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

August 30, 2016

Mr. James Connolly
Site Vice President
STP Nuclear Operating Company
P.O. Box 289
Wadsworth, TX 77483

SUBJECT: ALUMINUM BRONZE SELECTIVE LEACHING AGING MANAGEMENT PROGRAM AND PWR REACTOR INTERNALS PROGRAM INSPECTION PLAN AUDIT REPORT REGARDING THE SOUTH TEXAS PROJECT, UNITS 1 AND 2 (TAC NOS. ME4936 AND ME4937)

Dear Mr. Connolly:

By letter, dated October 25, 2010, STP Nuclear Operating Company (or the applicant) submitted an application for renewal of operating licenses NPF-76 and NPF-80 for the South Texas Project (STP), Units 1 and 2. The staff of the U.S. Nuclear Regulatory Commission (NRC or the staff) conducted an audit of aluminum bronze selective leaching aging management program in two parts: (1) during the week of March 21, 2016, onsite at STP in Bay City, Texas, and (2) on June 22, 2016, in the Westinghouse offices in Rockville, Maryland. In addition, the staff conducted an in-office audit of PWR Reactor Internals Program Inspection Plan for Reactor Vessel Internals. The audit report is enclosed.

If you have any questions, please contact me by telephone at (301) 415-3306 or by e-mail at Lois.James@nrc.gov.

Sincerely,

***/RA/***

Lois M. James, Sr. Project Manager
Projects Branch 1
Division of License Renewal
Office of Nuclear Reactor Regulation

Docket Nos. 50-498 and 50-499

Enclosure:
As stated

cc: Listserv

August 30, 2016

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ADAMS Accession No. **ML16218A256**

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| **NAME** | YDiaz-Sanabria | LJames | | |
| **DATE** | 8/30/16 | 8/30/16 | | |

**OFFICIAL RECORD COPY**

Letter to J. Connolly from L. James dated August 30, 2016

SUBJECT: ALUMINUM BRONZE SELECTIVE LEACHING AGING MANAGEMENT PROGRAM AND PWR REACTOR INTERNALS PROGRAM INSPECTION PLAN AUDIT REPORT REGARDING THE SOUTH TEXAS PROJECT, UNITS 1 AND 2 (TAC NOS. ME4936 AND ME4937)

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**U.S. NUCLEAR REGULATORY COMMISSION**
**OFFICE OF NUCLEAR REACTOR REGULATION, DIVISION OF LICENSE RENEWAL**

| | |
|---|---|
| Docket Nos: | 50-498 and 50-499 |
| License Nos: | NPF-76 |
| Licensee: | STP Nuclear Operating Company |
| Facility: | South Texas Project, Units 1 and 2 |
| Location: | P.O. Box 289<br>Wadsworth, TX 77483 |
| Dates: | March 21-24, 2016<br>June 22, 2016 |
| Reviewers: | Margaret Audrain, Materials Engineer, Corrosion and Metallurgy Branch, Division of Engineering (DE), Office of Regulatory Research (RES) (Formerly Mechanical & Civil Engineering Branch, DE, Office of Reactor Regulations (NRR))<br>William Holston, Senior Mechanical Engineer, Aging Management Reactor System Branch (RARB), Division of License Renewal (DLR), NRR<br>Matthew Homiack, Materials Engineer, RES/DE/Component Integrity Branch<br>Christopher Hovanec, Materials Engineer, Vessels & Internals Integrity Branch, DE, NRR (formerly of NRR/DLR/RARB)<br>Lois James, Senior Project Manager, Project Branch 1 (RBP1)<br>James Medoff, Senior Mechanical Engineer, Aging Management of Structural, Electrical & System Branch (RASB), DLR, NRR |
| Approved By: | Dennis Morey, Chief<br>Aging Management Reactor System Branch<br>Division of License Renewal<br><br>Brian Wittick, Chief<br>Aging Management of Structural, Electrical & System Branch<br>Division of License Renewal<br><br>Yoira Diaz-Sanabria, Chief<br>Projects Branch 1<br>Division of License Renewal |

