

C. TVA has not addressed changing the Technical Specifications to include a statement in the section on ISI regarding the Inservice Inspection Program for piping covered by GL 88-01 to reflect staff positions on schedule, methods and personnel, and sample expansion as provided in GL 88-01.

D. TVA has changed BFN 2 Technical Specifications to reflect the staff position on leak detection in GL 88-01.

E. TVA has committed to notify the NRC when new flaws are discovered, or a change in the condition of flaws previously detected. In these instances, TVA committed to provided a full report of the flaw evaluation and the strategy and technical justification for repair or continued operation.

Principal Contributor: D. Smith

Dated: December 8, 1988

TABLE 1

SUMMARY OF TVA'S RESPONSE TO STAFF POSITIONS - GL-88-01

Staff Position	TVA RESPONSE		TVA HAS/WILL	
	Accept	Document Submittal Date	Applied in Past	Consider for Future use
1. Materials	yes	all	yes*	yes
2. Processes	yes	all	yes**	yes
3. Water Chemistry	yes	12/31/87 and 3/11/86	no	yes
4. Weld Overlay	yes	3/11/86 and later	yes	yes
5. Partial Replacement	yes	12/31/87 and 8/1/88	yes	yes
6. Stress Improvement of Cracked Welds	yes	6/11/84 and later	yes	yes
7. Clamping Devices	yes	12/31/87	no	yes
8. Crack Evaluation and Repair Criteria	yes	3/11/86 and later	yes	yes
9. Inspection Method and Personnel	yes	all	yes	yes
10. Inspection Schedules	yes	8/1/88	yes	yes
11. Sample Expansion	no	none	no	no
12. Leak Detection	yes	12/15/86 and later	yes	yes
13. Reporting Requirements	yes	8/1/88	yes	yes

* TVA has used NRC Staff position to assign IGSCC Categories to the welds in service

** Has applied IHSI, CRC and HSW, but not SHT

Table 2

CLASSIFICATION OF WELDS AND

SUMMARY OF PRIOR ACTION TO MITIGATE IGSCC

IGSCC Category	Total Number of Welds in Category	Number of Welds With Indicated Treatment				
		No Treatment	Material	Overlay	IHSI	HSW
A	38	-	32*	-	-	6
B	0	-	-	-	-	-
C	54	-	-	-	54	-
D	6	6	-	-	-	-
E	6	-	-	2	4	-
F	0	-	-	-	-	-
G	76	5	-	-	71**	-
TOTALS	180	11	32	2	126	6

* 30 of these welds were also IHSI treated

** Welds were inspected before IHSI and found not cracked