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

January 16, 2001

10 CFR 50 Appendix H

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

Gentlemen:

In the Matter of) Docket No. 50-260
Tennessee Valley Authority)

BROWNS FERRY NUCLEAR PLANT (BFN) - PROPOSED REVISION TO THE UNIT 2 REACTOR PRESSURE VESSEL (RPV) MATERIAL SURVEILLANCE PROGRAM - TAC No. MB0741

The purpose of this letter is to submit a proposed schedule revision to the BFN Unit 2 RPV material surveillance program for NRC approval pursuant to 10 CFR 50, Appendix H, Section III.B.3. Appendix H of 10 CFR 50 requires licensees to withdraw surveillance capsules from their reactor vessels periodically according to the appropriate withdrawal schedule specified in ASTM E 185. ASTM E 185 provides guidelines for designing a minimum surveillance program, selecting surveillance materials, and evaluating test results. Section III.B.3 of Appendix H allows changes to the schedule as long as the proposed schedule is submitted with technical justification and NRC approval is obtained prior to implementation. TVA proposes to revise the withdrawal schedule for the second Unit 2 capsule from 14 Effective Full Power Years (EFPY) to 18 EFPY.

BACKGROUND

The proposed schedule change will allow BFN to realize the benefits of participation in the Boiling Water Reactor Owners' Group (BWROG) Integrated Surveillance Program (ISP) currently under review by the NRC staff. BFN's participation in the ISP is described in BWRVIP-78, ISP Plan. At this time Browns Ferry Unit 2 has not been selected as a representative plant by the ISP and, therefore, withdrawal of its surveillance capsules per the current schedule would not be the most effective use of this surveillance data. Additionally this request preserves BFN surveillance capsules for use during a renewed license term. On June 6, 1999, TVA notified NRC of its intent to submit an application to renew the operating licenses for BFN Units 2 and 3. The proposed surveillance program will also result in a cost savings of at least $500,000 associated with plant-specific surveillance specimen post-irradiation examination and analysis.

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Three capsules were originally installed in the Unit 2 RPV. The first capsule was removed in accordance with the current withdrawal schedule at 8 EFPY on October 22, 1994. Material testing was performed on this capsule, and in accordance with 10 CFR 50, Appendix H, the results were submitted to NRC by a October 18, 1995 letter (Reference 3).

The current BFN Unit 2 schedule for withdrawal of the remaining RPV surveillance capsules requires the second capsule to be withdrawn at the refueling outage which most closely approximates 14 EFPY with subsequent withdrawals at 6 EFPY intervals thereafter. This schedule was approved by NRC in a letter to TVA dated August 3, 1989 (Reference 1).

In the Reference 1 letter, NRC approved TVA's May 15, 1989 (Reference 2) request to update the BFN surveillance capsule withdrawal schedule from the ASTM E 185-70 guidance to ASTM E 185-82. The Reference 1 letter also approved the current capsule withdrawal schedule for the three capsules originally installed in the Unit 2 RPV. When NRC approved the current surveillance program in 1989, BFN maintained the RPV surveillance program in custom Technical Specifications. Following Improved Standard Technical Specifications implementation on July 7, 1998, the licensing basis for the RPV surveillance program was relocated to a licensee controlled program.

DISCUSSION

The BWRVIP established the ISP for monitoring radiation embrittlement of BWR RPVs. It is beneficial to combine all the separate BWR surveillance programs into a single integrated program. In the ISP, representative materials chosen for a specific RPV could be materials from another plant surveillance program or other source that better represents the limiting materials. The two objectives of the BWR ISP are:

- Select the "best" representative material to monitor radiation embrittlement for each plant
- Reduce the cost of surveillance monitoring to the BWR fleet

In addition, the BWROG has initiated a Supplemental Surveillance Program (SSP) to obtain additional high quality BWR surveillance data. The SSP is also described in BWRVIP-78. The BFN Unit 2 limiting weld and limiting plate material are included in the ISP and SSP programs, respectively. The current ISP and SSP schedules are consistent with this request to defer withdrawal of the second Unit 2 surveillance capsule.

The proposed change to the Unit 2 RPV material surveillance program is supported by the Enclosure 1 report, "Justification to Defer Removal of Surveillance Capsule #2 At the Browns Ferry Nuclear Plant Unit 2," SIR-00-165, January 2001. As discussed in the report, removal of the second capsule at 14 EFPY is not essential for continued safe operation for the following reasons:

- There is minimal value for removal of capsule #2 from BFN-2 at 14 EFPY. Expected shifts at the 30 ft-lb. transition temperature or in decrease in upper shelf energy are predicted to be nearly the same as for capsule #1.

- Data from BFN-2 capsule #1 were shown to be well-bounded and consistent with Regulatory Guideline 1.99, Revision 2, predictions and with other RPV surveillance data from the BWR fleet.

- Better data at higher fluences is anticipated from the ISP.

As demonstrated in the enclosed report, extension of the schedule is justified because 1) Evaluation of similar data from actual surveillance programs has shown that the measured fluence, shift, and chemistry are bounded by expected values, 2) The Unit 2 pressure-temperature curves are inherently conservative as a result of the use of a conservative licensing basis fluence, and 3) The SSP data will complement the available data and will identify any anomalous information in the predicted values.

Precedent exists for the approval of this request. Based on plant-specific circumstances, the NRC has previously approved similar surveillance program changes for other licensees including PECO Energy's Peach Bottom Atomic Power Station (July 14, 2000) and Commonwealth Edison Company's Dresden Nuclear Power Station (December 22, 2000). NRC approved a surveillance program change for BFN Unit 3 by the Reference 4 letter (September 20, 1999). The justifications contained in the enclosed report are similar to those previously provided for the Unit 3 schedule change.

The current RPV material surveillance program withdrawal schedule resides in Browns Ferry Technical Instruction (TI) 0-TI-381, Reactor Vessel Test Specimens. The proposed schedule change if approved by NRC will be placed in 0-TI-381. Material testing results from the ISP/SSP and/or the second Unit 2 capsule will be used to develop an appropriate schedule for the third surveillance capsule.

CONCLUSION

The proposed schedule conforms to the guidelines of the ASTM E 185-82,"Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels", and therefore, meets the requirements of 10 CFR 50, AppendixH. Based on the justifications summarized above and supported by the details contained in the enclosed report, the proposed 18 EFPY withdrawal schedule for the second surveillance capsule for Unit 2 is conservative.

NRC approval of the proposed change is requested by April 3, 2001. Enclosure 2 lists the commitment made in this letter. If you have any questions about this request, please telephone me at (256) 729-2636.

Sincerely,

T. E. Abney
Manager of Licensing
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Enclosures
cc: See page 6

REFERENCES

1. NRC Letter to TVA dated August 3, 1989, Revision To Technical Specifications Pertaining To Surveillance Requirement 4.6.A.3 And Bases Section 3.6/4.6.
2. TVA Letter to NRC dated May 15, 1989, TVA BFN Technical Specification No. 270 - Reactor Vessel Test Specimen Withdrawal.
3. TVA Letter to NRC dated October 18, 1995, Unit 2 - Submittal of Eight Effective Full Power Years (EFPY) Reactor Vessel Material Surveillance Specimen Test Results And Determination of Applicability of NEDO-32205-A, Revision 1, Topical Report on Upper Shelf Energy Equivalent Margin Analysis
4. NRC Letter to TVA dated September 20, 1999, Unit 3 Reactor Vessel Material Surveillance Program

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ENCLOSURE 1
TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNIT 2

PROPOSED REVISION TO THE UNIT 2 REACTOR PRESSURE
VESSEL MATERIAL SURVEILLANCE PROGRAM

Justification to Defer Removal of Surveillance Capsule #2 At the Browns Ferry Nuclear Plant Unit 2

SIR-00-165

[See the attached report]

Report No.: SIR-00-165
Revision No.: 0
Project No.: TVA-46Q
File No.: TVA-46Q-401
January 2001

Justification to Defer Removal of Surveillance Capsule #2 At the Browns Ferry Nuclear Power Plant Unit 2

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Section	Pages	Revision	Date	Comments
-	-	A	12/22/00	Initial Draft Issue
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1.0 INTRODUCTION

This report presents the justification to defer the removal of surveillance capsule #2 from the Browns Ferry Nuclear Power Plant Unit 2 (BFN-2) Reactor Pressure Vessel (RPV). It is the intent of the Tennessee Valley Authority (TVA) to leave the capsule in until a later time when the data obtained from the capsule can be more beneficial in demonstrating the embrittlement behavior of the RPV material. It is expected that if surveillance capsule #2 is removed after 14 EFPY, that data from the analysis is not likely to be as useful as if capsule removal is deferred for at least an additional 24-month fuel cycle.

