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Attention: Meena Khanna

Subject: Project No. 704 – BWRVIP-86-A-NP: BWR Vessel and Internals Project, Updated BWR Integrated Surveillance Program (ISP) Implementation Plan

Reference: Letter from Carl Terry (BWRVIP Chairman) to Document Control Desk (NRC), "Project No. 704 – BWRVIP-86-A: BWR Vessel and Internals Project, Updated BWR Integrated Surveillance Program (ISP) Implementation Plan," dated November 12, 2002.

Enclosed are ten (10) copies of a non-proprietary report entitled "BWRVIP-86-A-NP: BWR Vessel and Internals Project, Updated BWR Integrated Surveillance Program (ISP) Implementation Plan," EPRI Technical Report 1003346, September 2004. The enclosed report is a non-proprietary version of the BWRVIP-86-A report transmitted to the NRC by the letter referenced above.

If you have any questions on this subject please contact Bob Carter at EPRI by telephone at 704.547.6019.

Sincerely,

William A Eaton

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D058

BWRVIP-86-A-NP: BWR Vessel and Internals Project Updated BWR Integrated Surveillance Program (ISP) Implementation Plan

Technical Report

BWRVIP-86-A-NP: BWR Vessel and Internals Project

Updated BWR Integrated Surveillance Program (ISP) Implementation Plan

1003346NP

Final Report, September 2004

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This report is based on the following previously published reports:

"BWR Vessel and Internals Project, BWR Integrated Surveillance Program Plan (BWRVIP-78)", EPRI Report TR-114228, December 1999, authored by ATI Consulting and GE Nuclear Energy, principle investigators T.J. Griesbach and B.J. Branlund.

"BWRVIP-86: BWR Vessel and Internals Project, BWR Integrated Surveillance Program Implementation Plan", EPRI Technical Report 1000888, December 2000, authored by ATI Consulting, principle investigators T.C. Hardin and T.J. Griesbach.

PRODUCT DESCRIPTION

This report describes the boiling water reactor (BWR) Integrated Surveillance Program (ISP). Based on recommendations from BWR Vessel and Internals Project (BWRVIP) utilities, it was concluded that combining all separate BWR surveillance programs into a single integrated program would be beneficial. In the integrated program, representative materials chosen for a specific reactor pressure vessel (RPV) can be materials from another plant surveillance program or other source that better represents the limiting materials. The basis for the integrated program was established in BWRVIP-78 (EPRI report TR-114228), and the implementation plan was given in the previous edition of BWRVIP-86 (1000888). Some aspects and details of the program as outlined in both documents were subsequently modified during the regulatory review process. This document consolidates the fundamental information given in both reports with appropriate updates to reflect the final approved form of the ISP.

Results & Findings

In current U.S. BWR surveillance programs, 42 capsules remain to be tested through the end of original plant license dates. Evaluations performed as part of the ISP demonstrate that representative materials can be consolidated into 15 remaining untested capsules plus 9 capsules from the Supplemental Surveillance Program (SSP).

Challenges & Objectives

The objectives of this project were to define an integrated surveillance program that meets the requirements of 10CFR50, Appendix H; to identify specific capsules to be tested for the ISP and a schedule for testing; and, to define the plan for ISP test data sharing and utilization. The integrated program improves the quality of BWR surveillance data and results in a significant cost savings to the BWR fleet. Full participation by all U.S. BWRs ensures that the ISP will provide the necessary data to properly monitor changes in embrittlement of the RPVs.

Applications, Values & Use

Data obtained from future capsules, plus data from prior tested capsules, will be shared collectively to fulfill 10CFR50 Appendix H requirements for surveillance monitoring as an Integrated Surveillance Program for BWR vessels. The ISP has been designed for BWR vessels through the end of the current license period. The program also can address surveillance needs for license renewal.

