March 1, 2006

Bill Eaton, BWRVIP Chairman
Entergy Operations, Inc.
Echelon One
1340 Echelon Parkway
Jackson, MS 39213-8202

SUBJECT: NON-PROPRIETARY SAFETY EVALUATION OF THE "BWRVIP VESSEL AND INTERNALS PROJECT, INTEGRATED SURVEILLANCE PROGRAM (ISP) IMPLEMENTATION FOR LICENSE RENEWAL (BWRVIP-116)," EPRI REPORT TR-1007824, JULY 2003

Dear Mr. Eaton:

By letter dated July 29, 2003, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted the Electric Power Research Institute (EPRI) Proprietary Report TR-1007824, "BWR Vessel and Internals Project, Integrated Surveillance Program (ISP) Implementation for License Renewal, (BWRVIP-116)," for U. S. Nuclear Regulatory Commission (NRC) staff review. It was supplemented by a BWRVIP letter dated January 11, 2005, in response to the NRC's request for additional information (RAI) raised in the NRC's letters dated March 29, 2004, and June 23, 2004.

The BWRVIP-116 report, along with the BWRVIP responses dated January 11, 2005, provides the technical basis for the development and implementation of the integrated surveillance program for the extended period (ISP(E)) intended to support operation of all U.S. BWR reactor pressure vessels (RPVs) through the completion of each facility's proposed extended period of operation (60 year operating license). The BWRVIP ISP(E) was submitted under the regulatory provisions given in Appendix H to Title 10 of the *Code of Federal Regulations* Part 50 (Appendix H to 10 CFR Part 50), Paragraph III.C., "Requirements for an Integrated Surveillance Program."

The NRC staff has completed its review of the BWRVIP-116 report and the associated RAI responses. The staff finds that the final proposed BWRVIP ISP(E) (as addressed in the attached safety evaluation) is acceptable for BWR licensees implementation provided that all licensees continue to use one or more compatible neutron fluence methodologies acceptable to the NRC staff, i.e., which comply with the guidance in Regulatory Guide 1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence," to determine surveillance capsule and RPV neutron fluences. Compatible in this case may be understood to mean neutron fluence methodologies which provide results that are within acceptable levels of uncertainty for each calculation. This condition of ISP(E) implementation is necessary to ensure that data from surveillance capsules included in the ISP(E) may be appropriately shared between BWR facilities and that the basis for the neutron fluence determined from a specific capsule and the RPV which it is intended to represent are comparable. This issue is related to the requirements for an ISP found in items a., b., and c., of Appendix H to 10 CFR Part 50, Paragraph III.C.1.

The staff requests that the BWRVIP submit the proprietary and non-proprietary versions of the -A document of the BWRVIP-116 report within 180 days of receipt of this letter. Please contact Meena Khanna of my staff at 301-415-2150 if you have any further questions regarding this subject.

Sincerely,

/RA/

Matthew A. Mitchell, Branch Chief
Vessels & Internals Integrity Branch
Division of Component Integrity
Office of Nuclear Reactor Regulation

Enclosure: As stated

cc: BWRVIP Service List

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SAFETY EVALUATION REGARDING EPRI PROPRIETARY REPORT,

"BWR VESSEL AND INTERNALS PROJECT, INTEGRATED SURVEILLANCE

PROGRAM (ISP) IMPLEMENTATION FOR LICENSE RENEWAL (BWRVIP-116)"

1.0 INTRODUCTION

1.1 Background

By letter dated July 29, 2003[1], the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted the Electric Power Research Institute (EPRI) Proprietary Report TR-1007824, "BWR Vessel and Internals Project, Integrated Surveillance Program (ISP) Implementation for License Renewal, (BWRVIP-116)" dated July 2003, for U. S. Nuclear Regulatory Commission (NRC) staff review. It was supplemented by a BWRVIP letter dated January 11, 2005[2], in response to the NRC's request for additional information raised in the NRC's letters dated March 29, 2004[3], and June 23, 2004[4].

In a letter dated February 1, 2002[5], the NRC approved BWRVIP-78, "BWR Integrated Surveillance Program Plan," and BWRVIP-86, "BWR Integrated Surveillance Program Implementation Plan," as supplemented by the BWRVIP letters to the NRC dated December 15, 2000[6], and May 30, 2001[7], for use during each boiling water reactor (BWR) facility's original 40-year operating license. The recommendations provided in the February 1, 2002, letter were incorporated into the final approved version of the report, BWRVIP-86-A, "Updated BWR Integrated Surveillance Program (ISP) Implementation Plan."

The primary objective of BWRVIP-86-A was to satisfy the requirements of Appendix H to Title 10 of the *Code of Federal Regulations* Part 50 (Appendix H to 10 CFR Part 50) for the original 40-year operating licenses of the BWR fleet. However, during the design of this program, it was recognized that the ISP could be extended to meet the needs of individual BWR facilities submitting license renewal applications. Therefore, BWRVIP-116 was developed to extend the guidelines of BWRVIP-86-A for the extended period of operation, by expanding the capsule withdrawal schedules to include the withdrawal and testing of an additional surveillance capsule from each ISP host plant based on the criteria approved in the NRC's February 1, 2002, letter. In addition, the ISP during the license renewal period (hereafter referred to as ISP(E) to differentiate it from the ISP for the original 40-year license period) will continue to be designed, implemented, and managed to the same requirements of the current ISP detailed in BWRVIP-86-A.

The BWRVIP-116 report, along with the BWRVIP responses dated January 11, 2005, provides the technical basis for the development and implementation of the ISP(E) intended to support operation of the reactor pressure vessels (RPVs) in all U.S. BWRs through the completion of each facility's proposed extended period of operation (60 year operating license). The BWRVIP ISP(E) was submitted under the regulatory provisions given in Appendix H to 10 CFR Part 50, Paragraph III.C., "Requirements for an Integrated Surveillance Program."

1.2 Purpose

The staff reviewed the BWRVIP-116 report and the supplemental information that was submitted to the staff to determine whether it will provide an acceptable RPV material surveillance program in accordance with Appendix H to 10 CFR Part 50 for all operating U.S. BWR plants for the extended period of operation. The data from this program will be used to monitor changes in the fracture toughness properties of RPV materials due to irradiation and provide adequate information for required RPV integrity evaluations, such as those required by Appendix G to 10 CFR Part 50, "Fracture Toughness Requirements."

