



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

December 18, 2014

Mr. Joseph W. Shea
Vice President- Nuclear Licensing
Tennessee Valley Authority
1101 Market Street LP 3D-C
Chattanooga, TN 37402-2801

SUBJECT: BROWNS FERRY NUCLEAR PLANT, UNIT NO. 2 – REVIEW OF TENNESSEE VALLEY AUTHORITY COMPENSATORY MEASURES THAT REVISE THE PRESSURE AND TEMPERATURE LIMIT CURVES (TAC NO. MF3340)

Dear Mr. Shea:

By letter dated December 27, 2013, and supplemented by letters dated April 16, May 29, July 25, and August 29, 2014, Tennessee Valley Authority (TVA, the licensee) submitted a Status Update regarding Appendix H, "Reactor Vessel Material Surveillance Program Requirements," to Part 50 of Title 10 of the *Code of Federal Regulations* for the Browns Ferry Nuclear Plant, Unit 2 (BFN-2). In this update, the licensee notified the Nuclear Regulatory Commission (NRC) of a determination that the pressure-temperature limit curves contained in BFN-2 Technical Specification (TS) 3.4.9, "RCS [Reactor Coolant System] Pressure and Temperature (P/T) Limits," Figures 3.4.9-1 and 3.4.9-2, were nonconservative. Furthermore, the licensee indicated that corrective actions were being undertaken, and that TVA was treating the nonconservative P/T limit curves as a degraded condition and had established compensatory measures to ensure that the BFN-2 reactor vessel is maintained within acceptable limits. Since this status update affected the licensee's TSs and operating limits, the staff treated the submittal as a proposed TS change and reviewed it accordingly.

The NRC staff has completed the review of the information provided by the licensee. The staff's safety evaluation (SE) is enclosed. The NRC staff has determined that its documented SE (Enclosure) does not contain Sensitive Unclassified Information pursuant to Title 10 of the *Code of Federal Regulations* (10 CFR), Section 2.390, "Public inspections, exemptions, requests for withholding." However, the NRC will delay placing the enclosed SE in the public document room for a period of 10 working days from the date of this letter to provide TVA with the opportunity to comment on any sensitive aspects of the SE. If you believe that any information in Enclosure contains sensitive information, please identify such information line-by-line and define the basis for withholding pursuant to the criteria of 10 CFR 2.390. After 10 working days, the enclosed SE will be made publicly available.

J. Shea

- 2 -

If you have any questions, please contact me at (301) 415-1447.

Sincerely,

A handwritten signature in black ink that reads "Farideh E. Saba". The signature is written in a cursive style with a distinct loop at the end of the last name.

Farideh E. Saba, Senior Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-260

Enclosure: Safety Evaluation

cc with Enclosures: Distribution via Listserv



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

SAFETY EVALUATION BY THE OFFICE OF NUCLEAR REACTOR REGULATION

FOR COMPENSATORY MEASURES THAT REVISE THE PRESSURE

AND TEMPERATURE LIMIT CURVES

TENNESSEE VALLEY AUTHORITY

FOR BROWNS FERRY NUCLEAR PLANT, UNIT 2

DOCKET NO. 50-260

1.0 INTRODUCTION

By letter dated December 27, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML14008A108), as supplemented by a letters dated April 16, 2014, May 29, 2014, July 25, 2014, and August 29, 2014 (ADAMS Accession Nos. ML14108A328, ML14153A559, ML14209A849, and ML14246A254, respectively), Tennessee Valley Authority (TVA, the licensee) submitted a Status Update regarding Appendix H, "Reactor Vessel Material Surveillance Program Requirements," to Part 50 of Title 10 of the *Code of Federal Regulations* (10 CFR 50) for the Browns Ferry Nuclear Plant, Unit 2 (BFN-2). In this update, the applicant notified the U. S. Nuclear Regulatory Commission (NRC) of a determination that the pressure and temperature (P/T) limit curves contained in BFN-2 Technical Specification (TS) 3.4.9, "RCS [Reactor Coolant System] Pressure and Temperature (P/T) Limits," Figures 3.4.9-1 and 3.4.9-2, were non-conservative. Furthermore, the licensee indicated that corrective actions were being undertaken, and that TVA was treating the nonconservative P/T limit curves as a degraded condition and had established compensatory measures to ensure that the BFN-2 reactor vessel is maintained within acceptable limits.

Since this status update affected the licensee's TSs and operating limits, the NRC staff treated the submittal as a proposed TS change and reviewed it accordingly.

2.0 REGULATORY EVALUATION

The NRC has established requirements in 10 CFR 50 to protect the integrity of the reactor coolant pressure boundary in nuclear power plants. The staff evaluates the acceptability of a facility's proposed P/T limits curves based on the following NRC regulations and guidance:

- Appendix G, "Fracture Toughness Requirements," to 10 CFR 50;

Enclosure

- Appendix H, "Reactor Vessel Material Surveillance Program Requirements," to 10 CFR 50;
- Regulatory Guide (RG) 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials;"
- Generic Letter (GL) 92-01, Revision 1, "Reactor Vessel Structural Integrity;" GL 92-01, Revision 1, Supplement 1, "Reactor Vessel Structural Integrity;" and
- NUREG-0800 Standard Review Plan (SRP), Section 5.3.2, "Pressure-Temperature Limits, Upper-Shelf Energy, and Pressurized Thermal Shock."