## INTRODUCTION

The U.S. Nuclear Regulatory Commission (NRC or the staff) conducted an onsite audit at the South Texas Project (STP), Units 1 and 2, in Bay City, Texas, from March 21 to 24, 2016, an in-office audit from March 21 to 24, 2016, and an onsite audit in the Westinghouse Office in Rockville, Maryland, on June 22, 2016. The purpose of the audit was to examine STP Nuclear Operating Company (STPNOC) aging management programs (AMPs) and related documentation associated with the AMPs for Aluminum Bronze Selective Leaching and for Pressurized Water Reactor (PWR) Reactor Vessel Internals (RVI). Results of this audit will be ultimately documented in the staff's safety evaluation report (SER).

Regarding the Aluminum Bronze Selective Leaching AMP, the purpose of the audit was to gain an understanding of the applicant's AMP for welds that are susceptible to aluminum bronze selective leaching such that the staff has confidence that Open Item 3.0.3.3.3-1 in the 2013 Safety Evaluation Report with Open Items (Agency Document and Access Management System (ADAMS) Accession No. ML13044A115) has a closure path. This audit focused on material information, material process information, microstructure information, and structural integrity evaluations regarding the welds that may be susceptible to selective leaching needed in order for the staff to complete its review.

Regarding the PWR RVI AMP, the purpose of the audit was to determine if the supporting plant documents for this AMP provide an acceptable basis for demonstrating that the design stresses for the RVI components at STP, Units 1 and 2, are within the bounding design stress assumptions for these components in ERPI MRP Technical Report (TR) No. 1022863, "Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines (MRP-227-A)," dated January 2012, and EPRI MRP TR No. 1013234, "Materials Reliability Program: Screening, Categorization, and Ranking of Reactor Internals Components for Westinghouse and Combustion Engineering PWR Design (MRP-191)," dated November 2006.

In performing the audit, the staff examined the applicant's license renewal application (LRA), supplements to the LRA, program-bases documents, and related references, and interviewed various applicant representatives.

## PLANT-SPECIFIC PROGRAM

### Selective Leaching of Aluminum Bronze Aging Management Program

During this audit of the Selective Leaching of Aluminum Bronze Program, the staff interviewed the applicant's on-site and contractor staff, and reviewed on-site documentation provided by the applicant. The table below lists the documents that were reviewed by the staff and found relevant to the audit. These documents were provided by the applicant.

Relevant Documents Reviewed

| Document | Title | Revision/Date |
|---|---|---|
| 31511389 | Review of Buried Pipe Stresses and Leak Rate Margins in ECW System (APTECH Report AES 93061964-1Q-1) | 04/17/1995 |
| 920742 | Station Problem Report | 1994 |
| 5-Y-57 0-Y-10001 | Yard-Civil Essential Cooling Water Pipe Installation Details | Revision 7 |