1.3 Regulatory Requirements

Appendix G to 10 CFR Part 50, which is invoked by 10 CFR 50.60, "Acceptance Criteria for Fracture Prevention Measures for Lightwater Nuclear Power Reactors for Normal Operation," specifies fracture toughness requirements for ferritic materials of pressure-retaining components of the reactor coolant pressure boundary, including RPVs, during any condition of normal plant operation, including anticipated operational occurrences and system hydrostatic tests. In order to support evaluations that demonstrate compliance with these requirements will be maintained, information regarding irradiated RPV material properties and the neutron fluence level of a licensee's RPV is necessary. Therefore, 10 CFR 50.60 also invokes Appendix H to 10 CFR Part 50, which requires licensees to implement a RPV material surveillance program to "monitor changes in the fracture toughness properties of ferritic materials in the reactor vessel beltline region...which result from exposure of these materials to neutron irradiation and the thermal environment." In compliance with the requirements of Appendix H to 10 CFR Part 50, licensees for all operating U.S. BWRs had implemented plant-specific RPV material surveillance programs as part of each facility's licensing basis.

However, in early 1997, the NRC staff identified an issue with the existing Brunswick Unit 2 RPV surveillance program[8]. Based on the staff's review of a 1997 Brunswick Unit 2 RPV surveillance capsule report, it was noted that the licensee for Brunswick Unit 2 lacked adequate unirradiated baseline Charpy V-notch (CVN) data for one of the materials in the Brunswick Unit 2 RPV surveillance program. The NRC staff noted that this lack of baseline properties would inhibit the licensee's ability to effectively monitor changes in the fracture toughness properties of RPV materials in accordance with Appendix H to 10 CFR Part 50. Subsequent NRC staff discussions with the BWRVIP led to the identification of several plants [ ] that potentially lacked adequate unirradiated baseline CVN data for at least one material in their plant-specific RPV surveillance programs. In total, 14 BWR surveillance welds and 7 BWR surveillance plates were identified as being potentially affected by this issue[9].

The NRC staff met with BWRVIP representatives on November 7, 1997, to discuss this issue and potential paths for its resolution[10]. At that meeting, BWRVIP representatives indicated that they had attempted to locate unirradiated archival material samples and/or additional sources of baseline data for the potentially affected RPV surveillance program materials. This effort was not successful with regard to resolving the issue. As a result, the BWRVIP representatives indicated that they were pursuing the development of a BWR RPV ISP to address this issue and meet the requirements of Appendix H to 10 CFR Part 50 for all BWR licensees. The NRC staff agreed that such an approach, if appropriately developed, would be expected to resolve any outstanding issues regarding BWR RPV surveillance programs.

This alternative to individual plant-specific RPV surveillance programs is addressed in paragraph III.C. of Appendix H to 10 CFR Part 50. Pursuant to Paragraph III.C. of Appendix H to 10 CFR Part 50, an RPV ISP may be implemented, with the approval of Director of the Office of Nuclear Reactor Regulation, by two or more facilities with similar design and operating features. Paragraph III.C. of Appendix H also sets forth specific criteria upon which approval of an ISP shall be based. The specified criteria include:

a. the reactor in which the materials will be irradiated and the reactor for which the materials are being irradiated must have sufficiently similar design and operating features to permit accurate comparisons of the predicted amount of radiation damage;

b. each reactor must have an adequate dosimetry program;

c. there must be adequate arrangement for data sharing between plants;

d. there must be a contingency plan to assure that the surveillance program for each reactor will not be jeopardized by operation at reduced power level or by an extended outage of another reactor from which data are expected; and,

e. there must be substantial advantages to be gained, such as reduced power outages or reduced personnel exposure to radiation, as a direct result of not requiring surveillance capsules in all reactors in the set.

In addition, no reduction in the requirements for the number of materials to be irradiated, specimen types, or number of specimens per reactor is permitted. Finally, no reduction in the amount of testing is permitted unless authorized by the Director of the Office of Nuclear Reactor Regulation.

2.0 SUMMARY BWRVIP-116 REPORT

The information provided by the BWRVIP for the ISP(E) expands on the current ISP for the 40-year license period, while retaining the administrative and implementation requirements previously approved in the BWRVIP-86-A report.

2.1 Surveillance Material Selection for the BWR ISP(E)

The current ISP uses surveillance capsules from [ ] ISP host plants and [ ] capsules from the Supplemental Surveillance Program (SSP) to provide surveillance for the U.S. BWR fleet. The SSP was originally developed by the Boiling Water Reactors Owners Group (BWROG) as an irradiation and testing program for acquiring additional surveillance data with the intent of developing an irradiation shift correlation specifically for BWRs as an alternative to Regulatory Guide (RG) 1.99, Revision 2[11]. The BWROG SSP was developed from unirradiated, archival samples of BWR plate and weld materials related to several U.S. BWR plant-specific surveillance programs along with additional material from U.S. RPV fabricators and other sources. In total, [ ] different plate and [ ] different weld materials were included in the

BWROG SSP. Samples of these materials were fabricated into [ ] sets of Charpy specimens and placed into [ ] SSP surveillance capsules. [ ] of the SSP surveillance capsules were inserted into the [ ] RPV and [ ] were inserted into the [ ] RPV for irradiation.

The ISP in Table 4-6 of BWRVIP-86-A previously proposed [ ] surveillance capsules, [ ] surveillance capsule from each of the [ ] ISP host plants, for the proposed 60-year operating period. The ISP(E) will use these [ ] surveillance capsules originally proposed in BWRVIP-86-A for the 60-year operating period. There are also [ ] deferred surveillance capsules that will be available on a contingency basis. Table 3-1, "Detailed Test Plan by Plant, Capsule Already Tested," and Table 3-2, "Detailed Test Plan by Plant, Future ISP and ISP(E) Capsule Testing," of BWRVIP-116 documents the limiting material for each BWR plant and the representative surveillance material source capsules.

