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MAY 2 7 1999

U.S. Nuclear Regulatory Commission
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Gentlemen:

In the Matter of) Docket No. 50-390
Tennessee Valley Authority)

WATTS BAR NUCLEAR PLANT (WBN) UNIT 1 - REACTOR VESSEL CAPSULE SPECIMEN J-R TESTING (TAC NO. M89606)

The purpose of the letter is to document TVA's approach to resolve the J-R testing issue from Supplemental Safety Evaluation Report (SSER) 14 dated December 1994. SSER 14, Section 5.3.1.1.1, "Unit 1 Equivalent Margins Analysis," Item (4) stated the following:

> "The previously requested J-R curve data for forging 05 were not available. The Staff understands that the applicant will submit this information when the first specimens are removed from the reactor vessel. The Staff will track this action by TAC M89696. The actual fracture toughness data from these specimens will be used to verify the equivalent margins analysis."

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The first specimens are associated with Capsule U of the Watts Bar Unit 1 reactor vessel radiation surveillance program. J-R testing is a method of evaluating fracture toughness of material. This

method produces J-R curves which are a function of the material, the irradiation condition, the loading rate, and the material temperatures. This methodology is better than Charpy V-Notch testing at predicting the material's ability to resist cracking.

On October 13, 1998, TVA submitted to NRC the results of the testing from the first specimen removed during the Unit 1 Cycle 1 refueling outage in accordance with 10 CFR 50, Appendix H(IV). The analysis was performed using the Charpy V-Notch methodology as required in Appendix H. Charpy V-Notch is a methodology that is better at predicting the likelihood of brittle fracture. TVA unintentionally omitted the additional J-R testing as documented in the SSER. Since TVA had not submitted docketed correspondence committing to the performance of the J-R test, the SSER statement was not tracked in TVA's commitment tracking program.

In a teleconference with NRC's B. Elliott, K. Wickman, and R. Martin on December 5, 1998, TVA informed NRC that the remaining specimens from the first capsule, in addition to the capsules which have not been removed, could not be configured to meet any existing standard for J-R curve testing. At that point the Staff requested TVA develop a plan to resolve this issue.

On March 2, 1999, a followup teleconference was held to discuss TVA's proposed plan to resolve this issue. That plan is provided in the enclosure. In general, TVA plans to verify the equivalent margin analysis by the J-R testing methodology utilizing unirradiated archived material from the WBN vessel manufacturer, Rotterdam Dockyard Company. NRC requested in the SSER 14, that TVA provide any unirradiated or irradidated J-R curve data from material that was forged and heat treated by the WBN's vessel manufacturer to verify the equivalency margin data. From the SSER statement, it appears that either would have been acceptable.

In the equivalent margins analysis, Westinghouse used the correlations with Charpy V-Notch energy that are provided in NUREG/CR-5729, "Multivariable Modeling of Pressure Vessel and Piping J-R Data," to determine the J-R curve for the WBN vessel. Based on Regulatory Guide 1.161, "Evaluation of Reactor Pressure Vessels with Charpy Upper-Shelf Energy Less than 50 Ft-Lb," issued June 1995 (discussed in WBN SSER as Draft Regulatory Guide DG-1023) the use of this model was acceptable because the sulfur content of the forging in question is less than 0.018 weight percent (wt-%). WBN sulfur content for forging 05 is 0.016 wt-%. NRC noted in the SSER, that this approach was acceptable and was considered the more appropriate model. NUREG/CR-5729 is the

method accepted by NRC in Regulatory Guide 1.161. Regulatory Guide 1.161 does not differentiate between vessel manufacturers, however, the regulatory guide does note that the generic statistical analysis reported in NUREG/CR-5729 is from reactor vessels fabricated in the United States. The regulatory guide does not suggest that any further testing is necessary, i.e., J-R testing of reactor vessel surveillance coupons upon withdrawal from the vessel nor does it provide any additional guidance for a reactor vessel fabricated by a foreign manufacturer.