EPRI Perspective

Neutron irradiation exposure reduces the toughness of reactor vessel welds and base metals. Accurate methods for monitoring and predicting embrittlement are important for establishing plant operating pressure-temperature limits and pressure test temperatures. They also are critical for evaluating the remaining life of RPV materials. The ISP will result in significant cost savings to the BWR fleet and will provide more representative monitoring of embrittlement in vessel-limiting materials than current programs.

Approach

The project team collected available BWR reactor vessel fabrication records, surveillance program results, and the current status of each BWR surveillance program. They updated the ISP matrix presented in BWRVIP-78 and the previous edition of BWRVIP-86 to address NRC staff comments and recommendations. From the revised matrix, the team developed a detailed ISP test plan, associating each plant's limiting materials with representative materials in ISP capsules. A withdrawal/testing schedule was developed for the ISP plant capsules to provide for integration of SSP capsule test data within the next few years and optimal ISP capsule testing thereafter. Researchers developed ISP project administration and management responsibilities for capsule testing, reporting, data sharing, and utilization, along with a plan for incorporating the ISP in each plant's licensing basis.

Keywords

Reactor pressure vessel integrity
Reactor vessel surveillance program
Radiation embrittlement
Boiling water reactor
Charpy testing
Mechanical properties

RECORD OF REVISIONS

Revision Number	Revisions
BWRVIP-86	Original Report (1000888)
BWRVIP-86-A	Report 1000888 was revised to incorporate changes proposed by the BWRVIP in responses to NRC Requests for Additional Information, recommendations in the NRC Safety Evaluation (SE), and other necessary revisions identified since the last issuance of the report. All changes except corrections to typographical errors are marked with margin bars. In accordance with a NRC request, the NRC SE is included here as an appendix and the report number includes an "A" indicating the version of the report accepted by the NRC staff. Non-essential format changes were made to comply with the current EPRI publication guidelines. Appendix B added: NRC Final Safety Evaluation Details of the revision can be found in Appendix C.

ABSTRACT

This report describes the Integrated Surveillance Program (ISP) for monitoring radiation embrittlement of BWR reactor pressure vessels (RPVs).

Each U. S. BWR has a surveillance program for monitoring the changes in RPV material properties due to neutron irradiation. These programs consist of surveillance capsules installed inside the RPV that include specimens from RPV plate, weld and heat affected zone materials. These specimens are removed at periodic intervals, tested and analyzed to monitor the radiation embrittlement of the RPV. Each BWR has its own surveillance program and the specimen selection, testing, analysis and monitoring is conducted on a plant-specific basis.

Because U. S. BWRs were licensed over a period of years, the requirements and content of the individual surveillance programs vary. For example, as a result of changes to industry standards and NRC regulatory guidance, some plants do not have surveillance specimens for the limiting RPV plate or weld material. In 1998, the BWR Vessel and Internals Project (BWRVIP) developed an Integrated Surveillance Program (ISP) using similar heats of materials in the surveillance programs of BWRs to represent the limiting materials in other vessels and improve the monitoring of embrittlement in BWR vessels. The ISP combines all the separate U. S. BWR surveillance programs into a single integrated program and adds data from the ongoing Supplemental Surveillance Program (SSP). The ISP has been designed to meet the criteria for an integrated surveillance program in 10CFR50 Appendix H. The BWRVIP submitted a report in 1999 (BWRVIP-78) to describe the technical basis of the ISP related to material selection and the testing matrix. The previous edition of BWRVIP-86 addressed the implementation plan for the ISP and testing schedule, with additional revisions to the testing matrix. During the regulatory review process some aspects of both documents (e.g., the test matrix and schedule) were modified to facilitate regulatory approval, and all modifications are included in this report.

A test matrix was developed to identify those specimens that best meet the needs of each BWR. The materials for the ISP were specifically chosen to best represent the limiting plate and weld materials for each plant using specimens from the entire BWR fleet. Specimens that provide little or no added value are not included and need not be tested because other materials in the integrated program provide better quality and more representative data.