BWRVIP-116 also notes that [ ] BWR plants rely on representative materials that are only in the SSP surveillance capsules. These SSP surveillance capsules are being tested in the current ISP and, therefore, no SSP surveillance capsules will be available for testing under the ISP(E). However, the material in these SSP capsules will have accumulated neutron fluence values that represent the target vessel's estimated end-of-life for the extend period (EOLE) 1/4 thickness (1/4 T) fluence values. Therefore, the SSP surveillance capsules tested under the current ISP will also provide the required surveillance data for the 60-year operating period under the ISP(E).

2.2 Surveillance Capsule Withdrawal Schedule

The surveillance capsule withdrawal schedule for the ISP(E) was developed based on the expectation that license renewal (60-year operating period) would increase the BWR facilities effective full power years (EFPY) of operation from 32 EFPY to 48 EFPY. The BWRVIP proposes that the additional [ ] ISP(E) surveillance capsules be tested at 40 EFPY, which is an extension of, and consistent with the methodology of the current ISP, except for the [ ] surveillance capsule. The [ ] surveillance capsule was scheduled for withdrawal in [ ] as part of the current ISP, but the BWRVIP proposes to defer this capsule's withdrawal until [ ] for use under the ISP(E). The basis for determining that this capsule be deferred and used in the ISP(E) is provided below.

- This [ ] capsule would provide the [ ] irradiated data set for weld heat [ ] and the [ ] irradiated data set for plate heat [ ]. Only two irradiated data sets are required to realize a representative data set in accordance with RG 1.99, Revision 2.

- Withdrawing this [ ] surveillance capsule at [ ] is unproductive from the viewpoint of obtaining useful data, since the neutron fluence which was achieved by the [ ] material in SSP Capsule [ ] is greater than what would be achieved by the [ ] capsule.

- The only remaining [ ] capsule available after the withdrawal of the [ ], is a reconstituted capsule that was reinserted in the early 1990's. Since the [ ] surveillance capsule will have been exposed to a greater neutron fluence, it will provide better irradiated data than the reconstituted capsule.

The surveillance capsule test schedule was presented in Table 2-2 of BWRVIP-116. This schedule was determined by evaluating the projected neutron fluences of the ISP(E) surveillance capsules at 40 EFPY against the estimated 1/4 T neutron fluence values of the target vessels at EOLE, which is 48 EFPY. The results of this evaluation were presented in Tables 2-3 and 2-4 of BWRVIP-116 for the limiting plates and welds, respectively. This qualitative evaluation was made using assumptions in estimating the EOLE neutron fluence values since most plants did not have these neutron fluence calculations for the extended period of operation. These assumptions included:

- Lead factors of the ISP(E) capsules are unknown and are assumed to be the same as recent surveillance capsules tested.

- A nominal capacity factor of 80 percent is assumed, and actual plant operation may vary from this assumed value.

- Neutron fluence values of each capsule at 40 EFPY are assumed to be 1.25 times the neutron fluence calculations for 32 EFPY.

- Since the EOLE 1/4 T neutron fluence values of the target vessels limiting materials are not available from formal vessel neutron fluence calculations, they are estimated by multiplying the 32 EFPY 1/4 T fluences by a factor of 1.5, except for [ ], which is based on a recent neutron fluence calculation for 48 EFPY.

Since there are uncertainties in these estimates of the exact year that these plants will reach 40 EFPY, the BWRVIP will coordinate with these plants and inform the NRC staff of any schedule changes that exceed 2 years of the date given in Table 2-2. In addition, the BWRVIP will continue to update the plants EOLE neutron fluence values as the neutron fluence reevaluations are performed.

BWRVIP-116 stated that Tables 2-3 and 2-4 demonstrated that testing the ISP(E) surveillance capsules at 40 EFPY will, in most cases, have fluence levels greater than 100 percent of the EOLE 1/4 T fluence of their target vessel's limiting material, thereby meeting the requirements of American Society for Testing and Materials (ASTM) Standard E185 and RG 1.99, Revision 2. In the cases where the surveillance capsule neutron fluence values are less than 100 percent of the target RPV 1/4 T fluence values and the capsules are not the same heat as the target vessel material, the target plants will utilize RG 1.99, Revision 2, Tables 1 and 2 to determine a chemistry factor for calculating predicted embrittlement shifts. Since the representative material's Charpy shift data are not used directly to predict embrittlement in these cases, there is no effect on the surveillance capsules being less than 100 percent of the target RPV's EOLE 1/4 T fluence values. For the instances where the surveillance capsule neutron fluence values are less than 100 percent of the 1/4 T fluence values and the capsules is the same heat as the target vessel material, the ISP(E) host reactor vessel is also the target reactor vessel. The surveillance capsules in these plants lag the reactor vessel material in terms of neutron fluence exposure, and therefore it is not possible for these capsules to achieve 100 percent of the EOLE 1/4 T neutron fluence. However, three or more irradiated data points will still be obtained, and these plants will be able to calculate a surveillance based chemistry factor for calculating predicted embrittlement shifts in accordance with RG 1.99, Revision 2.

2.3 Evaluation of ISP Compliance with Appendix H Criteria

The ISP(E) is an extension of the current ISP providing additional surveillance data for the extended period of operation and uses the same methodology in determining compliance with Appendix H to 10 CFR Part 50. The guidelines of developing the ISP(E) are therefore based on the current ISP in BWRVIP-86-A which are discussed below.

On the topic of similarity of plant operating environments in Paragraph III.C.a of Appendix H to 10 CFR Part 50, the BWRVIP noted that normal operating temperatures in the downcomer region of BWRs range from 525 EF to 535 EF. The BWRVIP concluded that this temperature variation was minor and would not be significant with regard to the ability to monitor embrittlement for the BWR fleet through the use of the ISP. Regarding the neutron energy spectra issue, the BWRVIP cited the fact that neutron energy spectra for BWRs have been determined by General Electric over the years using neutron transport calculations. These determinations have been made for various BWR models, at original and uprated power levels, with original and new fuel designs, and with original and revised core loading patterns. Although the magnitude of neutron flux may vary from plant to plant based on specific operating characteristics, the neutron energy spectrum was found to be essentially the same at similar plant locations. Hence, the BWRVIP concluded that the overall operating environments for all reactors in the U.S. BWR fleet were sufficiently similar to support data sharing and the implementation of an ISP.

