February 1, 2002

Carl Terry, BWRVIP Chairman
Niagara Mohawk Power Company
Post Office Box 63
Lycoming, NY 13093

SUBJECT: SAFETY EVALUATION REGARDING EPRI PROPRIETARY REPORTS "BWR VESSEL AND INTERNALS PROJECT, BWR INTEGRATED SURVEILLANCE PROGRAM PLAN (BWRVIP-78)" AND "BWRVIP-86: BWR VESSEL AND INTERNALS PROJECT, BWR INTEGRATED SURVEILLANCE PROGRAM IMPLEMENTATION PLAN"

Dear Mr. Terry:

By letters dated December 22, 1999, and December 22, 2000, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted for staff review and approval the EPRI Proprietary Reports TR-114228, "BWR Vessel and Internals Project, BWR Integrated Surveillance Program Plan (BWRVIP-78)," and 1000888, "BWRVIP-86: BWR Vessel and Internals Project, BWR Integrated Surveillance Program Implementation Plan," respectively. These reports, along with BWRVIP responses (dated December 22, 2000, and May 30, 2001) to NRC staff requests for additional information (RAIs), described the technical basis for the development and implementation of an integrated surveillance program (ISP) intended to support operation of all U.S. BWR reactor pressure vessels (RPVs) through the completion of each facility's current 40-year operating license. The BWRVIP ISP 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 BWRVIP-78 report described the technical basis related to material selection and testing on which the proposed BWRVIP ISP was constructed. The report principally addressed the methodology established to identify existing plant-specific surveillance capsules and surveillance capsules from the Supplemental Surveillance Program initiated by the Boiling Water Reactors Owners' Group in the late 1980s, which contain important surveillance materials for inclusion within the ISP. In this case, "important" surveillance materials may be understood to be those which best represent the actual limiting (in terms of predicted fracture behavior) plate and weld materials from which BWR RPVs were constructed. The report also established the connection between the identified surveillance materials and the specific BWR RPV plate or weld materials which they represent and provided a proposed test matrix for the ISP. Proposed "surveillance material"-to-"limiting RPV material" relationships and the test matrix were subsequently revised in response to NRC staff questions.

The BWRVIP-86 report was submitted to follow up on the material presented in the BWRVIP-78 report by establishing specific guidelines for ISP implementation. The BWRVIP-86 report addressed determination of ISP surveillance capsule withdrawal and testing dates, information on ISP project administration, additional information on neutron fluence determination issues, additional information on data utilization and sharing, and information on licensing aspects of

ISP implementation. Information in this report, particularly that concerning determination of ISP surveillance capsule withdrawal and testing dates, was subsequently revised in response to NRC staff questions.

The NRC staff has completed its review of the BWRVIP-78 report, the BWRVIP-86 report, and the associated RAI responses. The staff finds that the final proposed BWRVIP ISP (as addressed in the attached safety evaluation) is acceptable for BWR licensee implementation provided that all licensees use one or more compatible neutron fluence methodologies acceptable to the NRC staff 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 implementation is necessary to ensure that data from surveillance capsules included in the ISP may be appropriately shared between BWR facilities and that the basis for the neutron fluence determined for 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.

Therefore, the proposed ISP, if implemented in accordance with the conditions in the attached safety evaluation, has been determined to be an acceptable alternative to all existing BWR plant-specific RPV surveillance programs for the purpose of maintaining compliance with the requirements of Appendix H to 10 CFR Part 50 through the end of current facility 40 year operating licenses. However, since implementation of the ISP may directly affect the licensing basis of every operating BWR in the U.S., licensees who elect to participate in the program will need to submit a license amendment to the NRC confirming their incorporation of the ISP into the licensing basis for each BWR facility. In addition, when these plant-specific license amendments are made, each licensee will be required to provide information regarding what specific neutron fluence methodology they will be implementing as part of their participation in the ISP. Each licensee will also be required to address the neutron fluence methodology compatibility issue as it applies to the comparison of neutron fluences calculated for its RPV versus the neutron fluences calculated for surveillance capsules in the ISP which are designated to represent its RPV.