The WBN vessel was built by a foreign manufacturer, however, the manufacturer used a standard, ASTM A508 Class 2, which is also used by domestic manufacturers. Since the equivalent margin analysis was based on generic data from domestic manufacturers, testing the unirradiated material should provide further evidence that the material would maintain an equivalent margin of safety required by ASME Section XI, Appendix G. If the testing validates the equivalent margin analysis, no further testing of this type would be performed. If the testing was not successful, irradiated specimen testing from the next removed capsule (Capsule W) would be tested by an NRC approved equivalent J-R testing methodology.

NRC Staff has not yet accepted TVA's proposal. The Staff did acknowledge that testing CT specimens from the first capsule (Capsule U) would provide no more benefit than testing the unirradiated specimens. In lieu of the test from the first capsule as documented in the SSER conclusion statement, the Staff has requested that J-R testing be performed on the unirradiated specimens and on the irradiated specimens from the next two capsules to be withdrawn from the reactor vessel (Capsules W and X). The testing now proposed by the NRC surpasses the SSER discussion and exceeds the requirements in 10 CFR 50, Appendix G(IV)(A)(1)(c) which requires that an analysis be submitted for review and approval at least three years prior to the date when the predicted Charpy upper-shelf energy will no longer satisfy the requirements. For WBN, this would be three years before decreasing below 43 ft-lbs as established in TVA's October 15, 1993, letter and as approved by NRC in SSER 14.

The testing that the Staff has proposed is estimated to have a combined cost of approximately $250,000 [1999 dollars] above that testing already required in 10 CFR 50, Appendix H. In addition, since the coupons can not be machined to an industry standard, an alternate testing methodology would have to be developed. The above cost does not include the development or the fees for review and approval of an alternate testing methodology. TVA does not

consider this to be the best use of resources and expenditures which could be used to implement plant improvements. TVA considers this to be an unnecessary burden for the expense that would be incurred without providing a substantial increased safety benefit over the enclosed testing plan.

The Staff's efforts to resolve the issue have been appreciated, however, TVA does not agree with the Staff's proposed request for resolution. As discussed above, enclosed is TVA's approach that should be acceptable to validate the equivalent margins analysis as stated in the SSER. This plan exceeds the requirements of 10 CFR 50 Appendix G(IV)(A)(1)(c) for resolution of the issue. Because of the expense associated with the test plan, TVA requests NRC's documented acceptance of this plan prior to proceeding. If necessary, TVA will be glad to meet with the Staff to discuss this issue further at NRC's convenience.

If you should have any questions concerning this matter, please contact P. L. Pace at (423)365-1824.

Sincerely,

R. T. Purcell

Enclosure
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ENCLOSURE

WATTS BAR NUCLEAR PLANT (WBN) UNIT 1
REACTOR VESSEL CAPSULE SPECIMEN TESTING
TAC M89606

SUPPLEMENTAL SAFETY EVALUATION REPORT (SSER) STATEMENT

Watts Bar Nuclear Plant Supplemental Safety Evaluation Report (SSER) 14, Section 5.3.1.1.1 "Unit 1 Equivalent Margins Analysis", Item (4) identifies an action which is being tracked by TAC M89606. The action states, "The previously requested J-R curve data for forging 05 were not available. The Staff understands that the applicant will submit this information when the first specimens are removed from the reactor vessel. The Staff will track this action by TAC M89606. The actual fracture toughness data from these specimens will be used to verify the equivalent margins analysis".

SUMMARY

TVA plans to augment the unirradiated data base for the WBN Unit 1 reactor pressure vessel (RPV) intermediate shell forging 05, to provide further evidence that the material will maintain an equivalent margin of safety to those required by the American Society Mechanical Engineers (ASME) Section XI, Appendix G, through the end-of-life (EOL). The actual data from Capsule U testing (Capsule removed at the WBN first refueling outage) evaluated using Regulatory Guide 1.99, "Radiation Embrittlement of Reactor Vessel Materials," Revision 2, indicates that the EOL upper shelf energy (USE) will be 54 ft-lb which is above the 50 ft-lb required by 10 CFR 50, Appendix G(IV)(A)(1). Since the analytical equivalent margins data provided in TVA's letter dated October 15, 1993 was based on an EOL USE of 43 ft-lb and the actual Charpy V-Notch (CVN) test data for testing performed on specimens taken from Capsule U when evaluated using Regulatory Guide 1.99, Revision 2, indicates the EOL USE will be 54 ft-lb, the most prudent path is for TVA to better quantify the unirradiated material properties by the J-R testing method, so the projection of irradiation effects would be more accurate. If this is not successful, irradiated material testing may be necessary.