Next, the BWRVIP considered the requirements in Paragraph III.C.b of Appendix H to 10 CFR Part 50, pertaining to the availability of dosimetry data and the ability to adequately determine both RPV surveillance capsule and BWR RPV fluences. The BWRVIP concluded that, given the availability of an acceptable, benchmarked fluence calculational methodology, these sources of data would continue to provide an accurate estimate of the RPV neutron fluence values unless a major change in core design is undertaken in the future. The BWRVIP noted that facilities which identify a need for additional dosimetry data to improve their RPV neutron fluence calculations may also consider the installation of ex-vessel dosimetry for that purpose. In addition, BWRVIP-116 stated that BWRs that will not be required to remove additional surveillance capsules will determine vessel fluence during the extended period utilizing an NRC approved neutron fluence determination methodology.

Regarding the criterion for adequate data sharing in Paragraph III.C.c of Appendix H to 10 CFR Part 50, BWRVIP-86-A committed the BWRVIP to the development of a program plan to exchange surveillance data (capsule reports) among BWR facilities as it becomes available. The ability to integrate and distribute data to all BWR licensees through the BWRVIP is a common feature which has been successfully implemented in many other BWRVIP programs. This commitment continues to apply for the ISP(E) as stated in Section 2.4 of BWRVIP-116. In addition, since all of the BWR participants have referenced the implementation of the current ISP in their facility's Updated Final Safety Analysis Reports (UFSARs), each BWR facility demonstrates compliance with the requirements of Appendix H to 10 CFR Part 50.

Regarding the need for contingency planning in accordance with Paragraph III.C.d of Appendix H to 10 CFR Part 50, Section 2.6 of BWRVIP-116, states that the contingency plans under the ISP(E) are the same as the current ISP. The first part of this plan would be to consider retrieving the necessary surveillance capsules from the facility prior to permanent shutdown. If removal of the capsules is not a viable option, a new best representative material would be selected from the surveillance materials not currently being tested as part of the ISP(E). This option highlights the inherent contingency plan which is available in the BWRVIP ISP(E). The work performed to develop the ISP(E) has identified several surveillance materials, other than the best representative material, that could represent a particular RPV's limiting plate or weld. Surveillance capsules containing the other potential representative materials will not be removed from their host reactors, but will instead continue to be irradiated during the course of normal plant operation. As such, these other surveillance materials will continue to be available for removal and testing should the reactor which houses the best representative surveillance material undergo an indefinite shutdown. Finally, if none of the potential representative capsules are a viable option, the target plant's own capsules, which were deferred under the ISP(E) but remain in the reactor, will be available as the last contingency.

The final criterion in Paragraph III.C.e of Appendix H to 10 CFR Part 50, regarding the identification of substantial advantages to be gained as a direct result of implementation of the ISP(E), was addressed based on information previously noted in this safety evaluation (SE). The ISP(E) would address the issue raised by the NRC staff regarding the lack of adequate unirradiated baseline CVN data for some BWR surveillance materials by identifying and substituting other materials as the method of monitoring changes in RPV material fracture toughness for some BWRs. In addition, the BWRVIP proposed that the implementation of the ISP(E) would also have additional benefits. The BWRVIP stated that when the original surveillance materials were selected for plant-specific surveillance programs, the existing state of knowledge about which RPV materials would be limiting with regard to fracture toughness after irradiation was not the same as it is today. As a result, many facilities did not include what would be identified today as the plant's limiting RPV materials in their surveillance programs.

Hence, this effort to identify and evaluate materials from other BWRs, which may better represent a facility's limiting materials, should improve the overall evaluation of BWR RPV embrittlement. The inclusion of data from the testing of BWROG SSP capsules will improve overall quality of the data being used to evaluate BWR RPV embrittlement. Finally, implementation of the ISP(E) is also expected to reduce the cost of surveillance testing and analysis for the BWR fleet since surveillance materials that are of little of no value (either because they lack adequate unirradiated baseline CVN data or because they are not the best representative material for any U.S. BWR) will no longer be tested.

Table 3-3 of BWRVIP-116 provides information in regards to Paragraph III.C. of Appendix H to 10 CFR Part 50 that state that an ISP shall entail no reduction in the number of materials being irradiated, number of specimen types, or number of specimens per reactor and no reduction in the amount of testing. Although some surveillance capsules will be deferred and not tested as part of the ISP(E), all capsules that were previously credited as part of plant-specific surveillance programs and carried forward under the current ISP will continue to be irradiated in

their host reactors. Therefore, all irradiated material samples continue to remain available to the ISP(E), if needed, and no overall reduction in the number of materials being irradiated, number of specimen types, or number of specimens per reactor occurs as a result of the ISP(E).

With regard to the number of specimens tested for the extended period, Table 3-3 shows that the [ ] host plants that will be testing one surveillance capsule each under the current ISP will also be testing an additional surveillance capsule for the ISP(E). Therefore, there will be no reduction in the required amount of specimens tested from the implementation of the proposed ISP(E).

Therefore, based on the consideration of these factors, the ISP(E) meets the regulatory criteria in Paragraph III.C. of Appendix H to 10 CFR Part 50.

3.0 NRC STAFF EVALUATION

The NRC staff has reviewed the information in the BWRVIP-116 report against the criteria specified in Paragraph III.C. of Appendix H to 10 CFR Part 50 for the establishment of an ISP. The staff has also reviewed the technical basis for, and comprehensive description of, the proposed ISP(E) against the objectives of being able to monitor changes in the fracture toughness properties of RPV materials due to irradiation and providing adequate information for required RPV integrity evaluations. The staff has concluded that, subject to the conditions discussed in this section and in Section 4.0 of this SE, the proposed BWR ISP(E) is acceptable. Additional details regarding the staff's evaluation of the ISP(E) are provided below.