Please contact Matthew A. Mitchell of my staff at (301) 415-3303 if you have any further questions regarding this subject.

Sincerely,

/ra/

William H. Bateman, Chief
Materials and Chemical Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

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U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION
SAFETY EVALUATION REGARDING EPRI PROPRIETARY REPORTS, "BWR VESSEL AND INTERNALS PROJECT, BWR INTEGRATED SURVEILLANCE PROGRAM PLAN (BWRVIP-78)" AND "BWRVIP-86: BWR VESSEL AND INTERNALS PROJECT, BWR INTEGRATED SURVEILLANCE PROGRAM IMPLEMENTATION PLAN"

1.0 INTRODUCTION

By letters dated December 22, 1999, and December 22, 2000, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted for staff review and approval the EPRI Proprietary Reports TR-114228, "BWR Vessel and Internals Project, BWR Integrated Surveillance Program Plan (BWRVIP-78)," and 1000888, "BWRVIP-86: BWR Vessel and Internals Project, BWR Integrated Surveillance Program Implementation Plan," respectively.[1,2] These reports, along with BWRVIP responses (dated December 22, 2000, and May 30, 2001) to NRC staff requests for additional information (RAIs), described the technical basis for the development and implementation of an integrated surveillance program (ISP) intended to support operation of all U.S. BWR reactor pressure vessels (RPVs) through the completion of each facility's current 40-year operating license.[3,4] The BWRVIP ISP was submitted under the regulatory provisions given in Appendix H to Title 10 of the Code of Federal Regulations Part 50 (10 CFR Part 50), Paragraph III.C., "Requirements for an Integrated Surveillance Program."

The BWRVIP-78 report described the technical basis related to material selection and testing on which the proposed BWRVIP ISP was constructed. The report principally addressed the methodology established to identify existing plant-specific surveillance capsules and surveillance capsules from the Supplemental Surveillance Program (SSP) initiated by the Boiling Water Reactors Owners' Group (BWROG) in the late 1980s which contain important surveillance materials for inclusion within the ISP. In this case, "important" surveillance materials may be understood to be those which best represent the actual limiting (in terms of predicted fracture behavior) plate and weld materials from which BWR RPVs were constructed. The report also established the connection between the identified surveillance materials and the specific BWR RPV plate or weld materials which they represent and provided a proposed test matrix for the ISP. Proposed surveillance material-to-limiting RPV material relationships and the test matrix were subsequently revised in response to NRC staff questions.

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ATTACHMENT

2.0 REGULATORY REQUIREMENTS AND BACKGROUND INFORMATION

2.1 Regulatory Requirements

Appendix G to 10 CFR Part 50, which is invoked by 10 CFR 50.60, specifies fracture toughness requirements for ferritic materials of pressure-retaining components of the reactor coolant pressure boundary, including reactor pressure vessels (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 (Appendix H), 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, licensees for all operating U.S. boiling water reactors (BWRs) have implemented plant-specific RPV material surveillance programs as part of each facility's licensing basis.

However, an 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, an RPV integrated surveillance program (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.

2.2 Additional Background Information

In early 1997, the NRC staff identified an issue with the existing Brunswick Unit 2 RPV surveillance program.[5] 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 (Browns Ferry Unit 3, Brunswick Units 1 and 2, Dresden Unit 2, Fermi Unit 2, FitzPatrick, Hatch Unit 1, LaSalle Unit 2, Limerick Units 1 and 2, Monticello, Nine Mile Point Unit 1, Oyster Creek, Quad Cities Units 1 and 2) 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.[1]

The NRC staff met with BWRVIP representatives on November 7, 1997, to discuss this issue and potential paths for its resolution.[6] 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. The BWRVIP-78 and BWRVIP-86 reports, as amended by BWRVIP responses to NRC staff RAIs, which were subsequently developed and submitted for NRC staff review and approval, were the result of the BWRVIP efforts in this area.