The BFN-2 surveillance program was designed by TVA to meet the intent of 10CFR50, Appendix H [1]. The BFN-2 surveillance program meets the intent of 10CFR50, Appendix H, and ASTM E185-82 [2] (for design) for the following reasons:

- The selected base and weld metals are representative of the RPV beltline materials,
- The capsule materials have a similar fabrication history to the vessel,
- The number, type, and design of capsule specimens are equivalent to those described in ASTM E185-82.

The surveillance program at BFN-2 consists of three surveillance capsule holders installed in the RPV at the time of construction. The number of surveillance capsule holders satisfies the requirements presented in ASTM E185-82. The RPV originally contained three surveillance capsules located at 30°, 120°, and 300° azimuths at the core midplane. Each capsule receives equal irradiation due to the placement locations and the symmetry of the core design. In fall 1994, surveillance capsule #1 was removed and the contents tested. This corresponded to the surveillance capsule located at the RPV 30° azimuthal location.

Figure 1-1 is a schematic of the RPV that identifies the location of the RPV plates and welds.

The technical justification for the surveillance capsule withdrawal deferral is comprised of the following components and are the subject of this report:

- Comparison of the BFN-2 surveillance capsule #1 measured shift results with the predicted shift results, including margin, which will demonstrate the conservatism in the predictive methodology.

- Demonstration that BFN-2 data are consistent with the BWR fleet data for plates and welds, the surveillance capsule #2 predicted shifts will be within the predicted shift and margin values as given by Regulatory Guide 1.99, Revision 2 [3] for 14 EFPY and the proposed outage when surveillance capsule #2 is to be removed (assumed to be 18 EFPY).

- Comparison of the BFN-2 surveillance capsule #1 fluence at refuel outage 11 (RFO11) with the predicted fluence for the proposed capsule removal along with the predicted shift plus margin for 3 effective full power year (EFPY) milestones (8.2 EFPY, 14 EFPY (next outage), proposed outage for surveillance capsule #2 removal at 18 EFPY).

- Discussion that the BFN-2 surveillance capsule is included in the Boiling Water Reactor Vessel and Internals Project (BWRVIP) Integrated Surveillance Program (ISP) and the benefit of deferring the removal of the second capsule until the time that the data is more valuable for BFN-2 as well as to the entire BWR fleet.

The United States Nuclear Regulatory Commission (USNRC) has granted the deferral of capsule withdrawals in the past. Recently, the USNRC allowed for request for deferral of capsule removal for no more than 1 refueling cycle [4]. It should be noted that deferral of withdrawal and testing of the first capsule until 18 EFPY was allowed for Browns Ferry Nuclear Power Plant Unit 3 (BFN-3). This deferral is discussed in the following section.

The information provided in Sections 2 and 3 of this report provide the technical information that responds to the three points requested by the USNRC in [4] to support capsule withdrawal deferral for one operating cycle.

1.1 Browns Ferry Unit 3 Surveillance Capsule #1 Deferral

A similar justification was developed in Reference 5 for BFN-3. This technical justification comprised part of the TVA submittal to the United States Nuclear Regulatory Commission (NRC). The NRC approved the revised surveillance capsule withdrawal schedule (References 6 and 7). The BFN-3 surveillance capsule was removed and placed in the spent fuel pool for one additional fuel cycle. The surveillance capsule was reinserted into the RPV, without testing the specimens, during the refuel outage U3C9. This surveillance capsule was renamed capsule #3. The original capsule #2 will be removed at 18 EFPY and will be the new capsule #1. Likewise, the original capsule #3 will be the new capsule #2. The evaluation in Reference 5 demonstrated that results from testing specimens from original capsule #1 at 8 EFPY would not be valuable since the resulting shifts would likely not be discernable from the data scatter.

The Reference 5 report used the following points to form the technical justification to defer the need to test the original surveillance capsule #1 for BFN-3.

- BFN-3 fluence used for shift prediction in accordance with Reg. Guide 1.99, Rev. 2 is based upon a conservative calculation and will bound the actual fluence.

- Predicted shifts will bound the measured results based on review of predicted RT_{NDT} shifts and measured RT_{NDT} shifts from other BWR surveillance capsules.

- The shift for the BFN-3 surveillance weld is calculated to be 60°F at 32 EFPY. If the first capsule is removed at 8 EFPY, the actual shift (predicted to be 13°F) may not be large enough to be differentiated from the data scatter, since the predicted fluence of the capsule at 8 EFPY (1.85×10^{17} n/cm^2) is low, and the chemistry of the BFN-3 capsule weld material is good (0.11% copper). Thus, the data obtained from a capsule removed at 8 EFPY may not be useful since the data cannot be distinguished from the unirradiated data.

- Supplemental Surveillance Program (SSP) specimens will provide early test data for a weld similar to the BFN-3 surveillance weld; the weld is the material of concern, as the vessel weld material is limiting throughout plant life. This program supplements the BFN-3 surveillance program by providing timely detection of anomalous RT_{NDT} shifts, should any occur. The fluences of the SSP capsules are comparable to the fluence for the BFN-3 vessel wall in the time frame of interest.

Reference 5 supported the extension of the surveillance capsule testing schedule for BFN-3 for the following reasons:

- The fluence experienced by the BFN-3 vessel wall is low;
- The BFN-3 capsule plate and weld material have good alloy chemistry (i.e., low copper in the range of 0.10% - 0.11%).
- The actual shift in the BFN-3 weld material may not be distinguishable from the data scatter with early testing, e.g., at 8 EFPY.

The justification for extending the schedule is based on the following reasons:

- Predicted shifts bound the actual BWR industry surveillance results, and are expected to bound the BFN-3 shifts as well;
- The P-T curve calculations are inherently conservative;
- The supplemental surveillance program will supplement the BFN-3 surveillance program by providing for the timely detection of anomalous RT_{NDT} shifts.

It should be noted that the justification for deferring the removal of surveillance capsule #2 for BFN-2 is very similar to that used in obtaining acceptance from the NRC for deferral of the BFN-3 capsule withdrawal. Each of the justifying factors listed in Section 1.0 are discussed in Section 3.0. Section 2.0 presents a summary of the results obtained from the testing of specimens contained in the BFN-2 surveillance capsule # 1.