3.1 Surveillance Material Selection for the BWR ISP(E)

The NRC staff has completed its review of the technical criteria used by the BWRVIP to select the surveillance materials to be included within the ISP(E) for all U.S. BWRs for the license renewal period. The NRC staff notes that the [ ] application to renew their license is currently being reviewed at the NRC. Therefore, the NRC staff in a letter dated June 23, 2004, requested the BWRVIP to discuss how [ ], which was not included in BWRVIP-116, would be incorporated into the ISP(E). In a BWRVIP letter dated January 11, 2005, an individual vessel evaluation was provided for [ ] including the final selection of the best representative weld and plate materials using the methodology and criteria previously established in BWRVIP-86-A. The individual vessel evaluation will be added to Appendix A of BWRVIP-86-A, to provide a complete list of the evaluations of all BWR vessels in the ISP and the proposed ISP(E).

The BWRVIP proposed that the best representative weld material for [ ] is SSP heat [ ], which is the same heat as the vessel limiting material. The BWRVIP also stated that SSP heat [ ] has been tested from SSP capsules [ ], with capsule [ ] receiving the highest neutron fluence at [ ] at the 1/4T location. The NRC staff notes that the [ ] response to a request for additional information in regards to the license renewal application, the licensee provided in a letter dated January 31, 2005[12], a fluence value of [ ] at the 1/4T location for the vessel weld heat [ ] for the extended period of operation. Therefore, the SSP capsule I for this heat still bounds the fluence value of the [ ] vessel for the extended period of time. Weld heat [ ] will

be a new addition to the list of ISP(E) representative surveillance materials, but will not require additional capsule testing since SSP capsule I has been tested already and provides the necessary surveillance data for the [ ] limiting weld. The best representative plate material for [ ] plate heat [ ] which is already proposed to be tested under the ISP(E).

The staff has concluded that the BWRVIP's material selection process was adequate to ensure that materials which effectively provide meaningful information to monitor changes in fracture toughness for all BWR RPV materials, including [ ] were included within the scope of the ISP(E). The criteria used (chemical composition, material heat number, fabricator, etc.) were consistent with current ISP, which included the best available technical understanding of irradiation damage mechanics for identifying surveillance materials that would best represent the limiting plate and weld materials in U.S. BWR RPVs. The staff also found that the criteria for having adequate unirradiated baseline data (or the ability to acquire such data) continues to be addressed under the ISP(E). Finally, the staff found that the BWRVIP's consideration of test matrix minimization based on use of a single surveillance material to represent more than one limiting BWR RPV material was also acceptable. Test matrix minimization led, in some cases, to a material which was not the absolute "best" representative surveillance material being used to represent a specific BWR RPV material. The staff found this to be acceptable because it was not necessary in all cases to use the absolute "best" representative material when a technically adequate material was already to be included in the program to represent a different BWR RPV material.

It should, however, be noted that although a surveillance material may be determined to be the "best" representative material for a specific RPV material, the similarity between the surveillance material and the RPV material may not be sufficient to justify direct use (see RG 1.99, Revision 2, position C.2) of the surveillance data in determining the behavior of the RPV material. Therefore, if position C.2. is used, appropriate adjustments for chemistry and irradiation temperature differences between the surveillance material and the RPV limiting material must be addressed. The NRC staff will review the direct utilization of surveillance data resulting from the ISP(E) as part of plant-specific RPV integrity evaluations. Surveillance materials which do not share the same heat number with the limiting RPV material may be used for general monitoring, but not for direct determination of RPV embrittlement. In such cases, the chemistry factor table of position C.1. of RG 1.99, Revision 2 should be used. It is sufficient to mention at this point that additional differences between surveillance materials and RPV materials (e.g., heat treatment during fabrication) can complicate the direct use of such surveillance data, particularly if advanced fracture mechanics-based evaluations (i.e., the Master Curve methodology), which are outside of the scope of this submittal, were to be employed.

3.2 Surveillance Capsule Withdrawal Schedule

The staff has also reviewed the BWRVIP's selection of surveillance capsule withdrawal/test dates (years) in order to achieve meaningful projected surveillance capsule fluence levels. The capsule test schedule is presented in Table 2-2, "ISP(E) Capsule Test Schedule" of BWRVIP-116, and detailed in Table 2-3, "Evaluation of ISP(E) Capsule Testing for BWR

Limiting Plates," and Table 2-4, "Evaluation of ISP(E) Capsule Testing for BWR Limiting Welds." The NRC requested in a letter dated June 23, 2004, that the BWRVIP discuss how they ensure that the objectives of being able to monitor changes in the fracture toughness properties due to irradiation and being able to provide adequate information for required RPV integrity evaluations are met, since some of the test dates of the surveillance capsules are performed after the end of the target plant's extended license. In a letter dated January 11, 2005, the BWRVIP provided a proposed schedule consistent with the method suggested by the NRC staff to withdraw the ISP(E) capsules from the affected plants in the approximate year when the ISP(E) capsule fluences as a percentage of EOLE 1/4T fluence is estimated to be approximately equal to 100 percent of the EOLE 1/4T fluence of the most limiting plant. This resulted in a schedule that would allow the target plants to use the surveillance data in their required RPV integrity evaluations and to monitor changes in fracture toughness properties during their extended period of operation. The BWRVIP noted that the [ ] ISP(E) capsule attained only [ ] percent of the plant's limiting weld EOLE 1/4T fluence instead of 100 percent. This, however, is acceptable to the NRC staff since it is approximately 100 percent while providing surveillance data that can be used by the limiting plant prior to the end of its extended period of operation. The NRC staff notes that the new capsule test schedule in Table 1 of the BWRVIP letter dated January 11, 2005, should replace Table 2-2 of BWRVIP-116.

Section 2.6 of BWRVIP-116 provides contingency planning for the ISP(E) to address any major interruptions in plant operation such as early, permanent plant shutdown or an extended outage of one of the host plants. However, this section does not address minor reassessments that take into account plant-specific variations in scheduled withdrawal dates due to modifications in fuel cycles, or changes in target fluences caused by power uprates or variations in capacity factors. In a letter dated January 11, 2005, the BWRVIP provided additional requirements to be added to Section 2.6 of BWRVIP-116 to address these situations. The NRC staff agrees with the information provided and the requirement that changes to the capsule withdrawal schedules will be submitted to the NRC for approval. This is in addition to the BWRVIP commitment in Section 3 of BWRVIP-116 to update the plant neutron fluence values as the plants perform fluence reevaluations for the extended period of operation. Since these reevaluated fluence values can affect the withdrawal schedules, the BWRVIP will implement changes to the withdrawal schedule and submit them for NRC approval as required by Section 2.6 of BWRVIP-116.