BACKGROUND

The limiting material for the WBN Unit 1 RPV beltline region is the intermediate shell forging 05. The unirradiated CVN testing data for intermediate shell forging 05 indicated a USE of 62 ft-lb. Based on a theoretical value for EOL fluence, the EOL USE when evaluated using Regulatory Guide 1.99, Revision 2, was predicted to be 43 ft-lb. Both these values were less than the 10 CFR 50, Appendix G, required 75 ft-lb initial and 50 ft-lb at the EOL. For that reason, TVA submitted to the NRC on October

15, 1993, an equivalency evaluation which demonstrated safety margins equivalent to those required by ASME Section XI, Appendix G.

While Regulatory Guide 1.99, Revision 2, requires two or more credible data sets for use of irradiated CVN data, the initial indication from Capsule U is that the original value of 62 ft-lb for USE was excessively conservative. The CVN results from Capsule U indicate a USE value of 72 ft-lb for intermediate shell forging 05 in the irradiated condition. Based upon Capsule U's location and the time of the capsule withdrawal, (approximately 1.20 effective full power years (EFPY) of actual operating exposure), this is equal to approximately 5.9 EFPY equivalent exposure at the RPV inner surface.

DISCUSSION

The SSER statement to use irradiated material to develop J-R curve data appears to have been based on material availability. SSER 14 (page 5-3) also states the following:

> "In subsequent teleconferences, the Staff also requested that the applicant's analyses include any unirradiated or irradiated J-R curve data from forging 05 or J-R curve data from material similar to forging 05 that was forged by Fried. Krupp Huttenwerke AG and heat treated by the Rotterdam Dockyard Company to a condition equivalent to forging 05 …."

From the above SSER statement, it is clear that NRC would accept either unirradiated or irradiated J-R curve data to verify the equivalent margin analysis. At the time, TVA was unaware of the archived unirradiated material from the WBN vessel manufacturer, Rotterdam Dockyard Company, being retained by Westinghouse. However, retrieval of this material now provides TVA with the best possibility of providing the requested data in accordance with the latest recognized standard (Regulatory Guide 1.161 endorses American Society for Testing and Materials (ASTM) E1152-1987, "Standard Test Method for Determining J-R Curves," however, this standard has been replaced by ASTM E1820-1996, "Standard Test Method for Measurement of Fracture Toughness") as noted below:

- TVA has nine specimens remaining from Capsule U. The specimens are four compact tension (CT) cuts in the T-L (axial) orientation, four CT cuts in the L-T (tangential) orientation, and one bend bar cut in the L-S (orthogonal)

orientation (orientation designations are as shown in ASTM E399-1974, "Standard Test Method for Plane-Strain Fracture Toughness of Metallic Materials," Figures 1 and 2). The bend bar as shown in ASTM E399-1974, Figure 2 would normally have a third component of orientation, however, it does not.

- Since the bend bar and the eight CT specimens are configured in accordance with Figures A.3.1 and A.4.1 of ASTM E399-1974 or Figure A2.2 of ASTM E1820-1996, machining of these specimens would be required to provide compliance with ASTM E1820-1996, Figures A1.1 and A2.1 for testing. Exact compliance with ASTM E1820-1996, Figure A2.1 cannot be achieved because of an interference between the holes in the existing ASTM E399-1974, Figure A.4.1 configured CT specimens and the required notch for the ASTM E1820-1996, Figure A2.1 specimen. However, since the Charpy data for the irradiated specimens in Capsule U when evaluated using Regulatory Guide 1.99, Revision 2, indicates that the EOL USE will be above 50 ft-lb, it is not apparent that supplemental testing of this irradiated material is necessary at this time.