This report identifies the test matrix of capsules containing the representative weld and plate materials and the planned schedule for withdrawal and testing. The ISP will replace the existing material surveillance monitoring programs with an integrated program using host reactor capsules containing the selected representative materials. This report also describes methods of data evaluation and utilization for implementation through the BWRVIP. Under the ISP, fewer capsules will be tested but the quality of data gained from those tests will

provide greater understanding of BWR vessel embrittlement than do the existing programs. The BWRVIP will share data from the host capsules with all participants. The greater efficiency that is inherent in the ISP will result in significant cost savings to the BWR fleet.

ACRONYMS, ABBREVIATIONS, AND DEFINITIONS

10CFR50 Appendix H	Appendix H to Part 50 of Title 10 of the Code of Federal Regulations, "Reactor Vessel Material Surveillance Program Requirements"
Adjusted Reference Temperature	(ART) The reference temperature adjusted for irradiation effects by adding to the initial RT_{NDT} the transition temperature shift (due to irradiation) and an appropriate margin
ASME Code	American Society of Mechanical Engineers Boiler and Pressure Vessel Code
ASTM E-185	American Society for Testing and Materials E-185, "Standard Practice for Conducting Surveillance Tests for Light-Water Cooled Nuclear Power Reactor Vessels"
Associated Material	An ISP candidate surveillance material which is given consideration because it has a good fluence match to a target (vessel limiting material), even though it may have a less representative chemistry match.
BWR	Boiling Water Reactor
BWROG	BWR Owners' Group
BWRVIP	BWR Vessel and Internals Project
Capsule Set	A capsule set includes three or more capsules installed in a plant
EFPY	Effective full power year
ESW	Electroslag Weld
EOL	End-of-license
Existing Surveillance Program	The set of surveillance capsules that were installed when each BWR was licensed. The surveillance capsules typically include specimens for plate, weld, and heat affected zone (HAZ) materials. The test results from the specimens are to be used for monitoring radiation embrittlement for the plant.

Full Charpy Curve	A Charpy curve based on Charpy tests of 8 or more specimens that are tested over a broad range of temperatures so that the shape of the curve can be clearly defined.
HAZ	Heat Affected Zone
ISP	BWR Integrated Surveillance Program
IVE	Individual Vessel Evaluation
Limiting material	The reactor vessel beltline material judged most likely to be controlling with regard to radiation embrittlement, based on calculation of the adjusted reference temperature (ART) defined by Reg. Guide 1.99 using best estimate chemistries and projected EOL fluence estimates.
MLE	mils Lateral Expansion
Reg. Guide 1.99	USNRC Regulatory Guide 1.99, Revision 2, "Radiation Embrittlement of Reactor Vessel Materials"
Representative Material	A plate or weld material that is selected from among existing surveillance programs or the SSP to represent the corresponding limiting plate or weld material in a plant.
Representative Data Set	The data set from the Charpy Impact test of the representative material that consists of three Charpy curves: 1) unirradiated, 2) 1st irradiated, and 3) 2nd irradiated.
RPV	Reactor Pressure Vessel
SAW	Submerged Arc Weld
SMAW	Shielded Metal Arc Weld
SRM	Standard Reference Material is a material used to provide an independent check on the measurement of irradiation conditions for the surveillance materials.
SSP	BWR Supplemental Surveillance Program
USE	Upper Shelf Energy

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1 INTRODUCTION

Neutron irradiation embrittlement of U.S. boiling water reactor (BWR) vessel beltline materials is currently monitored by a set of surveillance capsules placed in each individual reactor. Each reactor plant is responsible to periodically withdraw a capsule and test its material specimens. The irradiation-induced shift in the material properties of the capsule test specimens is used as an indication of embrittlement in the reactor vessel itself, which cannot be tested directly.