The staff also finds the BWRVIP's basis for the deferral of the withdrawal of the [ ] surveillance capsule from [ ] (as part of the current ISP) until [ ] (under the ISP(E)) to be acceptable. Irradiated data currently exists for the same heats of material in the [ ] surveillance capsule (weld heat [ ] and plate heat [ ]) based on previous plant-specific and SSP testing. Deferring the testing of the [ ] surveillance capsule will provide irradiated data that is more consistent with the fluences that will be seen in the target RPV during the 60-year extended licensing period. Therefore, since the deferral of the [ ] surveillance capsule will provide better irradiated data for the target plants to utilize for their RPV integrity evaluations, the NRC staff has no objections to deferring this capsule. However, deferring this capsule for use under the ISP(E) will reduce the number of capsules tested under the current ISP. The acceptability of the number of test capsules in the current ISP and ISP(E) is discussed in Section 3.3 of this SE.

Based on the above, the NRC staff concluded that the program described by these tables was acceptable to meet the objectives of being able to monitor changes in the fracture toughness properties of RPV materials due to irradiation and providing adequate information for required RPV integrity evaluations.

3.3 Evaluation of ISP Compliance with Appendix H Criteria

After concluding that an acceptable technical basis existed for the proposed ISP(E), the NRC staff next evaluated the proposed ISP(E) against the criteria for an ISP specified in Paragraph III.C. of Appendix H to 10 CFR Part 50 as was done for the current ISP. Each of the criteria is addressed below.

First, concerning Paragraph III.C.a of Appendix H, the NRC staff concluded that sufficient similarity exists regarding the design of U.S. BWRs such that accurate comparisons of the predicted amount of radiation damage can be made for the BWR fleet through an ISP. The staff continues to accept that no significant plant-to-plant differences in neutron energy spectra should be expected at similar BWR RPV wall or surveillance capsule locations based on current operating practice. This is based on the current ISP plant designs, including the addition of [ ] which is of the same design and construction as [ ] currently in the ISP. The staff also accepts that the range of operating temperatures for the BWR fleet (525 EF to 535 EF) cited by the BWRVIP bounds the current operating characteristics of these units. Plant-to-plant temperature differences of this magnitude are minor and may be corrected for, as necessary, to support direct use of surveillance data (see Position C.2 of RG 1.99, Revision 2) based on the use of adjustment methodologies that have been approved by the NRC staff. In addition, the staff accepts that no other effects that may contribute to plant-to-plant differences in irradiation conditions (e.g., significantly different gamma flux levels, etc.) are known to exist.

The next criteria the NRC staff considered was that specified in Paragraph III.C.b of Appendix H concerning the need for an adequate dosimetry program for each reactor participating in the ISP(E). The staff recognized that in order to define what an “adequate” dosimetry program may be, it was necessary to examine the underlying purpose of a RPV dosimetry program. RPV dosimetry programs were considered to be necessary to support the determination of RPV neutron fluence values for limiting RPV materials through the application of neutron fluence calculational methodologies. In addition, the dosimetry data associated with each surveillance capsule directly provides information important for the accurate determination of the surveillance capsule fluence. Therefore, the staff considered whether the information provided by the ISP(E) was sufficient to conclude that acceptable RPV fluence and surveillance capsule fluence values could continue to be determined given implementation of the ISP(E).

The proposed ISP(E) will continue to utilize dosimetry as delineated under the current ISP. Under the current ISP, a limited amount of dosimetry data exists from each operating BWR, either as a result of the analysis of first cycle dosimetry capsules or as a result of previously tested surveillance capsules. The BWRVIP provided additional information in a letter dated January 11, 2005, that BWR plants removing additional surveillance capsules for the purpose of assessing RPV integrity will also use an NRC-approved methodology for determining neutron fluences. The BWRVIP further clarified that all ISP(E) fluence evaluations, whether host or target plant, will be performed in a consistent manner using a RPV neutron fluence calculational methodology consistent with the guidance of RG 1.190[13]. As a continuation of the

current ISP in BWRVIP-86-A, the implementation of the ISP(E) would ensure that each facility which supplies surveillance capsules for the ISP(E) will continue to obtain additional dosimetry data. For those facilities which supply capsules to the ISP(E), the amount of dosimetry data which will be obtained through participation in the ISP(E) will be equal to or greater than the amount of data which would have been acquired as a result of continuing either with the current ISP, or with a plant-specific surveillance program. Therefore, given that the current ISP has been determined to be adequate, the NRC staff concluded that their access to dosimetry data will continue to be adequate through implementation of the ISP(E). Finally, the dosimetry data from each surveillance capsule included in the ISP(E) ensures that adequate dosimetry data is available for the determination of surveillance capsule fluences.

As a continuation of the current ISP in BWRVIP-86-A, facilities which are not required to remove additional capsules may (e.g., through the installation and testing of ex-vessel dosimetry) or may not acquire additional dosimetry data. However, adequacy of dosimetry data for BWR facilities which will not be required to remove additional surveillance capsules will be dependent upon the methodology utilized by each licensee to determine their RPV fluences. Section 2.5 of BWRVIP-116 provides information about dosimetry for BWR plants that will not be required to remove additional surveillance capsules. These BWR plants will determine vessel fluences during the extended license period utilizing an NRC-approved neutron fluence determination methodology. Currently, at least one NRC-approved neutron fluence determination methodology in NEDC-32983P which was approved by NRC letter dated September 14, 2001[14], in accordance with RG 1.190 exists for BWRs which provides adequate results with little or no plant-specific dosimetry data. Additional neutron fluence determination methodologies which may offer the same capability could be developed. It is noted that the staff has approved the BWRVIP Radiation Analysis Modeling Application (RAMA) fluence methodology in its SE dated May 13, 2005. However, it should be noted that calculational methodologies have been, or will be, benchmarked against existing dosimetry databases to demonstrate their adequacy for determining BWR RPV fluences.