Appendix G to 10 CFR 50 requires that the P/T limit curves for the facility's reactor pressure vessel (RPV) be at least as conservative as those obtained by applying the linear elastic fracture mechanics methodology of Appendix G to Section XI of the American Society of Mechanical Engineers Boiler and Pressure Vessel Code (ASME Code). The most recent version of Appendix G to Section XI of the ASME Code that has been endorsed in 10 CFR 50.55a(b)(2), and therefore by reference in 10 CFR 50, Appendix G, is the 2008 Addenda of the ASME Code. Additionally, Appendix G to 10 CFR 50 imposes minimum head flange temperatures when system pressure is at or above 20 percent of the preservice hydrostatic test pressure.

Appendix H to 10 CFR 50 establishes requirements for each facility related to its RPV material surveillance program and requires periodic testing of RPV material surveillance capsules to monitor the neutron irradiation embrittlement behavior of the RPV materials.

RG 1.99, Revision 2, contains methodologies for determining the increase in transition temperature and the decrease in upper-shelf energy resulting from neutron radiation.

GL 92-01, Revision 1 requested that licensees submit the RPV data for their plants to the staff for review, and GL 92-01, Revision 1, Supplement 1, requested that licensees provide and assess data from other licensees that could affect their RPV integrity evaluations.

SRP Section 5.3.2 provides an acceptable method for determining the P/T limit curves for ferritic materials in the beltline of the RPV based on the ASME Code Appendix G methodology.

3.0 TECHNICAL EVALUATION

3.1 Licensee's Evaluation

In its letter dated December 27, 2013, the licensee informed the NRC that the P/T limit curves contained in the BFN-2 TS Figures 3.4.9-1 and 3.4.9-2 were nonconservative. The licensee stated that corrective actions are being managed by TVA's corrective action program under Problem Evaluation Report 816957, which the licensee is treating the nonconservative P/T limit curves as a degraded condition, and that it has established compensatory measures to ensure that the BFN-2 RPV is maintained within acceptable limits.

The licensee's identification of the degraded condition for BFN-2 was triggered by its review of test results in an Electric Power Research Institute (EPRI) report prepared on behalf of the Boiling Water Reactor Vessel and Internals Project (BWRVIP), "BWRVIP-271NP: BWR Vessel and Internals Project, Testing and Evaluation of the Browns Ferry Unit 2 120° [Degree] Capsule," which was submitted to the NRC on April 17, 2013 (ADAMS Accession No. ML13227A353). EPRI Report BWRVIP-271NP was submitted under the provisions of Section IV.B of 10 CFR 50, Appendix H and provided new, additional information relevant to some of the BFN-2 RPV materials that required evaluation in accordance with 10 CFR 50, Appendix G.

The licensee's letter also noted that, as part of the BFN-2 License Renewal Application, the licensee committed to submit revised BFN-2 P/T limit curves prior to the period of extended operation, and that the License Amendment Request to do so would be submitted to the NRC for review by June 27, 2014.

Finally, the licensee letter stated that approval and implementation of the revised P/T limit curves will resolve the degraded condition.

3.2 NRC Staff Evaluation

The current P/T limit curves in the BFN-2 TS are applicable for 23 and 30 effective full-power years (EFPYs). These limit curves were approved by NRC safety evaluation (SE) dated March 10, 2004 (ADAMS Accession No. ML040480013). In the SE, the NRC staff evaluated the licensee's P/T limit curves for the beltline region by performing independent calculations using the methodology referenced in the ASME Code (as indicated by SRP 5.3.2), and verified that the licensee's proposed P/T limit curves satisfied the requirements in paragraph IV.A.2 of 10 CFR 50, Appendix G. The NRC staff determined that the licensee's proposed P/T limit curves met the requirements of Appendix G of Section XI of the ASME Code, 1998 Edition, 2000 Addenda. Therefore, the NRC staff concluded that the licensee's proposed P/T limit curves were acceptable and granted permission for a TS change to adopt the P/T limit curves.

As a part of this SE, the NRC staff performed independent calculations of the adjusted reference temperature (ART) values for the limiting RPV materials using the methodology in RG 1.99, Revision 2. Based on the calculations, the NRC staff verified that the licensee's limiting material for the BFN-2 RPV is the lower intermediate shell plate axial welds (heat electroslag weld (ESW)). The NRC staff's calculated ART values for the limiting material agreed with the licensee's calculated ART values.