The BWR Vessel and Internals Project (BWRVIP) utilities concluded that an integrated surveillance program would provide significant benefits over the current individual programs. Report BWRVIP-78 [Reference 1] provided the program plan for an Integrated Surveillance Program (ISP) for the BWR fleet in the U.S. The two primary benefits of the ISP are that the quality of BWR surveillance data is improved and overall costs to the BWR fleet are reduced.

The U.S. NRC Staff reviewed BWRVIP-78 and issued a Request for Additional Information (RAI) [2]. The BWRVIP provided a written response [3] and also issued Report BWRVIP-86 [4]. BWRVIP-86 made additional refinements to the Program Plan outlined in BWRVIP-78, addressed NRC Staff comments from the first RAI, and presented the Implementation Plan and testing schedule for the ISP. A second RAI [5], addressing additional NRC Staff questions and recommendations regarding both reports, and the BWRVIP's response [6] ultimately led to the US NRC issuance of a Safety Evaluation (SE) [7] regarding the BWR ISP.

This document provides a summary of both the Program Plan (BWRVIP-78) and the Implementation Plan (BWRVIP-86) in order to incorporate the final changes made to those reports as a result of the regulatory review and approval process. This report will recap some of the more significant background and developmental information from reports BWRVIP-78 and BWRVIP-86, but emphasis in this document is given to description of the final approved form of the BWR ISP and its implementation.

2
BACKGROUND

2.1 Historical Background

A reactor pressure vessel (RPV) surveillance program is intended to monitor the changes in vessel material properties due to neutron irradiation. In July 1973, the Code of Federal Regulations, 10CFR50, Appendix H [8], established the first legal requirements for comprehensive surveillance programs in nuclear plants. Plants already licensed prior to that time had installed irradiation test samples using the guidance of the 1961 (tentative), 1962, 1966, 1970 or the then-emerging 1973 version of ASTM E-185 [9]. Today, reactor pressure vessels that exceed a peak neutron fluence of 10^{17} n/cm^2 at the end-of-license are required to have an RPV material surveillance program that monitors radiation embrittlement in accordance with 10CFR50 Appendix H.

Currently, each BWR plant has an existing surveillance program that includes weld and plate materials. However, many plants do not have a surveillance material that represents the limiting plate and/or weld material of the RPV, and there are two reasons for this. First, many of the surveillance programs were implemented prior to the establishment of 10CFR50 Appendix H, and there were no specific requirements to choose materials that represent the limiting beltline material for plants built prior to 1973. Second, for some plants, a revision to Reg. Guide 1.99 [10] resulted in a change in the limiting beltline material for that vessel.

In addition, some plants have limited or no unirradiated surveillance specimen data. For some plants, the unirradiated specimens were misplaced. The unirradiated data is needed to measure the irradiation shift of the tested surveillance materials.

Given the limitations in the existing plant surveillance programs, a program was introduced in the late 1980s to obtain additional BWR surveillance data on well-characterized BWR vessel materials. That program is called the Supplemental Surveillance Program (SSP) [11, 12]. The SSP was designed to supplement the available vessel embrittlement database and to examine BWR specific irradiation trends. Selecting materials that are suitable for a fleet-wide correlation also results in a selection of materials representing a broad range of BWR fleet RPV materials chemistry. The SSP fills in gaps in the existing plant surveillance programs to match the BWR fleet limiting beltline materials. The scope of the SSP includes 84 sets of BWR Charpy specimens that represent both BWR plate and weld materials. In fact, most of the materials in the SSP are actual BWR vessel archive materials. Each of the 84 sets also has an excellent set of unirradiated data.