Since all BWR plants have implemented the current ISP and use neutron fluence determination methodologies that have been or will be benchmarked against existing dosimetry data bases, except for Duane Arnold and FitzPatrick which are in-process of implementing the current ISP, the NRC staff concludes that the dosimetry data which would be available for BWR facilities that will not be required to remove additional surveillance capsules as part of the ISP(E) will be sufficient to ensure that adequate RPV neutron fluence determinations continue to be performed. However, if a BWR facility proposes to change its neutron fluence determination methodology, the facility must request approval from the NRC staff to determine its acceptability, and whether the neutron fluence determination methodologies have been or will be benchmarked against existing dosimetry data bases. The information submitted to the NRC staff must be sufficient for the staff to determine that:

> (1) RPV and surveillance capsule fluences will be established based on the use of an NRC-approved fluence methodology that will provide acceptable results based on the available dosimetry data, and

(2) if one “best estimate” methodology is used to determine the neutron fluence values for a licensee’s RPV and one or more different methodologies are used to establish the neutron fluence values for the ISP(E) surveillance capsules which “represent” that RPV in the ISP(E), the results of these differing methodologies are compatible (i.e., within acceptable levels of uncertainty for each calculation).

Regarding the criterion of adequate data sharing between plants in Paragraph III.C.c of Appendix H to 10 CFR Part 50, the NRC recognizes that BWRVIP processes have been demonstrated in other programs to be sufficient for establishing methods to share data between BWR facilities. The staff also notes that the data sharing will continue under the ISP(E) in the same manner as addressed and committed to in the current ISP. Therefore, the NRC staff accepts the continued commitment by the BWRVIP in the development and implementation of a “program plan to manage data sharing.” The NRC staff, however, would also note that by the incorporation of the ISP(E) into the licensing basis for each participating BWR facility, each licensee is further responsible for ensuring that they acquire and evaluate in a timely manner all relevant ISP(E) data which may affect RPV integrity evaluations for their facility. Hence, after implementation of the ISP(E), a performance basis should become available from NRC staff licensing reviews to evaluate whether acceptable data sharing is occurring as part of the ISP(E).

Regarding the criterion in Paragraph III.C.d of Appendix H to 10 CFR Part 50 for establishing a contingency plan to ensure that the ISP(E) will not be jeopardized by an extended outage of a reactor from which surveillance capsules are to be obtained, the NRC staff concluded that the BWR ISP(E) has inherently established an adequate contingency plan, which is the same as under the current ISP. The evaluational work which was performed by the BWRVIP to select the “best representative” materials for inclusion in the ISP(E) also identified other surveillance materials in other BWR RPVs that could be used to monitor changes in fracture toughness properties for the BWR fleet. These other, “backup” surveillance materials could be used by the BWRVIP in the event that one or more facilities which are currently slated to provide capsules to the ISP(E) are forced to sustain an indefinite shutdown or unanticipated termination of operations. By having this preestablished list of available backup surveillance materials, the BWRVIP could act in a timely and efficient manner to arrange for the appropriate acquisition and evaluation of data from a backup material to support the goals of the ISP(E). However, to assure that these backup material are available for possible future testing, these backup material, which includes any surveillance material with unirradiated baseline data, must be kept in a condition which allows for testing. Therefore, the BWRVIP-116 report should include the necessary information to ensure the contingency plan continues to meet the criterion in Paragraph III.C.d of Appendix H to 10 CFR Part 50. This information should ensure:

- All surveillance material with unirradiated CVN baseline data, which includes tested/broken CVN specimens and partially and/or untested surveillance capsule material, must be kept in a condition to allow for possible future testing.

- If these surveillance materials are removed from the RPV, without the intent to test them, these capsules must be stored in a manner which maintains them in a condition which would support possible re-insertion into an RPV, if necessary under the contingency plan.

- Prior to any changes to the storage of these materials, the BWRVIP must be notified to determine whether these changes are acceptable. The BWRVIP must obtain NRC approval for any changes that would prevent the possible testing of these surveillance materials under the contingency plan.

Based on the inclusion of the above mentioned information in the BWRVIP-116 report, the availability of these backup materials, and the periodic reviews to be conducted by the BWRVIP to assess whether any changes to the ISP(E) are necessary, the NRC staff has concluded that the BWRVIP has adequately addressed the need to consider ISP(E) contingency planning in its submittal.

The NRC staff also concluded that there are substantial advantages to be gained by the implementation of the BWR ISP(E) in response to the criterion in Paragraph III.C.e of Appendix H to 10 CFR Part 50. First, the proposed ISP(E) will address the concerns raised by the staff regarding the current reliance by some BWR licensees on surveillance materials that lack unirradiated baseline CVN data to meet the requirements of Appendix H to 10 CFR Part 50. Second, by not testing some existing plant-specific capsules as part of the ISP(E), significant savings may be realized by the BWR fleet relating to the cost of capsule removal, shipping, testing, time added to outage critical path schedules, etc. Third, the ISP(E) will improve the overall quality of data that will be obtained and reported based on the formal incorporation of the SSP capsules in the ISP(E) test matrix. Other advantages of the ISP(E) may be identified, however, the staff has found that those noted above are substantial.

Finally, regarding the positions raised in Paragraph III.C. of Appendix H to 10 CFR Part 50 which state that an ISP shall entail no reduction in the number of materials being irradiated, number of specimen types, or number of specimens per reactor and no reduction in the amount of testing, the NRC staff has concluded, based on the following, that the proposed ISP(E) complies with the following provisions:

- The staff has concluded that the continued availability of all capsules which were previously credited as part of current ISP, which includes all capsules in the previous plant-specific surveillance programs, supports the determination that no overall reduction in the number of materials being irradiated, number of specimen types, or number of specimens per reactor would result from implementing the ISP(E).

- As discussed above in Section 3.2 of this SER, the deferral of the [ ] surveillance capsule from the current ISP to the proposed ISP(E) will affect the number of surveillance capsules tested under the current ISP. To determine if the current ISP still meets the requirements of no reduction in the amount of testing, the NRC staff evaluated this change in the current ISP using the criteria in the staff's letter dated February 1, 2002, that originally determined that the current ISP did not result in a reduction in the required amount of CVN testing from the plant-specific surveillance programs. Since the total number of CVN specimen sets to be tested under the current ISP was [ ], as determined in the February 1, 2002, letter, deferring the [ ] surveillance capsule (two CVN specimen sets per capsule) will bring the total number of CVN specimen sets to [ ]. This still exceeds the total number of [ ] specimen sets that were approved under the previous plant-specific programs.