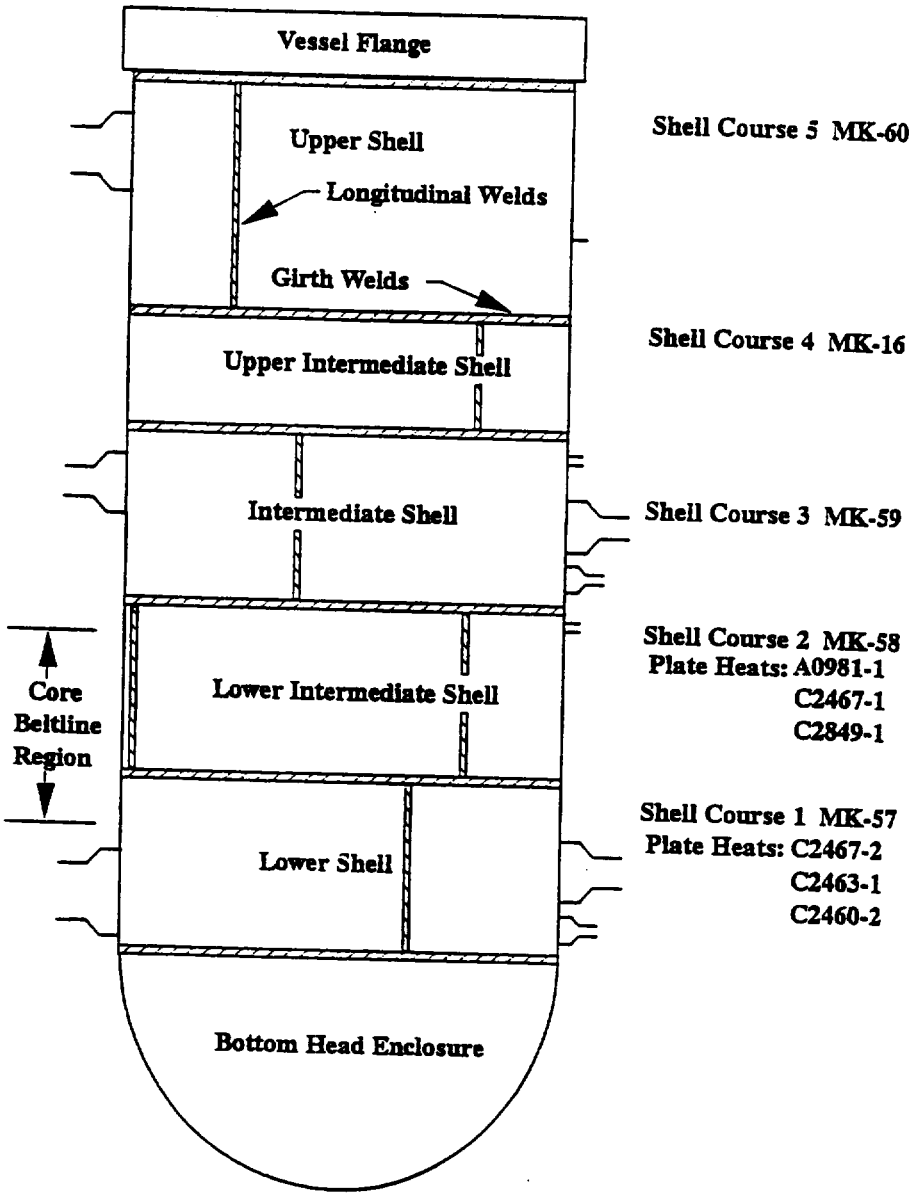

Figure 1-1. BFN-2 RPV Schematic

2.0 SURVEILLANCE CAPSULE #1 RESULTS

Surveillance capsule #1 was removed from the BFN-2 RPV in the fall of 1994 consistent with the current RPV material surveillance program [13]. Capsule #1 was at the 30° azimuth location in the BFN-2 RPV. The capsule contained flux wires for neutron fluence measurement and Charpy and tensile test specimens for material property evaluation. Charpy V-notch impact testing and uniaxial tensile testing were performed to determine the properties of the irradiated surveillance materials. Flux wires were used to establish the fluence, to which the mechanical test specimens had been subjected. In addition to the irradiated specimens, unirradiated specimens were also tested in order to have a baseline data set for comparison purposes.

Following is a summary of the significant results from Reference 8:

- Surveillance capsule #1 (at the RPV 30° azimuth position) was removed from BFN-2. The capsule contained 9 flux wires: 3 copper, 3 iron, and 3 nickel. The capsule contained 36 Charpy V-notch specimens: 12 plate material, 12 weld material, and 12 heat affected zone (HAZ) material. The 8 tensile specimens consisted of 3 plate, 2 weld, and 3 HAZ metal specimens.

- The chemical compositions of the beltline materials were determined from data obtained from GE QA records. The copper and nickel contents were determined for all beltline heats of plate material. The values for the limiting beltline plate are 0.16% copper and 0.52% nickel. The limiting beltline weld values are 0.28% copper and 0.35% nickel.

- The flux wire results show that the fluence (E>1 MeV) received by the surveillance capsule specimens was 1.52×10^{17} n/cm^2 at time of removal.

- The lead factor (relating the surveillance capsule flux to the peak surface flux for the RPV) was 0.98 based on neutron transport computation.

- Upper Shelf Energy (USE) and index temperature for 30 ft-lb, 50 ft-lb and 35 mils lateral expansion (MLE) were obtained from the Charpy V-notch specimens.

- Based on the Charpy specimen testing for the irradiated and unirradiated specimens, the 30 ft-lb index temperature irradiation shift and the decrease in USE were established. The surveillance plate material showed a measured 38° F shift and a 6 ft-lb decrease in USE. The weld material showed a 1°F shift and essentially no decrease in USE.

- The measured shifts of 38°F for plate and 1°F for weld, for a fluence of 1.52×10^{17} n/cm^2, were within their respective Reg. Guide 1.99, Rev. 2 range predictions ($\Delta RT_{NDT} \pm 2\sigma$) of -20°F to 48°F, and -39°F to 73°F, respectively.

- The results of the irradiated tensile testing generally showed increasing strength and decreasing ductility, consistent with expectations for irradiation embrittlement.

- The 32 EFPY fluence prediction of 6.05×10^{17} n/cm^2, based on the flux wire test and lead factor results presented, was about 43% lower than that previously established (1.1×10^{18} n/cm^2) for development of P-T curves.

- The adjusted reference temperatures (ARTs) were predicted for each beltline material, based on Reg. Guide 1.99, Rev. 2. The ARTs for the limiting material, weld ESW, at 32 EFPY is 92.1°F.

- The beltline material USE values at 32 EFPY were predicted using the methods of Reg. Guide 1.99, Rev. 2 with initial beltline USE values based on generic USE values. It is expected that the actual 32 EFPY USE will be in excess of 50 ft-lbs for all beltline plates and welds. In addition, the results of

the USE testing for the surveillance materials show that the Boiling Water Reactor Owners Group (BWROG) equivalent margin analysis is applicable.

Based on these results, the Reference 8 report concluded that the 30 ft-lb shifts and decreases in measured USE were within Reg. Guide 1.99, Rev. 2 predictions. Also, the values of ART and USE for the reactor vessel beltline materials are expected to remain within limits prescribed in 10CFR50 Appendix G [9] for at least 32 EFPY of operation.

2.1 Fluence Estimations

As stated above, the peak vessel fluence based on the flux wire measurements at the time of the surveillance capsule #1 removal (8.2 EFPY) was 1.52×10^{17} n/cm^2. Based on this fluence, Reference 5 estimated the fluence to be 6.05×10^{17} n/cm^2 at 32 EFPY. By linear extrapolation, the approximate fluence at 14 EFPY is:

$$14 \text{ EFPY} \Rightarrow \qquad f_{surf} = 1.52 \times 10^{17} * (14/8.2)/0.98 = 2.65 \times 10^{17} \text{ n/cm}^2$$

The fluence at 18 EFPY can similarly be determined by:

$$18\text{EFPY} \Rightarrow \qquad f_{surf} = 1.52 \times 10^{17} * (18/8.2)/0.98 = 3.40 \times 10^{17} \text{ n/cm}^2$$

Recognize that these fluence predictions are based on the measured fluence after 8.2 EFPY. For conservatism, a fluence of 1.1×10^{18} n/cm^2 at 32 EFPY, which was the basis to develop the current P-T curves, continues to be used for all operating parameters, i.e. P-T curves. Reference [14] contains the USNRC acceptance of the current P-T curves, which were based on the original conservative fluence of 1.1×10^{18} n/cm^2 at 32 EFPY.