3.0 INDUSTRY EVALUATION

The information discussed in this section of the safety evaluation (SE) will address the technical and regulatory considerations addressed by the BWRVIP regarding the development of, and proposed implementation plan for, their BWR ISP. In response to NRC staff questions, substantial changes were made by the BWRVIP to the proposed ISP. Regarding specific provisions of the ISP, the information addressed in this section will reflect the final version of the ISP as contained in both the BWRVIP-78 and BWRVIP-86 reports, as well as information submitted in BWRVIP responses to NRC staff RAIs.

It should be noted that in addition to addressing the issue raised by the NRC staff regarding the lack of adequate unirradiated baseline CVN data, the BWRVIP proposed that their implementation of an ISP would also have additional benefits. The BWRVIP stated that when the original surveillance materials were selected for plant-specific surveillance programs, the state of knowledge concerning RPV material response to irradiation and post-irradiation fracture toughness 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. Second, the inclusion of data from the testing of BWROG SSP capsules

(discussed further in Section 3.1) will improve overall quality of the data being used to evaluate BWR RPV embrittlement. Finally, implementation of an ISP is also expected to reduce the cost of surveillance testing and analysis for the BWR fleet since surveillance materials that are of little or 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.

3.1 Surveillance Material Selection for the BWR ISP

The fundamental technical basis for the BWRVIP's approach to developing an ISP involves the BWRVIP's process for the selection of surveillance materials for inclusion in the ISP. This process was presented in the BWRVIP-78 report. First, the BWRVIP identified all available surveillance plate and weld materials which could potentially be used within the BWR ISP. This group of materials included all surveillance materials in existing U.S. BWR plant-specific surveillance programs and materials included in the BWROG's SSP.[7,8] The BWROG SSP was originally developed 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 NRC Regulatory Guide 1.99, Revision 2. 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, 13 different plate and 12 different weld materials were included in the BWROG SSP. Samples of these materials were fabricated into 84 sets of Charpy specimens and placed into 9 SSP surveillance capsules. Three of the SSP surveillance capsules were inserted into the Cooper RPV and six were inserted into the Oyster Creek RPV for irradiation. A complete listing of available U.S. BWR surveillance program and SSP materials, along with their respective copper and nickel weight percents, was provided in Tables 2-1 through 2-4 of the proprietary BWRVIP-78 report.

The next step in the BWRVIP process was to identify the limiting beltline materials (in most cases, one plate and one weld) for each operating U.S. BWR RPV based on the materials' projected level of embrittlement at the end of each facility's current operating license. The end of license (EOL) embrittlement projections were based on the available unirradiated material properties of each material (initial reference temperature), each materials' chemical composition (weight percent copper and nickel), and the projected neutron fluence at the 1/4-T depth for the highest fluence location for that material. Changes in material embrittlement as a result of irradiation were evaluated using the correlations in NRC Regulatory Guide 1.99, Revision 2. The limiting RPV materials were identified in Tables 2-5 and 2-6 of the BWRVIP-78 report for each operating U.S. BWR.

Based on the information discussed above, the BWRVIP program then sought to identify and associate available surveillance materials with RPV limiting materials. The concept employed by the BWRVIP was to assume that a set of approximately six "candidate" surveillance materials could be identified as matches for each BWR limiting material (also referred to as a "target material" in the matching process). These lists of candidate surveillance materials were provided in Appendix B, "Individual Vessel Evaluations," of the BWRVIP-78 report. Candidate materials were evaluated and identified based on a specific set of criteria which included:

a. How well does the copper content of the surveillance material match the copper content of the target material?

b. How well does the nickel content of the surveillance material match the nickel content of the target material?

c. Does the heat number of the surveillance material match the heat number of the target material?

d. Was the fabricator of the surveillance material the same as the fabricator of the target material?

e. Does the available unirradiated, baseline data for the surveillance material constitute a full CVN curve?

f. Is the candidate material a potential representative material for more than one target material?