- With regard to the number of specimens tested for the extended period, the NRC concludes that no reduction in the required amount of CVN specimen set testing would result from the implementation of the proposed ISP(E) since each of the [ ] host plants currently testing under the current ISP, will be testing an additional surveillance capsule under the ISP(E). In addition, with these [ ] additional surveillance capsules ([ ] CVN specimen sets), and the [ ] CVN specimen sets in the current ISP which are incorporated into the ISP(E), a total of [ ] CVN specimen sets will be tested under the ISP(E). This is essentially equivalent to the estimated [ ] CVN specimen sets that would have been tested under plant-specific programs. The estimated number of CVN specimen sets for the plant-specific programs was based on the EOLE operating period, the projected EOLE neutron fluence values, and the guidelines of ASTM Standard E185.

Based on the consideration of these factors, the NRC staff concludes that the regulatory criteria in Paragraph III.C. of Appendix H to 10 CFR Part 50 for the approval of an ISP have been met.

4.0 CONCLUSIONS

The NRC staff has concluded that the ISP(E) proposed by the BWRVIP in the BWRVIP-116 report, and as amended by its responses dated January 11, 2005, to NRC staff RAIs, is acceptable, subject to the conditions discussed in Sections 3 and 4 of this SE. The ISP(E) adequately addresses the requirements of Appendix H to 10 CFR Part 50 for BWR licensees through the end of facility's proposed 60 year operating license. In particular, the information contained in Tables 2-2, 3-1 and 3-2 of BWRVIP-116 was found by the staff to be acceptable for defining the ISP(E) test matrix, surveillance capsule withdrawal dates, and material associations for the BWR ISP(E). Other aspects of the ISP(E), in particular plant-specific data utilization, were also found to be acceptable provided appropriate adjustments are made for chemical composition and irradiation temperature differences when data is shared between facilities.

The staff's approval of the ISP(E) is further predicated on the adoption of the ISP(E) by all BWR facilities who are identified within the ISP(E) test matrix as supplying surveillance capsules for the ISP(E). If any BWR licensee which should be providing surveillance capsules to the ISP(E) elects not to participate, the BWRVIP must submit, for NRC staff review and approval, changes to the ISP(E) that must be made to address this event.

It is the staff's understanding that the BWRVIP will produce a program document which will be all inclusive, i.e., the updated version of the BWRVIP-116 report will include the RPV surveillance program for all operating U.S. BWR plants for the current 40-year term as well as through the period of extended operation and, therefore, will replace the BWRVIP-86-A report. BWR licensees who wish to participate in the ISP(E) must complete the ISP(E) implementation as follows, based on the status of its license renewal application:

a. BWR licensees that have already been approved for a 60 year license by the NRC shall implement the ISP(E) as dictated in the SER that approved their renewed license by revising their licensing basis to replace the BWRVIP-86-A reference with the approved version of the BWRVIP-116 report.

b. BWR licensees that have their license renewal applications currently being reviewed by the NRC as of the date of this SER shall either:

   (1) revise their proposed licensing basis for the extended period by replacing the BWRVIP-86-A reference with the approved version of BWRVIP-116, if early in the license renewal process, or

   (2) implement the ISP(E) of BWRVIP-116 as will be specified in the staff's upcoming license renewal SER.

c. BWR licensees that will submit a license renewal application shall implement the ISP(E) by revising their licensing basis to include the approved version of BWRVIP-116 in its application and the proposed licensing basis for the extended period of operation.

Modifications to the facilities' licensing bases, as discussed above, may be implemented through the 10 CFR 50.59 process. The NRC staff notes that by the incorporation of the ISP(E) into the licensing basis for each participating BWR facility, each licensee is further responsible for ensuring that they acquire and evaluate in a timely manner all relevant ISP(E) data which may affect RPV integrity evaluations for their facility.

In addition to the information in the BWRVIP's letter dated January 11, 2005, which amends BWRVIP-116, the BWRVIP shall include in the approved version of BWRVIP-116, the following concerning the withdrawal schedule and contingency plans as discussed in this SE.

a. NRC staff notes that the new capsule test schedule in Table 1 of the BWRVIP letter dated January 11, 2005, should replace Table 2-2 of BWRVIP-116.

b. The BWRVIP-116 report should include the necessary information to ensure the contingency plan continues to meet the criterion in Paragraph III.C.d of Appendix H to 10 CFR Part 50. This information should ensure:

   (1) All surveillance material with unirradiated CVN baseline data, which includes tested/broken CVN specimens and partially and/or untested surveillance capsule material, must be kept in a condition to allow for possible future testing.

   (2) If these surveillance material are removed from the RPV, without the intent to test them, these capsules must be stored in a manner which maintains them in a condition which would support possible re-insertion into an RPV, if necessary under the contingency plan.

   (3) Prior to any changes to the storage of these materials, the BWRVIP must be notified to determine whether these changes are acceptable. The BWRVIP must obtain NRC approval for any changes that would prevent the possible testing of these surveillance material under the contingency plan.

Finally, if a BWR facility proposes to change its neutron fluence determination methodology, the facility must request approval from the NRC staff to determine its acceptability, determine whether the neutron fluence determination methodologies are compatible for use in the ISP(E) and determine if the methodologies have been or will be benchmarked against existing dosimetry data bases. The information submitted to the NRC staff must be sufficient for the staff to determine that:

(1) RPV and surveillance capsule fluences will be established as based on the use of an NRC-approved fluence methodology that will provide acceptable results based on the available dosimetry data, and

(2) if one methodology is used to determine the neutron fluence values for a licensee's RPV and one or more different methodologies are used to establish the neutron fluence values for the ISP(E) surveillance capsules which "represent" that RPV in the ISP, the results of these differing methodologies are compatible (i.e, within acceptable levels of uncertainty for each calculation).

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