Relevant Documents Reviewed

| Document | Title | Revision/Date |
|---|---|---|
| 5-Y-57 0-Y-10002 | Yard-Civil Essential Cooling Water Pipe Installation Plan Section and Details | Revision 3 |
| AES-C-1630-1 | Bounding Stress Analysis of Buried ECW Piping | Revision 0, 05/26/1992 |
| AES-C-1630-2 | Calculation of Critical Bending Stress for Flawed Pipe Welds in the ECW System | Revision 0, 07/06/1992 |
| AES-C-5862-1 | Significance of Circumferential Cracking in 30" [diameter] Al-Br [aluminum bronze] Pipe in ECW [essential cooling water] | 07/25/2005 |
| AES-C-1964-7 | Leak Rate Analysis for a Circumferential Crack in 10-Inch and 30-Inch Underground ECW Piping | 04/13/1995 |
| CREE 12-29261-108 | Condition Report Engineering Evaluation | 05/25/2016 |
| Letter from R. Cipolla to S. Timmaraju | Review of Buried Pipe Stresses and Leak Rate Margins in ECW (APTECH Report AES 93061964-1Q-1) | 04/17/1995 |
| Letter from J. Thompson to B. McCullough | South Texas Project Electric Generating Station Materials Applications Department Report #540 Titled Welding of Aluminum Bronze Essential Cooling Water Piping System | 04/06/1984 |
| Letter from R. Keilbach to D. Denver | Welding of Aluminum Bronze ECW Piping System | 08/19/1992 |
| MT-3521A | Evaluation of Cracked Elbow-Nozzle Weld from South Texas Project Unit 1 Essential Cooling Water System | 12/17/1991 |
| MT-3521B | Evaluation of Cracked Aluminum Bronze Pipe-to-Pipe Weld from South Texas Project Unit 2 Essential Cooling Water System | 01/08/1992 |
| MT3800 | Evaluation of Cracked Aluminum Bronze Repair Weld from South Texas Project Unit 1 Essential Cooling Water System | 05/06/1992 |
| MT-5623 | Evaluation of Cracked Pipe Weld Joint EW1302/FW0032 from South Texas Project Unit 1 | 03/03/1995 |
| MT-4181 | Evaluation of Dealloying in Boat Sample from 30-inch Weld Number EW1102-FW0032 | 01/28/1993 |
| MT-5487 | Evaluation of Aluminum Bronze Pipe to Elbow Weld in ECW Line | 04/24/1995 |
| MT-5050 | Metallurgical Evaluation of Two Failed Aluminum-Bronze Pipe Sections from ECW System at South Texas Project Unit 2 | 06/06/1994 |
| Office Memorandum from S. L. Wilson to S. Timmaraju | Evaluation of a Leak in an Aluminum Bronze Pipe-to-Tee Weld from South Texas Project, Unit 1, EW 1202-AQ | 11/13/1992 |
| QW-483 | ASME Welding Procedure Qualification Record (PQR) Houston Lighting and Power Company Procedure Qualification Record No. 093 | 06/26/1992 |
| PQR No. 093 | Welding Procedure Qualification Sheet | 02/24/1992 |
| RC 9890 | Stress Summary for Large Bore ECW Piping (2-1/2" and above) | 05/20/1991 |
| STP-AMP-PSALBZ | South Texas Project License Renewal Program Evaluation Report – Selective Leaching of Aluminum Bronze – B2.1.37 STP – PSALBZ | Revision 9 |
| WPS-120 | Welding Procedure Specification No. 120 | 09/28/1982 |

Relevant Documents Reviewed

| Document | Title | Revision/Date |
|---|---|---|
| WPS-158 | Welding Procedure Specification No. 158 | 05/15/1985 |
| WPS-2016 | Welding Procedure Specification No. 2016 | 06/31/1981 |

The staff reviewed reports, calculations, procedures, condition reports, and other basis documents associated with dealloying of aluminum-bronze welds. These reports summarized the evaluations performed on welds that were found leaking while in-service. The staff made the following observations based on the content of the reports.

1. The staff noted that all the reported instances of dealloying occurred in welds with backing rings.

2. The staff noted that all the reported instances of dealloying occurred in welds that had preexisting fabrication defects.

3. The staff noted that the dealloying was generally observed to occur locally adjacent to the crack sides and locally in front of the crack tip.

4. The staff noted that for upset loads:
   - The length of a crack necessary to generate a 10 gpm in 30-inch underground piping is 14.9 inches on the supply side and 21.2” on the discharge side.
   - The length of a crack necessary to generate a 10 gpm in 10-inch underground piping is 11.8 inches on the supply side and 13.8” on the discharge side.

5. The staff reviewed the yard installation details for the ECW system and confirmed that the ECW piping is installed within a concrete saddle for most of its length. There are short portions (i.e., where lines cross over each other) that are not in a saddle.