From the list of candidate materials, one was selected as the "best representative" for a specific target material and included in an initial material list for the ISP. Each best representative material in this initial ISP material list was further required to have a full unirradiated baseline CVN curve and to be included in a sufficient number of surveillance capsules such that at least two irradiated CVN curves could be produced.

Working from this initial material list, the BWRVIP then used an iterative process to review the entire set of materials and make modifications to the ISP based on other considerations. The BWRVIP considered whether a single surveillance material could be used as the best representative material for a number of RPV limiting materials, thereby allowing for a reduction in the overall number of surveillance materials included in the ISP. If a particular surveillance material, which could serve as the best representative material for one or more RPV limiting materials, did not make the first draft of the ISP because of a lack of adequate unirradiated baseline CVN data, the BWRVIP considered whether actions could be taken to acquire such information. The BWRVIP also considered whether it was feasible to use both the surveillance weld and surveillance plate from a particular plant-specific surveillance program within the ISP. This was preferable since it reduced the overall number of surveillance capsules which would have to be removed and tested to support the ISP. Finally, although the ISP was not explicitly designed to address license renewal, the BWRVIP also considered whether additional capsules (beyond the minimum of two) were available for each material so that extension of the test matrix to higher neutron fluences was possible to address future license renewal surveillance program concerns.

After the best representative materials were selected, the BWRVIP sought to determine the specific time at which surveillance capsules incorporated within the ISP should be withdrawn and tested to optimize the usefulness of the data acquired. In any surveillance program, whether plant-specific or integrated, some degree of latitude exists in selecting the time when a particular capsule will be removed for testing. Usually, the time at which a capsule is to be withdrawn is selected based on comparing the neutron fluence level that the capsule is believed to have achieved (later confirmed by dosimetry wire measurements) to a fluence level of significance for the RPV material which it represents. For BWRs, the most significant issue related to RPV integrity evaluations is the development of pressure-temperature (P-T) limit curves in accordance with Appendix G to 10 CFR Part 50. P-T limit curves are indexed to the embrittlement of a RPV's limiting material at the 1/4-T and 3/4-T throughwall depths because of

the size of the postulated flaw used in the fracture evaluation associated with P-T limit curve determination. P-T limits curves may be defined for any period of operation (i.e., number of effective full power years (EFPY) of operation), but are commonly indexed to end of license (EOL) conditions and thereby bound operation of the vessel through EOL.

As a result of the BWRVIP ISP development process and NRC staff questions, the BWRVIP evaluated if it would be appropriate to acquire surveillance data points at or near the projected EOL 1/4-T neutron fluence values for limiting materials from the BWR fleet. Although the BWRVIP noted that no technical requirement exists for having capsules at the projected EOL RPV 1/4-T fluence level, it was acknowledged that the proposed withdrawal dates in Reference 4 would achieve a better consistency between capsule fluences and EOL RPV 1/4-T fluences than the withdrawal dates originally proposed in the BWRVIP-78 or BWRVIP-86 reports.

The information in Tables 4-1 through 4-5 of Reference 4 provided a complete overview of the ISP. Table 4-1 graphically showed the relationship between surveillance capsules and the target RPV welds or plates they are intended to represent. Table 4-2 provided similar information, but included details regarding the heat numbers for the ISP materials. Table 4-3 graphically showed the current projected withdrawal dates (years) for surveillance capsules included within the ISP, and Table 4-4 added information on which plant-specific capsules were associated with those withdrawal dates. Finally, Table 4-5 combined the information into a detailed test plan, which added information regarding the projected fluences of RPV limiting materials and the surveillance capsules that were intended to represent them.

3.2 Evaluation of ISP Compliance with Appendix H Criteria

After establishing a proposed set of surveillance materials for the ISP, the BWRVIP's development process then continued with the evaluation of whether the ISP complied with the requirements of Appendix H to 10 CFR Part 50. In order to assure that these requirements would be met, the BWRVIP considered the need to demonstrate the similarity of plant operating environments, the need for RPV neutron dosimetry program modifications or enhancements, contingency plan development, and data sharing arrangements. These specific topics were also considered to be directly related to the subject of ISP implementation, and information to address them was included not only in the BWRVIP-78 report but also in the BWRVIP-86 report.