3.0 TECHNICAL JUSTIFICATION FOR DEFERRAL

This section presents the technical justification and supporting information to defer the withdrawal of surveillance capsule #2 from the BFN-2 RPV.

3.1 Comparison of Capsule #1 Shifts with Predicted Shifts

As discussed earlier, Reference 8 presented the results of the calculations for determination of the flux, ART, USE, and other mechanical test results. Results of the Reference 8 evaluation demonstrated compliance with all requirements regarding assurance of the RPV structural integrity. Methods presented in Reg. Guide 1.99, Rev. 2, were used to assess the data. Of most interest from the data obtained from the surveillance capsule specimens is the shift in RT_{NDT} (ΔRT_{NDT}).

The measured shifts for the capsule #1 specimens of 38°F for plate and 1°F for weld, for a fluence of 1.52×10^{17} n/cm^2, were within their respective Reg. Guide 1.99 Rev. 2 range predictions ($\Delta RT_{NDT} \pm 2\sigma$) of -20°F to 48°F, and -39°F to 73°F, respectively. The margin was 34° F for the plate and 56° F for the welds, which corresponds to a standard deviation of 28° F for welds and 17°F for the plate (from Reg. Guide 1.99, Rev. 2).

It is important to compare the measured shifts for the plate and weld with the margin of $\pm 2\sigma$. The measured shifts of 38°F and 1°F for the weld are well within the band defined by $\pm 2\sigma$, which includes consideration for data scatter. Figure 3-1 and Figure 3-2 show the measured and predicted shifts. It can be seen that both shifts are well within the bands (shift ± margin) predicted using the fluence used for the current P-T curves and bands using the fluence based on the flux wire results (Note that the "minus margin" curve is not shown on the curve).

This comparison, between actual measured and predicted values, demonstrates that the predictive modeling, as provided in Reg. Guide 1.99, Rev. 2, as applied to BFN-2 is conservative since the BFN-2 data falls within the bands. Later in this report, data from other BWRs will be discussed to further demonstrate the conservatism of the methodology, including higher EFPY values.

3.2 Comparison of BWR Fleet Data with Predictions

In Section 3.1, a comparison between the Capsule #1 shifts was made with that predicted using the Reg. Guide 1.99, Rev. 2, methodology. As shown in Figure 3-1, the methodology is conservative for BFN-2 since the actual data is well bounded by the prediction. This demonstrates that the methodology was conservative in terms of bounding the BFN-2 data at an EFPY of 8.2 years. It is important to demonstrate that this trend will continue for BFN-2. To support the conservatism of the methodology for higher levels of EFPY, data from other BWRs can be used.

Figure 3-1 also shows the shift through the original licensed term equivalent to 32 EFPY. In addition, the shift is given through 54 EFPY, which corresponds to the end of 60 years for consideration of license renewal (assuming 90% availability). The dotted line in Figure 3-1 labeled "Capsule 1 Dosimetry + Margin on shift" corresponds to the predicted shifts using the fluence from the flux wires evaluated from capsule #1 with the 34°F margin added to the predicted shift. Also shown in this figure is the shift using the fluence that was used to determine the current P-T curves (labeled "Committed Flux [14]"). The curve labeled " Flux per Capsule 1 Dosimetry" does not contain the margin term.

As an additional check, the fluence based on the capsule #1 flux wires was increased by 20%, the uncertainty in the fast flux measurements stated in Reference 8. The shift based on this conservatively adjusted fluence is shown by the curve labeled "Flux per Dosimetry + 20%".

A significant number of surveillance capsules from BWRs have been tested. Table 3-1 is a tabulation of the base metal results from these surveillance programs. Evaluation of the data in this table shows that the expected shift is bounded by that calculated using the Reg. Guide 1.99, Rev. 2 methodology for a range of material chemistries and fluences. Table 3-2 shows the similar results for the weld material. Again, the measured shifts are bounded by the predicted shift plus margin values.

Figures 3-3 and 3-4 show the predicted shift data from Table 3-1 and 3-2 for the base and weld metal, respectively. These figures show that the measured shifts are bounded by the predicted shift considering the margin. The data from the BFN-2 surveillance capsule #1 is also plotted in Figures 3-3 and 3-4. It can be clearly seen that the BFN-2 surveillance capsule data is consistent with the other data and lies well within the predicted shift lines including margin. Thus, based on these data, including the BFN-2 capsule #1 data, the measured shift for BFN-2 would be conservatively bounded by the Reg. Guide 1.99, Rev. 2 predictions.

Based on the evaluation of previous surveillance data of actual shifts and fluences, the expected measured fluence for BFN-2 and the chemistry of the BFN-2 vessel material, the actual shift for BFN-2 is expected to be conservatively bounded by the calculated value of shift + margin at higher EFPY and even into the license renewal period. This is further supported by the fact that the BFN-2 surveillance data when plotted with the available BWR plant data and predicted values based on Reg. Guide 1.99, Rev. 2, falls well within the predicted values considering margin.

3.3 Compare Fluence and Predicted Shifts + Margin for 3 EFPY Milestones

As shown in Section 2.1, the estimated peak vessel fluences are shown below for various EFPY milestones based on the measured capsule 1 results.

EFPY	Fluence (n/cm^2)
8.2	1.52×10^{17}
14	2.64×10^{17}
18	3.4×10^{17}
32	6.05×10^{17}

These fluences were calculated based on the flux wire measurements from surveillance capsule #1. These fluences demonstrate that the BFN-2 fluence is relatively low. Although the fluence may be considered low, it is the shift in RT_{NDT}, which is more important in assessing the structural integrity of the vessel material and the adequacy of the BFN-2 surveillance program.

Figures 3-1 and 3-2 illustrate several important features. By evaluating these curves at the three EFPY milestones, 8.2, 14, and 18 EFPY, the expected behavior of the RPV material may be projected for the remaining operating license of BFN-2. As mentioned in Section 3-1, the capsule #1 results were well bounded by the predictive methodology of Reg. Guide 1.99, Rev. 2. Figure 3-1 and 3-2 show the curves for up to 60 operating years (48 EFPY to 54 EFPY, for 80% and 90% availability, respectively) and the predicted shift using various assumptions for fluence. These curves were discussed in Section 3.2.

The shift and shift plus margin at 14 EFPY and 18 EFPY, as well as at higher EFPY, is expected to remain well within the predicted values using Reg. Guide 1.99, Rev. 2. This is based on the fact that the capsule #1 results are bounded and that the Reg. Guide 1.99, Rev. 2, predictions have bounded the BWR fleet data as shown in Figures 3-3 and 3-4. Since the Reg. Guide 1.99, Rev. 2, methodology conservatively predicts the shifts and the capsule #1 was within the range considering margin, it is expected that the BFN-2 behavior at 14, 18, and 32 EFPY will also be bounded. Evaluation of the BFN-2 materials and RPV conditions does not reveal any reason why the capsule #2 would behave differently than the remainder of the BWR fleet so that the conclusions drawn from Figures 3-3 and 3-4 are applicable to BFN-2 at 14 EFPY and 18 EFPY.

3.4 BWRVIP Integrated Surveillance Program

The BWRVIP established the Integrated Surveillance Program (ISP) [10] for monitoring radiation embrittlement of BWR RPVs. It is beneficial to combine all the separate BWR surveillance programs into a single integrated program. In the ISP, representative materials chosen for a specific RPV could be materials from another plant surveillance program or other source that better represents the limiting materials. The two objectives of the BWR ISP are:

- Select the "best" representative material to monitor radiation embrittlement for each plant.
- Reduce the cost of surveillance monitoring to the BWR fleet.