6. The staff reviewed Station Problem Report (SPR) 920742 and noted that through-wall dealloying occurred in the vicinity of a vendor weld repair in a 30” by 14” extruded tee (not cast). The SPR stated that there are a total of 50 extruded tees, with 6 being installed below ground. The SPR and associated documents also state that:

   - “17 tees have similar repairs.”
   - “repair lengths ranged from 0 inch to 12.25 inch, i.e., from 0% to 38% of the circumference.”
   - The operability evaluation for the station problem report, dated April 2, 1993, states that, “a thru-wall crack on the order of 25 [percent] of the circumference would be needed to cause failure.”

   The staff lacks sufficient information to conclude that the aging effects associated with the extruded tees subject to weld repairs during fabrication will be adequately managed because the operability evaluation states that a flaw size up to 25 percent of the circumference will meet structural integrity requirements; however, at least one repaired area encompassed 38 percent of the circumference. The staff will consider issuing a request for additional information requesting: (a) a list of the extruded tees subject to weld repairs during fabrication including the size of each tee, the associated repair area, and the tee's location in the plant (i.e., above ground or below ground); (b) a copy of the engineering documents that are used to determine whether the tees can perform the pressure boundary function; (c) a comparison of the characteristics of the extruded tee repair welds to that of pipe-to-pipe welds in the essential cooling water system (e.g., phase structure, aluminum content); and (d) how the aging effects associated with the aboveground and below ground extruded tees subject to weld repairs during fabrication will be managed during the period of extended operation.

7. The staff reviewed the applicant's weld root pass cooling rate analysis and noted that it would be possible to perform its own confirmatory analysis of the cooling rate. The staff noted several details that might be useful in performing such an analysis. Specifically, from the welding qualification data, the amperage ranged from 167 to 200 amps, with a mode of 180 amps; the voltage ranged from 11-12 volts, with a mode of 11 volts; and the travel speed ranged from 2.875 to 8.5 inches per minute, with a mode of 4.875 inches per minute. The staff also noted details about the piping geometry and weld configuration. Specifically, the thickness of the nominal 30-inch pipe is 0.25 inches with an outside diameter of 30 inches, and the thickness of the nominal 10-inch pipe is 0.365 inches with a 10.75-inch outside diameter. A typical backing ring is approximately 2 inches wide and made from the piping base metal. In addition, a typical repair weld with two root passes would have a total of nine weld beads in three layers.

8. The staff noted that the dealloying observed in report MT-5050, dated June 6, 1994, was not limited to the volume immediately in front of the crack tip. The component in report MT-5050 is a pipe-to-tee weld with a backing ring that had a preexisting crack. The preexisting crack appeared to propagate some distance before becoming inactive; however, the dealloying continued throughwall past the crack tip resulting in a leak. Report MT-5050 was reevaluated by the applicant and the results are documented in Report CREE 12-29261-108, dated May 25, 2016. The staff's review of CREE 12-29261-108 confirmed that the (a) crack is in the weld metal and a result of a fabrication flaw; (b) general dealloying occurred beyond the crack and absent of crack growth; (c) general dealloying was completely contained in the weld metal. Therefore, there is OE showing that general dealloying can occur, once the root pass is breached, without the assistance of crack growth.

**LRA AMP B2.1.35, PWR Reactor Internals Program**

During the week of March 21 to 24, 2016, the staff performed a supplemental audit of the LRA for STP, Units 1 and 2. As part of this audit, the staff audited the applicant's basis for demonstrating conformance with the design assumptions stated in Section 2.4 of the MRP-227-A report and for resolving the question on "cold-worked materials" in EPRI Letter No. 2013-025. Bases for resolving the fuel design or fuel management related matters in EPRI Letter 2013-025 are documented in SER Section 3.0.3.3.2.

Audit Activities.

During its audit, the staff interviewed the applicant's staff and reviewed onsite documentation provided by the applicant. The table below lists the documents which were reviewed by the staff and were found relevant to the audit of the applicant's Applicant/Licensee Action Items (A/LAIs) No. 1 basis. These documents were provided by the applicant, issued by the NRC, or docketed by the EPRI MRP.