On the topic of similarity of plant operating environments, the BWRVIP evaluation focused on consideration of operating temperatures and the neutron energy spectrums for the BWR fleet. The BWRVIP noted that normal operating temperatures in the downcomer region of BWRs range from 525 °F to 535 °F. 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 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.

Regarding the availability of dosimetry data and the ability to adequately determine both RPV surveillance capsule and BWR RPV fluences, several potential options were noted depending on what category a facility falls into. For the 13 BWRs that will continue to remove and test surveillance capsules as part of the ISP, there will be little or no change in the availability of dosimetry data. For those facilities that will not be testing capsules as part of the ISP, two current sources of dosimetry wire data may exist. First, a facility may have previously removed and tested one or more surveillance capsules, as would be the case for 15 BWRs, and have dosimetry data available from that capsule. For the remaining 6 BWRs, at a minimum, first cycle dosimetry data would exist. 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.

Regarding the criterion for adequate data sharing, the BWRVIP-78 and BWRVIP-86 reports commit 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. The BWRVIP-86 report, however, also identifies that each BWR facility will continue to demonstrate compliance with the requirements of Appendix H by reference to the ISP in facility Technical Specifications or Updated Final Safety Analysis Reports. As such, the individual BWR licensees who comprise the BWRVIP will continue to be subject to regulatory requirements that ensure that sharing of surveillance data will be achieved in order to support their continued compliance with the requirements of Appendices G and H to 10 CFR Part 50.

Regarding the need for contingency planning, the BWRVIP-78 report identifies several options that may be undertaken by the BWRVIP to ensure that adequate surveillance data continues to be obtained in the event of the indefinite shutdown of a facility that is supplying capsules for the ISP. First, consideration would be given to 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. This option highlights the inherent contingency plan which is available in the BWRVIP ISP. The work performed to develop the ISP 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.

The final criterion regarding the identification of substantial advantages to be gained as a direct result of implementation of the ISP, was addressed based on information previously noted in this SE. The ISP 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 an ISP 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 an ISP 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.

The BWRVIP also submitted information to address the positions raised in 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, all capsules that were previously credited as part of plant-specific surveillance programs will continue to be irradiated in their host reactors. Therefore, all irradiated material samples continue to remain available to the ISP, 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.

With regard to the number of specimens tested, the structure of all BWR plant-specific surveillance programs would have required, according to Table 3-1 of the BWRVIP-86 report, a total of 78 surveillance capsules to be tested (not including capsules that could be held as standby capsules per currently approved facility surveillance programs). With two applicable CVN specimen sets per capsule (one weld and one plate), this equates to a total of 156 irradiated CVN specimen sets to be tested under the current plant-specific programs. The ISP will incorporate 51 capsules from plant-specific surveillance programs (36 already tested and 15 yet to be tested) and 84 sets of CVN specimens from the SSP capsules. This equates to a total of 186 sets of irradiated CVN specimens to be tested under the ISP. Therefore, no reduction in the required amount of CVN testing would result from the implementation of the proposed ISP.

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

3.3 Additional Topics Regarding the ISP

Beyond the scope of the information discussed in Sections 3.1 and 3.2 of this SE, additional topics related to the proposed ISP were presented in the BWRVIP-78 and BWRVIP-86 reports. First, the topic of how the data acquired through the ISP would be utilized in plant-specific RPV integrity evaluations was discussed. The BWRVIP proposed that two options existed for facilities covered under the ISP. If the best representative surveillance material included in the ISP has the same material heat number as a facility's limiting RPV plate or weld, the data acquired as part of the ISP could be used to directly predict the embrittlement of the RPV material using the methodology outlined in Position C.2 of NRC Regulatory Guide 1.99, Revision 2. Any adjustments to the data required because of chemical compositional differences could be resolved based on the use of adjustment methodologies that have been

approved by the NRC staff. If the heat number of the best representative material does not match the heat number of a facility's limiting plate or weld, the licensee would utilize Position C.1 and the chemistry factor tables in NRC Regulatory Guide 1.99, Revision 2 as the basis for their RPV integrity evaluations. In this case, the data from the ISP surveillance program serves as a general method for monitoring RPV embrittlement for the facility, but does not provide the level of data compatibility necessary to make plant-specific integrity evaluations based on the use of Position C.2.