The overall general benefits of the BWR ISP are:

- Improve compliance for each plant with the current version of 10CFR50 Appendix H and ASTM-E-185.
- Better match capsule data to the limiting materials for each plant.
- Share BWR data within the BWR fleet.
- Provide additional data for BWR vessels with missing or incomplete data from their plant specific surveillance programs.
- Improve the knowledge of embrittlement effects in BWR vessels.
- Support license renewal by identifying appropriate surveillance capsules.
- Reduce cost, exposure and outage time for the BWR fleet by eliminating testing of surveillance capsule materials that have no direct bearing on the irradiation behavior of plant specific limiting beltline materials.
- Obtain SSP data that will improve the quality of materials used to assess embrittlement. Consequently, the ISP will not only provide data that is considerably more representative of limiting materials, but the data base will be larger and will be available well before actual end-of-license for the plants in the fleet. The quality of the data will be consistent because of the standard methods that will be used for subsequent testing and also improved because of the high quality of the unirradiated and irradiated specimens.

Therefore, there are substantial benefits to integrating the existing surveillance programs and the Supplemental Surveillance Program (SSP) for monitoring radiation embrittlement of BWR RPVs.

BFN-2 is included in the BWRVIP ISP as shown in Reference 10. Per Table 3-1 of BWRVIP-78 [10], the BFN-2 weld metal is best represented in the ISP by electroslag weld metal from the Dresden-3 RPV. The Dresden-3 weld metal contains 0.2% copper and 0.3% nickel and is therefore a very good match. The Dresden-3 fabricator is the same as that for BFN-2, B&W. Based on the original BWRVIP-78 evaluation [10], the next Dresden-3 capsule is scheduled to be removed at 17 EFPY. Since the time of the original submittal [10], Dresden-3 has requested

that the withdrawal of the capsule be deferred until September 2002 [11]. The US NRC accepted this revised schedule as documented in Reference 12. Testing would be performed shortly after the capsule is removed.

According to Reference 10, there are no comparable specimen materials for BFN-2 plate in the regular capsules. However, the Supplemental Surveillance Program (SSP) contains plate whose chemistry compares well with the BFN-2 limiting plate. For example, A-302B MOD from Nine Mile Point-1, contained in Cooper SSP Capsules A and B and Oyster Creek SSP Capsules D and E, is of the same grade and of similar copper and nickel content as the limiting plate from BFN-2. Capsule D was removed in 1996 and is being tested. Capsules A and B are scheduled to be removed in 2002. Capsule E was scheduled to be removed in 2000.

The recently revised schedule for the removal of the Dresden-3 capsule (match for weld material) and the schedule for Cooper SSP Capsules A and B or Oyster Creek SSP Capsules D and E (match for plate material) are consistent with supporting this request to defer the withdrawal of the BFN-2 surveillance capsule until 18 EFPY. The results from the Dresden-3, Cooper and Oyster Creek surveillance capsules are expected to be available before BFN-2 removes surveillance capsule #2 at 18 EFPY.

PLANT	BWR	RPV ID (in)	Capsule I.D. (deg)	Cu	Ni	P	CF	>1 MeV FLUENCE (x10^17) (n/cm^2)	@EFPY	1.99,REV2 DELTA RTNDT	REV2 DELTA+ MARGIN	30 FT-LB TEST SHIFT
BWR/2												
AC	2	213	30	0.24	0.58	0.041	146.7	3.60	5.80	35.8	69.8	55
			300	0.24	0.58	0.041	146.7	4.78	7.98	41.9	75.9	79
AS	2	213	210	0.17	0.11	0.011	79.5	7.46	8.15	28.7	62.7	72
BWR/3												
H	3	251	215	0.20	0.45	0.030	131.0	0.52	6.23	9.0	43.0	23
AR	3	251	95	0.13	0.54	0.008	89.5	0.48	2.85	5.1	39.1	5
			215	0.13	0.54	0.008	89.5	0.71	5.98	7.7	41.7	12
AL	3	224	210	0.21	0.49	0.010	148.7	3.30	8.96	32.7	66.7	61
			300				140.7	6.60	14.80	48.0	82.0	78
A	3	205	30	0.17	0.66		138.3	2.90	7.63	27.6	61.6	N/A
AJ	3	188	10	0.08	0.72	0.012	66.0	5.70	6.90	20.7	54.7	0
			190				66.0	12.60	15.85	30.7	64.7	2
AG	3	224	30	0.13	0.63	0.015	91.8	2.30	4.17	17.2	51.2	25
W	3	251	215	0.26	0.55	0.010	143.0	0.55	6.64	10.3	44.3	4
AB	3	251	215	0.09	0.52	0.008	65.0	0.66	5.63	5.3	39.3	-2
BWR/4												
Y	4	251	30	0.14	0.55	0.007	98.0	1.52	9.05	14.2	48.2	38
V	4	201	30	0.17	0.53	0.016		1.30	7.06	0.0	34.0	25
G	4	201	30	0.11	0.53	0.011		1.30	7.43	0.0	34.0	40
Q	4	218	30	0.21	0.76	0.009	164.6	2.10	6.80	30.9	64.9	52
			300				164.6	2.80	11.20	34.7	68.7	53
N	4	183	288	0.15	0.70	0.006	112.5	4.90	5.90	32.6	66.6	42
			36	0.15	0.61	0.011	165.0	11.00	14.70	72.0	106.0	77
C	4	218	30	0.12	0.63	0.011	83.5	2.60	5.98	16.9	50.9	33
			120				74.8	5.00	13.40	21.7	55.7	15
R	4	218	30	0.11	0.63	0.010	93.5	2.40	5.75	18.0	52.0	42
			120	0.13	0.70	0.010	245.0	4.60	14.30	68.5	102.5	62
F	4	218	30	0.08	0.63	0.010	51.0	2.30	6.58	9.6	43.6	3
AY	4	251	30	0.09	0.64	0.012	58.0	1.42	6.01	8.0	42.0	4
P	4	251	120	0.10	0.54		65.0	1.80	7.53	10.5	44.5	N/A
J	4	251	30	0.13	0.63	0.011	91.8	1.60	7.58	13.7	47.7	16
AW	4	251	30	0.09	0.61	0.009	58.0	1.40	6.68	8.0	42.0	24
AT	4	251	30	0.12	0.63	0.010	83.0	1.30	6.20	10.8	44.8	-2
O	4	205	30	0.10	0.68	0.014	74.9	0.43	7.54	4.5	38.5	19
BWR/5												
AX	5	251	300	0.14	0.54	0.014	97.0	0.90	6.58	9.9	43.9	28
AZ	5	251	300	0.10	0.48	0.010	65.0	1.15	6.98	7.8	41.8	N/A
AK	5	251	300	0.14	0.50	0.017	88.0	1.55	7.20	12.9	46.9	-1
BWR/6												
R	6	218	3	0.029	0.6	0.005	20	8.4	5.67	7.7	41.7	17
AE	6	218	177	0.06	0.6	0.008	37	9.6	6.85	15.1	49.1	4
AF	6	218	3	0.09	0.58	0.008	58	11.0	6.99	25.3	59.3	14
D	6	239	345	0.06	0.63		37	2.2	9.28	6.8	40.8	7.2
AU	6	238	3	0.06	0.61	0.010	33	3.5	5.50	8.0	42.0	-6