By an electronic mail (e-mail) dated March 18, 2014 (ADAMS Accession No. ML14077A212), the NRC staff transmitted a Request for Additional Information (RAI) that requested the licensee to provide details of the evaluation performed to demonstrate that the BFN-2 P/T limit curves are nonconservative, and to provide an assessment demonstrating the adequacy of the compensatory measures implemented for BFN-2. On April 16, 2014, the licensee responded that the BFN-2 P/T limit curves are nonconservative because the limiting beltline material ART values shifted by 35 ° Fahrenheit (F) higher at 30 EFPYs and 27 °F higher at 26 EFPYs based on the test results reported in BWRVIP-271NP for weld heat ESW. The licensee also noted that BFN-2 has operated for approximately 26 EFPYs and that the ART values were evaluated using RG 1.99, Revision 2. Furthermore, the licensee assessed operability (both past and immediate) of the BFN-2 RPV to demonstrate the adequacy of the implemented compensatory measures.

By an e-mail dated April 30, 2014 (ADAMS Accession No. ML14125A007), the NRC staff transmitted an additional RAI that requested details of how the 35 °F and 27 °F temperature shifts were calculated. By letter dated May 29, 2014, the licensee provided additional details of its temperature shift calculations and noted that the temperature shifts were caused by an increase in the chemistry factor for weld heat ESW from 141 °F to 285.8 °F.

In supplementary letters dated July 25 and August 29, 2014, the licensee provided additional details of how the revised chemistry factor was calculated and excerpts from two EPRI proprietary documents associated with the BFN-2 representative weld material. The licensee requested that the proprietary EPRI documents be withheld from public disclosure pursuant to 10 CFR 2.390, "Public inspections, exemptions, requests for withholding," paragraph (a)4. As a result of the proprietary nature of the information submitted by the licensee, the NRC is not disclosing that information in this SE.

The test results of interest in BWRVIP-271NP for BFN-2 are those that apply to weld heat ESW. Table 5-2 of BWRVIP-271NP reports a measured shift of 92.3 °F compared to a RG 1.99, Revision 2 predicted shift plus margin value of 80.5 °F for this heat. As a result, an adjustment of the chemistry factor for this material is necessary to compensate for the larger measured shift. A change in the chemistry factor will affect the ART value used to develop the P/T limit curves. Therefore, an assessment of the impact of the BWRVIP-271NP test results on the BFN-2 P/T limit curves may be made by evaluating the change in the ART for weld heat ESW.

The licensee reported the revised chemistry factor was 285.8 °F in their May 29, 2014, letter. The supporting details for the revised chemistry factor were included in the proprietary excerpts enclosed with the licensee's July 25 and August 29, 2014, letters. The NRC staff reviewed that information and found the basis for the revised chemistry factor to be acceptable. The staff also performed independent ART calculations for BFN-2 in accordance with RG 1.99, Revision 2 using the revised chemistry factor and verified the licensee's temperature shift of 35 °F for 30 EFPYs. Based on these calculations, the staff finds that the licensee's compensatory measures to ensure that the BFN-2 reactor vessel is maintained are within acceptable limits.

4.0 CONCLUSION

Based on the NRC staff's review of the information provided in the licensee's December 27, 2013 submittal, as supplemented by the licensee's four letters dated April 16, May 29, July 25, and August 29, 2014, the staff concludes that the compensatory measures made to the BFN-2 RPV P/T limit curves for 30 EFPYs are acceptable. The staff performed independent calculations and verified that the P/T limit curves adjustment of 35 °F was developed appropriately using the methodology of RG 1.99, Revision 2. The adjustment for the 30 EFPYs P/T limit curves satisfy the requirements of Appendix G to Section XI of the ASME Code and Appendix G to 10 CFR 50. The staff notes that revised P/T limit curves for BFN-2 were submitted by the licensee for NRC review on June 19, 2014 (ADAMS Accession No. ML14175A307).

Therefore, the compensatory measures made to the BFN-2 RPV P/T limit curves associated with this SE are acceptable for use until the staff's review of the revised P/T limit curves has been completed.

Principle Contributor: Gary Stevens
Dan Widrevitz

Date of Issuance: December 18, 2014

J. Shea

- 2 -

If you have any questions, please contact me at (301) 415-1447.

Sincerely,

/RA/

Farideh E. Saba, Senior Project Manager
Plant Licensing Branch II-2
Division of Operating Reactor Licensing
Office of Nuclear Reactor Regulation

Docket No. 50-260

Enclosure: Safety Evaluation

cc with Enclosures: Distribution via Listserv

DISTRIBUTION:

PUBLIC

LPL2-2 R/F

D. Widrevitz, NRO

RidsNrrPMBrowns Ferry

RidsRgn2MailCenter

RidsNrrDeEvib

RidsAcrcAcnwMailCenter

RidsNrrDorIDpr

G. Stevens, RES

RidsNrrLABClayton

RidsNrrDorILp2-2

ADAMS Accession No.: ML14345A963

***By a memorandum**

OFFICE	LPL2-2/PM	LPL2-2/PM	DE/EVIB/BC*	LPL2-2/BC(A)	LPL2-2/PM
NAME	FSaba	BClayton	SRosenberg	LRegner	FSaba
DATE	12/15/14	12/15/14	09/23/14	12/18/14	12/18/14

OFFICIAL RECORD COPY