A second topic which was discussed involved plans for the overall administration of the ISP by the BWRVIP. The BWRVIP-86 report identifies specific activities relating to the administration of the ISP which will be performed by the BWRVIP. These activities include:

(1) Working with licensees to identify required capsule withdrawals so that the licensee can make necessary plans and arrangements,

(2) Shipping and testing of ISP capsules and associated dosimetry per applicable standards,

(3) Reporting the results of the surveillance specimen testing in a report as required by Appendix H to 10 CFR Part 50 within one year of the capsule withdrawal date,

(4) Distributing capsule reports to all licensees that have representative materials in the capsule,

(5) Planning for changes and contingencies in the ISP testing matrix,

(6) Consideration of surveillance needs for plant license renewal.

Of these items, (1), (2), and (3) are straightforward. Items (4) and (5), as they relate to data sharing and contingency planning, were discussed in Section 3.2. Planning changes to the ISP based on new information and/or consideration of license renewal needs will also be a significant function for the BWRVIP. The BWRVIP noted that periodic re-evaluations of the ISP test matrix will be performed based on new information such as updated fluence predictions for the BWR RPVs or for the ISP surveillance capsules. Minor changes may be required to surveillance capsule withdrawal dates based on these changing fluence predictions. When specific changes are identified to the ISP testing matrix, withdrawal schedule, or testing and reporting of individual capsule results, the BWRVIP committed to submitting these modifications to the NRC in a timely manner so that appropriate arrangements can be made for implementation.

Although the version of the ISP which is described by the BWRVIP-78 report, the BWRVIP-86 report, and associated RAI responses was not intended to address BWR surveillance program concerns through a period of extended operation, as noted in item (6) above, consideration has been given to being able extend the ISP at a later date. Based on the materials and surveillance capsules selected for inclusion in the ISP, a total of 13 additional surveillance capsules containing materials already in the ISP were identified as being specifically considered to address BWR license renewal concerns. In addition, 62 other deferred surveillance capsules would also be available if needed. The staff understands that the BWRVIP is currently engaged in developing a program plan for extending the ISP to cover license renewal issues and that a submittal to the NRC on this topic may be expected in 2002.

4.0 NRC STAFF EVALUATION

The NRC staff has reviewed the information submitted by the BWRVIP in References 1 through 4 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 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 5.0 of this SE, the proposed BWR ISP is acceptable. Additional details regarding the staff's evaluation of the ISP are provided below.

4.1 Surveillance Material Selection for the BWR ISP

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 and the proposed ISP capsule withdrawal schedule. 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 BWR RPV materials were included within the scope of the ISP. The criteria used (chemical composition, material heat number, fabricator, etc.) were consistent with 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) directly results in the ISP addressing the issue originally raised by the NRC staff with regard to Brunswick Unit 2. 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 Regulatory Guide 1.99, Revision 2, position C.2) of the surveillance data in determining the behavior of the RPV material. This topic is discussed further in Section 4.3 below. 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.

The staff has also reviewed the outcome of the BWRVIP material selection and surveillance capsule withdrawal date selection process. The outcome of this process was taken to be the surveillance materials selected for the ISP, the assignment of specific surveillance materials to represent specific BWR RPV limiting plates or welds, and the selection of surveillance capsule withdrawal dates (years) in order to achieve meaningful projected surveillance capsule fluence levels. The final version of this information was submitted to the NRC in Tables 4-1 through 4-5 of Reference 4. 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.