Table 3-1 BWR Surveillance Program Results for Base Metal

PLANT	BWR	RPV ID (in)	Capsule I.D. (deg)	Cu (%)	Ni (%)	P (%)	CF	>1 MeV FLUENCE (x10^17) (n/cm^2)	@EFPY	1.99,REV2 DELTA RTNDT	REV2 DELTA+ MARGIN	30 FT-LB TEST SHIFT
BWR/2												
AC	2	213	30	0.17	0.07		81	3.6	5.80	19.8	75.8	N/A
			300	0.17	0.07		81	4.78	7.98	23.1	79.1	N/A
AS	2	213	210	0.29	0.05	0.022	131.5	7.5	8.15	47.6	103.6	N/A
BWR/3												
H	3	251	215									
AR	3	251	95	0.21	0.35	0.009	119	0.4	2.65	6.7	62.7	4
			215	0.21	0.35	0.009	119	0.28	5.98	5.1	61.1	4
AL	3	224	210	0.20	1.05	0.019	228.5	3.3	8.96	53.8	109.0	22
			300					6.6	14.80	77.4	133.4	76
A	3	205	30	0.05	0.92		68	2.9	7.63	14.6	70.6	N/A
AJ	3	188	10	0.30	0.09	0.016	138	5.7	6.90	43.3	99.3	110.5
			190					12.6	15.85	64.1	120.1	95
AG	3	224	30	0.16	0.79	0.014	178	2.3	4.17	33.4	89.4	55
W	3	251	215	0.19	0.32	0.012	105.5	0.55	6.64	7.6	63.6	0
AB	3	251	215	0.16	0.34	0.009	100.1	0.66	5.63	8.2	64.2	43
BWR/4												
Y	4	251	30	0.20	0.33	0.010	120	1.52	9.05	17.4	73.4	1
V	4	201	30	0.14	0.68	0.011		1.3	7.06	0.0	56.0	N/A
G	4	201	30	0.12	0.66	0.012		1.3	7.43	0.0	56.0	N/A
Q	4	218	30	0.23	0.75	0.014	194.5	2.3	6.80	36.5	92.5	61
			300					2.8	11.20	41.0	97.0	62
N	4	183	288	0.08	0.95	0.011	27	4.9	5.90	7.8	63.8	0
							29	11	14.70	12.7	68.7	16
C	4	218	30	0.31	0.72	0.015	216	2.6	5.98	43.6	99.6	N/A
			120				208	5	13.40	68.9	116.9	N/A
K	4	218	30	0.28	0.76	0.013	212	2.4	5.75	40.8	96.8	N/A
								4.6	14.30	0.0	56.0	N/A
F	4	218	30	0.13	0.10	0.014	68.8	2.3	6.58	12.9	68.9	0
AY	4	251	30	0.08	0.59	0.014	105	1.42	6.01	14.5	70.5	61
P	4	251	120	0.18	0.32		84.2	1.8	7.53	13.6	69.6	21
J	4	251	30	0.11	0.41	0.009	102.5	1.6	7.58	15.3	71.3	16
AW	4	251	30	0.02	0.95	0.012	27	1.4	6.68	3.7	59.7	21
AT	4	251	30	0.02	0.95	0.014	27	1.3	6.20	3.5	59.5	-32
O	4	205	30	0.03	0.95	0.013	41	0.43	7.54	2.5	58.5	5
BWR/5												
AX	5	251	300	0.21	0.78	0.016	194	0.9	6.58	19.8	75.8	35
AZ	5	251	300	0.04	0.89	0.010	54	1.15	6.98	6.5	62.5	19
AK	5	251	300	0.03	0.90	0.011	34	1.55	7.28	7.9	63.9	-5
BWR/6												
R	6	218	3	0.07	0.76	0.013	97.5	8.4	5.67	37.3	93.3	-28
AE	6	218	177	0.08	0.88	0.009	108	9.6	6.85	44.1	100.1	23
AF	6	218	3	0.05	0.87	0.010	68	11.0	6.99	29.7	85.7	35
D	6	239	345	0.05	0.7		68	2.2	9.28	12.4	68.4	-7.2
D	6	239	9	0.01	0.04		20	2.9	9.28	4.3	60.3	-5.4
AU	6	238	3	0.02	0.82	0.013	34	3.5	3.50	8.2	64.2	-14.7