Relevant Documents Reviewed

| Document | Title | Revision / Date |
|---|---|---|
| EPRI TR No. 1022863 | Materials Reliability Program: Pressurized Water Reactor Internals Inspection and Evaluation Guidelines (MRP-227-A) | January 2012<br><br>(See Footnote 1 for ADAMS ML #s) |
| NRC Safety Evaluation | Final Safety Evaluation of Electric Power Research Institute (EPRI) . . . Materials Reliability Program (MPR) Report 1016596 (MRP-227-A), Revision 0, "Pressurized Water Reactor (PWR) Internals Inspection and Evaluation Guidelines." | Revision 1, December 16, 2011<br><br>(ML11308A770) |
| Chapter XI.M16A in NUREG-1801, Revision 2, as documented and amended in NRC LR-ISG-2011-04 | PWR Vessel Internals | June 3, 2013<br><br>(ML12270A436) |
| PWROG-15027 | South Texas Units 1&2 Summary Report from the Cold Work Assessment report. | |
| EPRI MRP Letter No. 2013-025 | MRP-227-A Applicability Template Guideline | Oct. 14, 2013<br><br>(ML13322A454) |

STP RVI Design – Conformance with the Design Assumptions in MRP-277-A.

The staff found that the "scope of program" element for the AMP provides an acceptable basis for demonstrating that the MRP-227-A report is bounding for the RVI design at STP Units 1 and 2. Specifically, in relation to resolving A/LAI No. 1 for MRP-227-A, the staff noted that the applicant's "scope of program" element basis identifies that:

1) the STP reactor units have operated for less than thirty years with high leakage fuel loading patterns

2) the STP reactor units operate at fixed load and do not normally vary power based on calendar or load demand schedules

3) the applicant has not implemented any design changes at STP Units 1 or 2 not recommended by applicable industry vendors or organizations.

The staff verified that the "scope of program" element provides sufficient demonstration that: (a) the reactor units have operated for more than 30 years of operations using a low leakage fuel management strategy, (b) the reactor operates using base-load operations, and (c) the applicant has not implemented any design modifications outside of those recommended by Westinghouse Electric Company, the EPRI MRP, or other applicable industry organizations. Therefore, the staff concludes that the applicant has provided sufficient demonstration that the designs of the RVI components at Units 1 and 2 are in conformance with the design criteria and assumptions stated in Section 2.4 of the MRP-227-A report. A/LAI No. 1 is resolved with respect to demonstrating conformance with these design assumptions.

STP RVI Design – Stress Load and Cold-Work Levels Assumed in the RVI Design

The staff found that the supporting plant documents for this AMP provide an acceptable basis for demonstrating that the design stresses for the RVI components at STP Units 1 and 2 are within the bounding design stress assumptions for these components in the MRP-227-A and MRP-191 reports. Specifically, the staff verified that the applicant's documents provide sufficient demonstration that the RVI components were not sufficiently cold-worked during component or plant fabrication practices, or else that the additional residual stress loads on the loading of the components was appropriately accounted for in the EPRI MRP design assumptions for the components in the MRP-191 report. Specifically, based on the review of the applicable plant records, the staff noted that the design documents provide sufficient demonstration that the applicant had restricted the procured yield strengths of the component materials to acceptable levels, such that any amounts of strain hardening imparted to the components during the fabrication process would be minimized. Based on this, review, the staff concludes that the applicant has provided sufficient demonstration that the levels of cold work and stress loads for the RVI components are within the design assumptions for these parameters in either the MRP-227-A or MRP-191 reports. Bases for resolving fluence related assessment criteria (i.e., average core power density, heat generation, figure of merit, and active fuel-to-upper core plate distances values) will be evaluated in the SER for STP, Units 1 and 2. A/LAI No. 1 is resolved with respect to demonstrating conformance with design assumptions.