The staff did note, however, that one weakness existed regarding the proposed surveillance capsule withdrawal dates. Significant questions have been raised recently concerning the methodologies used to calculate BWR RPV neutron fluences. The staff is aware that the methodologies which have been used for this purpose prior to September 2001 would not conform to the recent NRC staff guidance published on this topic in NRC Regulatory Guide 1.190.[9] However, given that existing fluence predictions have been accepted in current facility licensing bases, the available projected neutron fluence values for the capsules and the BWR RPV limiting materials have been determined by the staff to be adequate for the purpose of establishing the initial withdrawal schedule for the ISP surveillance capsules. The staff expects that the BWRVIP will evaluate the need to modify the ISP surveillance capsule withdrawal schedule as it obtains additional results that may modify the information in Table 4-5 of Reference 4. The NRC staff's evaluation of dosimetry and neutron fluence calculation issues is addressed further in Section 4.2 below.

4.2 Evaluation of ISP Compliance with Appendix H Criteria

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

First, 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 accepts that no significant plant-to-plant difference in neutron energy spectra should be expected at similar BWR RPV wall or surveillance capsule locations based on current operating practice. The staff also accepts that the range of operating temperatures for the BWR fleet (525 °F to 535 °F) 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 NRC Regulatory Guide 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 the need for an adequate dosimetry program for each reactor participating in the ISP. 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 was sufficient to conclude that acceptable RPV fluence and surveillance capsule fluence values could continue to be determined given implementation of the ISP.

Currently, 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. Implementation of the ISP would ensure that facilities which supply surveillance capsules for the ISP will continue to obtain additional dosimetry data, while 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. For those facilities which supply capsules to the ISP, the amount of dosimetry data which will be obtained through participation in the ISP will be equal to or greater than the amount of data which would have been acquired as a result of continuing with a plant-specific surveillance program. Therefore, given that these facilities' current surveillance programs have 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. Finally, the dosimetry data from each surveillance capsule included in the ISP ensures that adequate dosimetry data is available for the determination of surveillance capsule fluences.

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. Currently, at least one NRC-approved neutron fluence determination methodology exists for BWRs which provides adequate results with little or no plant-specific dosimetry data.[10] Additional neutron fluence determination methodologies which may offer the same capability could be developed. Calculational methodologies have been, or will be, benchmarked against existing dosimetry databases to demonstrate their adequacy for determining BWR RPV fluences. Therefore, given the use of an acceptable methodology as described above, the NRC staff has concluded 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 will be sufficient to ensure that adequate RPV neutron fluence determinations continue to be performed.

Based on the information above, one condition of the NRC's approval of the ISP is that an individual BWR licensee who wishes to participate in the BWR ISP shall provide, for NRC staff approval, information that defines how it will determine RPV and/or surveillance capsule fluences based on the dosimetry data which will become available for its facility. The staff will require that this information be submitted concurrently with each licensee's submittal to replace their existing plant-specific surveillance program with BWR ISP as part of their facility's licensing basis. The information submitted 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 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).

Regarding the criterion of adequate data sharing between plants, 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 accepts the commitment by the

BWRVIP in the BWRVIP-78 and BWRVIP-86 reports to develop a "program plan to manage data sharing...in the implementation phase of the ISP." The NRC staff, however, would also note that by the incorporation of the ISP 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 data which may affect RPV integrity evaluations for their facility. Hence, after implementation of the ISP, a performance basis should become available from NRC staff licensing reviews to evaluate whether acceptable data sharing is occurring as part of the ISP.

Regarding the criterion for establishing a contingency plan to ensure that the ISP 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 has inherently established an adequate contingency plan. The evaluational work which was performed by the BWRVIP to select the "best representative" materials for inclusion in the ISP 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 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. Based on the availability of this information, and the periodic reviews to be conducted by the BWRVIP to assess whether any changes to the ISP are necessary, the NRC staff has concluded that the BWRVIP has adequately addressed the need to consider ISP contingency planning in its submittals.