Table 3-2 BWR Surveillance Program Results for Weld Metal

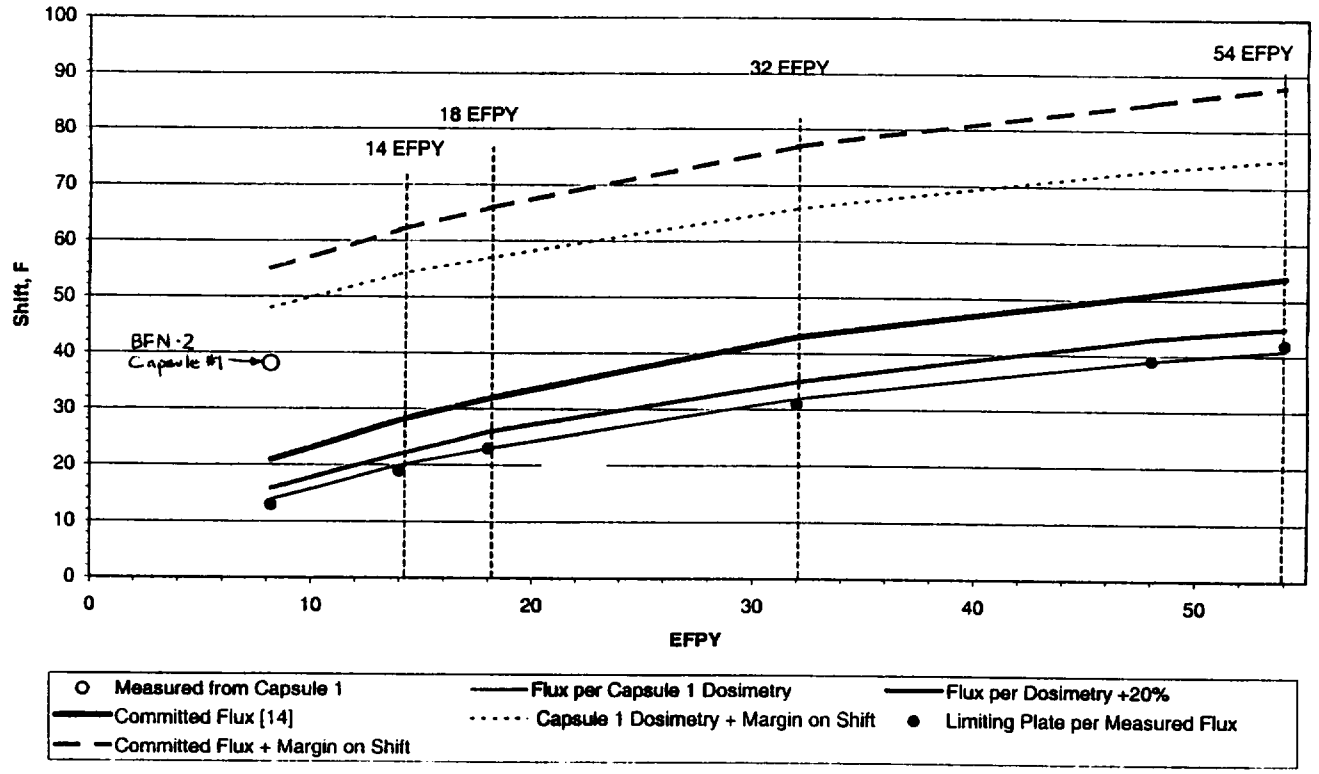

Figure 3-1 Predicted Shifts Surveillance Plate and Limiting Plate

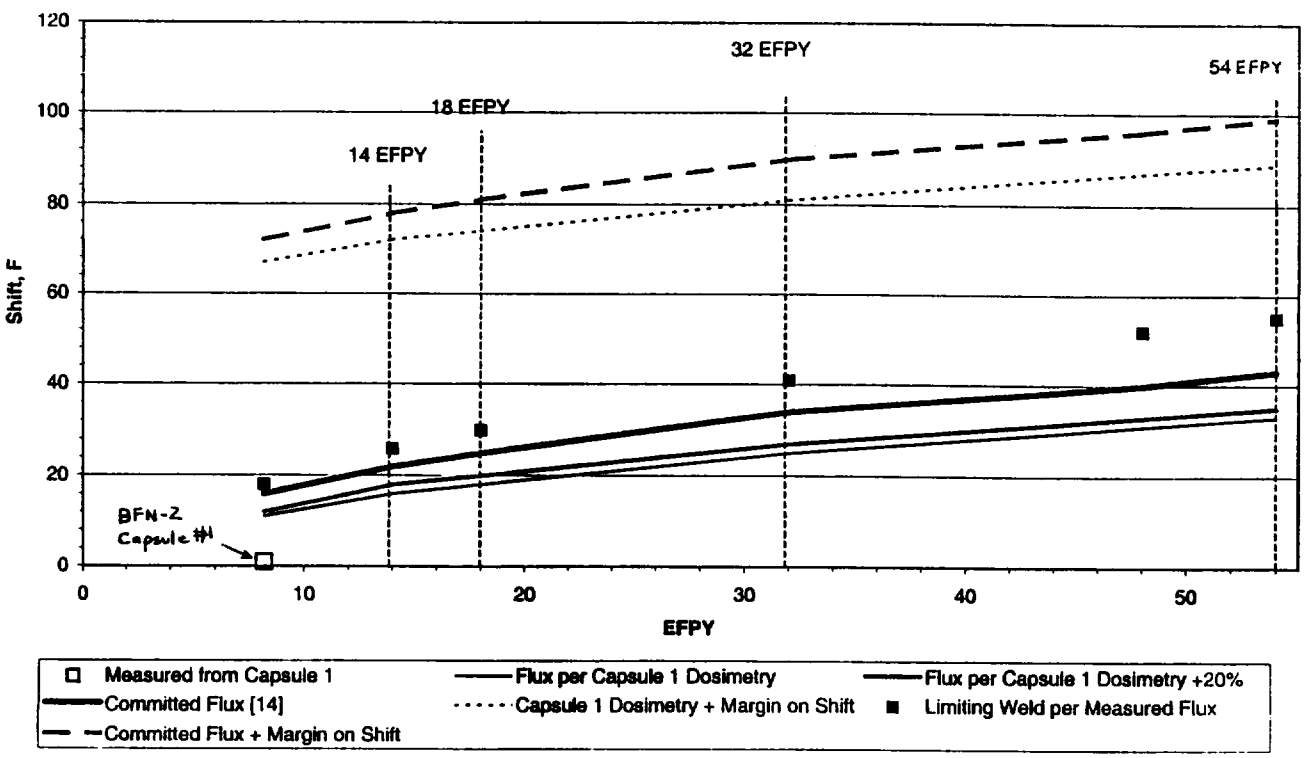

Figure 3-2 Predicted Shifts Surveillance Weld and Limiting Weld

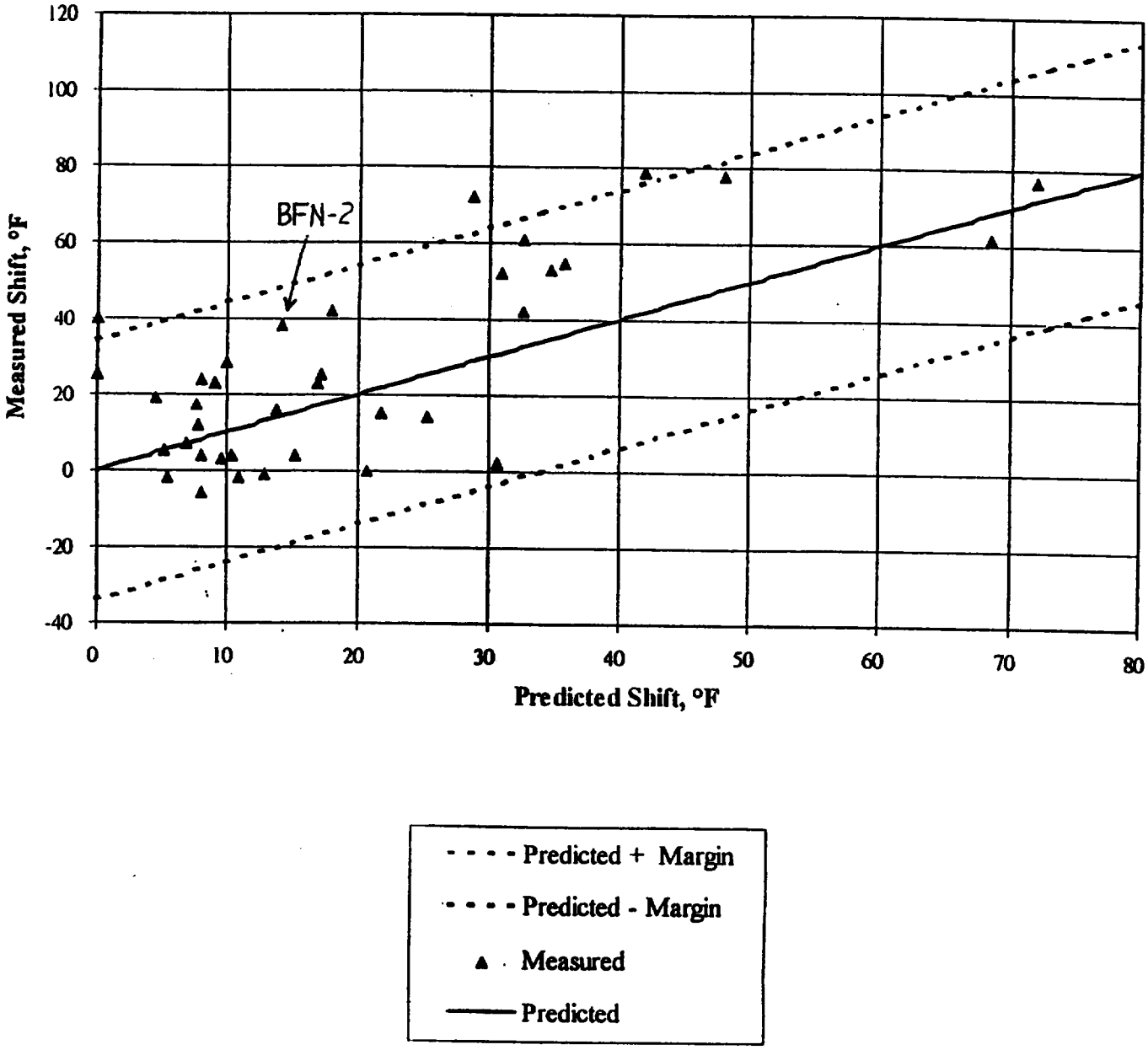

Figure 3-3. BWR Fleet Measured Shift vs. Predicted Shift for Base Metal

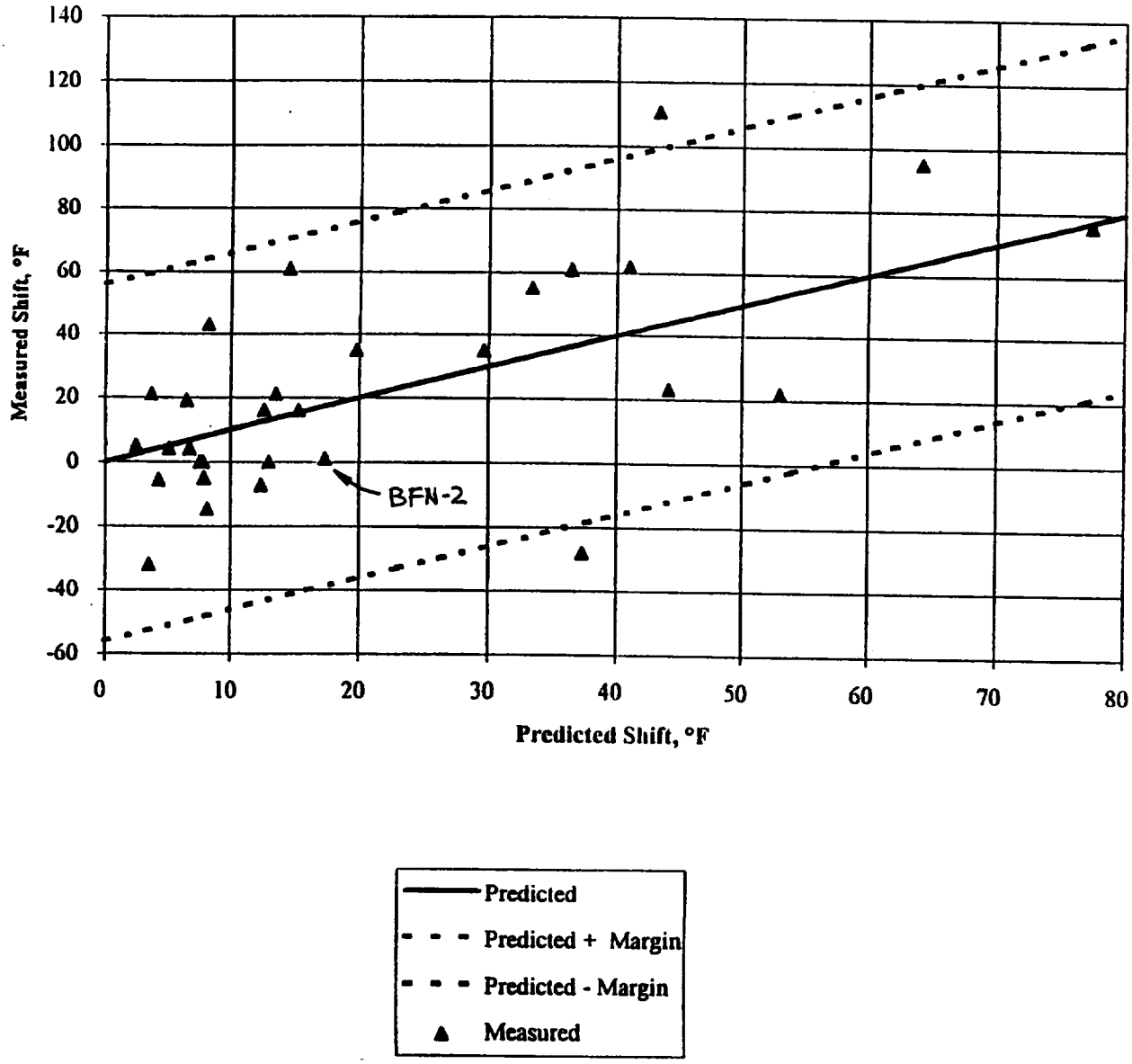

Figure 3-4. BWR Fleet Measured Shift vs. Predicted Shift for Weld Metal

4.0 CONCLUSIONS

This report has presented the technical justification for deferring the withdrawal of Surveillance Capsule #2 to a later time of 18 EFPY. The original surveillance program schedule included removal of capsule #2 at 14 EFPY. The original schedule was developed according to 10CFR50, Appendix H. The revised schedule, reflecting deferral of capsule withdrawal until 18 EFPY, is consistent with the recommendations of ASTM E185-82 and 10CFR50, Appendix H. This justification considered the low fluence in the BFN-2 RPV to adjust the schedule established using 10CFR50, Appendix H. The conclusions from this evaluation are:

- There is minimal value to removal of capsule #2 from BFN-2 at the end of the cycle that most closely approximates 14 EFPY. Expected shifts at 30 ft-lb transition temperature or in decrease in USE are predicted to be nearly the same as for capsule #1.
- Data from BFN-2 capsule #1 were shown to be well bounded and consistent with Regulatory Guide 1.99, Rev. 2, predictions and with other RPV surveillance data from the BWR fleet.
- Better data at higher fluences is anticipated from the ISP (Dresden-3 for weld metal; SSP capsules A, B, D, and E for plate)

Even when the fluence used to generate the current P-T curves is used, the deferral of capsule #2 is justified. Comparison of the predicted shift ± margin curves (committed fluence and measured fluence) demonstrate that a very significant change in fluence would be required in order for the measured and predicted shifts to be inconsistent.

5.0 REFERENCES

1. "Reactor Vessel Material Surveillance Program Report Requirements," Appendix H to Part 50, Title 10 of the Code of Federal Regulations, December 1995.

2. ASTM E185-82, "Standard Recommended Practice for Surveillance Tests for Nuclear Reactor Vessels," ASTM, 1982.

3. "Radiation Embrittlement of Reactor Vessel Materials," US NRC Regulatory Guide 1.99, Revision 2, May 1988.