TEST PLAN

TVA plans to provide NRC with the requested J-R curve data as follows:

1. Machine four unirradiated CT specimens from the Westinghouse archived material in the ASTM E399-1974, Figure 1, L-T and T-L orientations (2 each) and configured in accordance with ASTM E1820-1996, Figure A2.1. It is not necessary to test bend bar specimens to provide the requested data.

2. Perform testing of the CT specimens in accordance with ASTM E1820-1996 to establish unirradiated J-R curves for the intermediate shell forging 05 material. The Westinghouse analysis found that the $J_{applied}$ values for Service Levels A and B were controlling; therefore, testing will be performed at a temperature of 390°F which is the temperature at which the highest stress occurs at the quarter thickness (¼T) location for Service Level A (normal operating conditions) and Service Level B (upset conditions) during cooldown from normal operating temperature at 100°F per hour.

3. In addition, six CVN specimens will be machined from the unirradiated material in the T-L orientation to the dimensions shown in WCAP-9298, "Tennessee Valley Authority

Watts Bar Unit 1 Reactor Vessel Radiation Surveillance Program."

4. Two sets of three each CVN specimens will be tested in accordance with ASTM E23, "Standard Test Methods for Notched Bars Impact Testing Of Metallic Materials," at two elevated temperatures (one set at each temperature) to confirm the USE in the axial direction.

5. Perform an evaluation of the test data to verify that the equivalent safety margins provided in TVA's letter to NRC dated October 15, 1993, were conservative.

This testing can be performed, evaluated, and the submittal of results made to NRC six months after NRC's acceptance of this plan.

Assuming that the results of the testing are favorable, the WBN Unit 1 RPV would be in compliance with the requirements of 10 CFR 50, Appendix G until such time as the USE had decreased to a value of 43 ft-lb as established in TVA's October 15, 1993, letter. However, if the results of the testing and subsequent evaluation do not establish that the safety margins from that letter were conservative, TVA would conduct the following testing:

1. Based on data from Capsule U, the capsule withdrawal schedule was revised as shown in Table 7-1 of WCAP-15046, "Analysis of Capsule U from the Tennessee Valley Authority Watts Bar Unit 1 Reactor Vessel Radiation Surveillance Program," and Revision 6 of the Pressure Temperature Limits Report (PTLR), Table 4.0-1 (both submitted to NRC October 13, 1998). Capsule W is scheduled to be pulled at approximately 3.9 EFPY (the third refueling outage) in lieu of previous schedule of 5.4 EFPY. The fluence for Capsule W is projected to represent approximately the same fluence at a ¼T as at EOL (32 EFPY). Four CT specimens from Capsule W, (2) L-Ts and (2) T-Ls, would be tested to develop J-R curves.

2. Along with the normal testing of the CVN and tensile specimens from Capsule W in accordance with ASTM E23 and ASTM E8, "Standard Test Methods for Tension Testing of Metallic Materials," TVA would test the four CT specimens in accordance with the latest standard in effect at the time of the testing (assuming ASTM E399-1974, Figure A.4.1 CT specimens are incorporated into a J-R testing methodology).

3. The results of this testing would be submitted to NRC as required by 10 CFR 50, Appendix H, within one year of the time the capsule is removed from the core.

CONCLUSION

In conclusion, the action plan outlined above provides the requested data as originally conceived in SSER 14. Testing of the remaining irradiated specimens from Capsule U is not warranted since results from that capsule indicate compliance with Section IV of 10 CFR 50, Appendix G criteria for EOL USE may be achieved without the requirement for equivalent margins analysis. Fracture toughness J-R testing of the Capsule U CT specimens as configured, in total compliance with the latest recognized standard or any previous standard for J-R testing, cannot be performed and would require developing an NRC approved methodology.

Should a problem be indicated by the results of the supplemental testing of unirradiated CT specimens outlined above, TVA considers it to be more prudent to perform fracture toughness testing of the Capsule W CT specimens that would be irradiated to the equivalent of ¼T fluence at EOL. This testing could be more indicative of EOL (32 EFPY) vessel properties and would be completed in adequate time (approximately 5 EFPY) for TVA to consider additional planning for resolution of the issue, if needed.