The NRC staff also concluded that there are substantial advantages to be gained by the implementation of a BWR ISP. First, the proposed ISP program 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. Second, by not testing some existing plant-specific capsules as part of the ISP, 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 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 test matrix (without approval of the ISP, no requirement would exist for the testing of the SSP capsules). Other advantages of the ISP 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 that the proposed ISP complies with these provisions. The staff has concluded that the continued availability of all capsules which were previously credited as part of 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 ISP implementation. Further, based on a comparison of the number of irradiated CVN specimen sets which would be required under the current plant-specific surveillance programs versus the number which would be required to be tested under the ISP, the staff has concluded that no reduction in the required amount of CVN

testing would result from the implementation of the proposed ISP (which, as noted previously, includes the SSP capsule materials which were not incorporated into any plant-specific surveillance program).

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.

4.3 Additional Topics Regarding the ISP

The NRC staff also reviewed the other topics regarding the ISP which were addressed in the BWRVIP-78 and BWRVIP-86 reports. The staff has concluded that the BWRVIP proposal for how surveillance data resulting from the ISP may be used to support BWR RPV fracture toughness (integrity) evaluations was acceptable. Consistent with current practice based on the use of data from plant-specific surveillance programs, data which is to be used directly (see position C.2. of NRC Regulatory Guide 1.99, Revision 2) to modify RPV integrity evaluations should come from surveillance material samples with the same heat number as the limiting RPV material. 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 program 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 NRC Regulatory Guide 1.99, Revision 2 should be used.

Finally, regarding the objectives and actions submitted related to BWRVIP administration of the ISP, the NRC staff agrees with the provisions set forth in the BWRVIP-78 and BWRVIP-86 reports. The staff has concluded that the BWRVIP should conduct periodic re-evaluations of the ISP test matrix based on new information such as updated fluence predictions for the BWR RPVs or for the ISP surveillance capsules. The BWRVIP shall submit any changes regarding the ISP testing matrix, withdrawal schedule, or testing and reporting of individual capsule results to the NRC for review and approval prior to implementing these changes. Further, the BWRVIP will perform testing and submit surveillance capsule reports to the NRC in accordance with the provisions found in Appendix H to 10 CFR Part 50 on behalf of BWR licensees. This is acceptable to the NRC staff. However, with regard to the application of test data acquired though the ISP, individual BWR licensees must retain the responsibility for addressing the implication of ISP surveillance capsule results to the RPV integrity evaluations for their RPVs. These revised RPV evaluations must be conducted by individual BWR licensees in a timely manner to ensure they maintain compliance with the requirements of Appendix G to 10 CFR Part 50.

5.0 CONCLUSIONS

The NRC staff has concluded that the ISP proposed by the BWRVIP in the BWRVIP-78 report, the BWRVIP-86 report, and as amended by responses dated December 22, 2000 and May 30, 2001, to NRC staff RAIs, is acceptable, subject to the conditions discussed below. The approved ISP adequately addresses the requirements of Appendix H to 10 CFR Part 50 for BWR licensees through the end of current facility 40 year operating licenses. In particular, the information contained in Tables 4-1 through 4-5 of Reference 4, was found by the staff to be

acceptable for defining the ISP test matrix, surveillance capsule withdrawal dates, and material associations for the BWR ISP. Other aspects of the ISP, 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 is further predicated on the adoption of the ISP by all BWR facilities who are identified within the ISP test matrix as supplying surveillance capsules for the ISP. If any BWR licensee which should be providing surveillance capsules to the ISP elects not to participate, the BWRVIP must submit, for NRC staff review and approval, changes to the ISP that must be made to address this event.

Finally, in order to complete ISP implementation, individual BWR licensees who wish to participate in the BWR ISP must provide, for NRC staff review and approval, information which defines how they will determine RPV and/or surveillance capsule fluences based on the dosimetry data which will be available for their facilities. This information must be submitted concurrently with each licensee's submittal to replace their existing plant-specific surveillance program with the BWR ISP as part of their facility's licensing basis. The information submitted 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,

(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 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).

6.0 REFERENCES

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