4. Letter from Jack Strosnider to Carl Terry, Niagara Mohawk Power Company, "BWR Integrated Surveillance Program (BWRVIP-78) (TAC NO. M99894)," May 16, 2000

5. "Surveillance Specimen Program Evaluation for Tennessee Valley Authority Browns Ferry Unit 3," GENE B1302026-00-01, April 1999.

6. "Browns Ferry Nuclear Plant, Unit 3, Reactor Pressure Vessel Material Surveillance Program (TAC No. MA5403)," US NRC Docket No. 50-296, September 20, 1999.

7. "Safety Evaluation by the Office of Nuclear Reactor Regulation Request to Revise the Reactor Vessel Surveillance Capsule Withdrawal Schedules for Browns Ferry Nuclear Plant, Unit 3," Docket No 50-296, September 1999.

8. "Browns Ferry Steam Electric Station Unit 2 Vessel Surveillance Material Testing and Fracture Toughness Analysis," GE Nuclear Energy report GENE-B1100639-01, June 1995.

9. "Fracture Toughness Requirements," Appendix G to Part 50, Title 10 of the Code of Federal Regulation, December 1995.

10. "BWR Vessel and Internals Project BWR Integrated Surveillance Program (BWRVIP-78),"Prepared for BWRVIP and EPRI, EPRI Report TR-114228, December 1999.

11. Letter from Preston Swafford, Commonwealth Edison Company to US NRC, "Revision to Reactor Pressure Vessel Material Specimen Removal Schedule," July 28, 2000.

12. Letter from Anthony Mendiola to Oliver Kingsley, Commonwealth Edison Company, "Dresden, Units 2 and 3 – Approval of reactor Pressure Vessel Surveillance Capsule Withdrawal Schedule (TAC NOS. MA 9593 and MA 9594)," December 22, 2000.

13. Letter from Suzanne Black (USNRC) to Oliver Kingsley, Tennessee Valley Authority, "Revision to Technical Specification Pertaining to Surveillance Requirement 4.6.A.3 and Bases Section 3.6/4.6 – (TAC 73141, 73142, 73143) (TS 270) – Browns Ferry Nuclear Plants, Units 1, 2, and 3," August 3, 1989.

14. Letter from L. Raghavan (USNRC) to J.A. Scalice, Tennessee Valley Authority, "Amendment NOS 257 and 217 to Facility Operating License NOS. DPR-52 and DPR-68: Pressure and Temperature Limits-Technical Specification Change TS 393 (TAC NOS. MA 1304 and MA 1305)," January 15, 1999.

ENCLOSURE 2
TENNESSEE VALLEY AUTHORITY
BROWNS FERRY NUCLEAR PLANT (BFN)
UNIT 2

PROPOSED REVISION TO THE UNIT 2 REACTOR PRESSURE VESSEL MATERIAL SURVEILLANCE PROGRAM

COMMITMENT

Material testing results from the ISP/SSP and/or the second Unit 2 capsule will be used to develop an appropriate schedule for the third surveillance capsule.