2.2 Development of the ISP

The BWR ISP was conceived as a program that combines surveillance materials from the existing programs and materials from the SSP to make sufficient materials available to improve compliance with 10CFR50 Appendix H. Instead of using the plant-specific surveillance data from a given plant, the data from all BWR surveillance programs has been evaluated to select the "best" representative material to monitor radiation embrittlement for that plant. Selection of the best representative materials for a particular plant considers heat number, similar chemistries, common fabricator, and the availability of unirradiated data. In matching the available surveillance plates and welds, some capsule materials are good representatives for the limiting materials of multiple plants. As a result, the ISP results in better representation of the limiting beltline materials for each plant, while reducing the number of capsules to be tested. The withdrawal schedule for the capsules not chosen as ISP capsules will be deferred indefinitely. Therefore, the cost of the ISP will be reduced compared to the existing surveillance programs for the BWR fleet.

Development of the ISP consisted of the following general activities:

- Identification of the limiting materials in each reactor vessel that the program would be designed to monitor
- Selecting the best surveillance material from all available candidates to represent each limiting material
- Developing a schedule for withdrawing and testing the ISP capsules (i.e., those capsules containing the best representative materials selected in the previous activity); and,
- Developing a program management plan that defines responsibilities, provides for timely reporting and data sharing, and ensures periodic program reevaluation and update.

The first activity (identifying limiting materials) was documented in BWRVIP-78; a summary discussion of method and results is provided in Section 3, which also provides a survey of all available BWR surveillance materials. Selection of the best representative materials is described in Section 4.1. The schedule for withdrawal of ISP capsules is discussed in Section 4.2, and program management is discussed in Section 5.

2.3 Benefits of the ISP

The BWR ISP offers many advantages compared to the existing BWR capsule programs. The integrated program is based on those capsules that best meet the needs of the BWR fleet. The benefits of the ISP to the BWR fleet are as follows:

- Improve compliance for each plant with the current version of 10CFR50 Appendix H [8] and ASTM E-185 [9].
- Better matching capsule data to the limiting materials for each plant
- Sharing BWR data within the BWR fleet

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

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

2.4 Review of Definitions Used in the ISP

For ease of reference, the definitions of two fundamental terms used in the ISP are reviewed below. The ISP has identified a "representative material" from the materials in the entire fleet of BWR surveillance capsules to best represent the limiting material in each plant. It is an objective of the ISP testing program to obtain a "representative data set" for each representative material. BWRVIP-78 [1] definitions of these terms are reiterated below.

2.4.1 Representative Materials

A representative material is a plate or weld material that is selected from among all the existing plant surveillance programs or the SSP to represent the corresponding limiting plate or weld material in a plant. The choice of a representative material considers chemistry (%Cu and %Ni), heat number, fabricator and welding process as it represents the plants' limiting materials.
The "best" representative material is a material that has the following three qualities: 1) a good or excellent chemistry match, 2) the same welding process (if a weld) and fabricator, and 3) results in optimal consolidation of the test matrix (i.e., a candidate is better if it is capable of representing a number of plants rather than just one plant). In choosing a representative material, the availability of a plant capsule for license renewal is also considered.

2.4.2 A Representative Data Set for the Limiting Plate or Weld Material

A representative data set for the limiting plate or weld material consists of three Charpy curves: 1) unirradiated, 2) 1st irradiated and 3) 2nd irradiated. The Charpy specimens used to develop the curves are of the same heat with the same orientation (either transverse or longitudinal) and irradiated in the same plant. The source of the unirradiated data set can be from a BWR, the SSP or other source. The source of the irradiated data set can only be from existing BWR capsules or SSP capsules. Each curve should be based on Charpy tests of 8 or more specimens that are tested over a broad range of temperatures so that the shape of the curve can be clearly defined (this is called a full Charpy curve). At a minimum, these temperatures should be chosen to define the 30 ft-lb and 50 ft-lb Charpy impact energy, 35 mils Lateral Expansion (MLE) and the Upper Shelf Energy (USE). Unirradiated and irradiated data that can be used to develop a full Charpy curve and has a defined chemistry is considered "good quality data." An illustration of a representative data set (full Charpy curve) is shown in Figure 2-1 below.

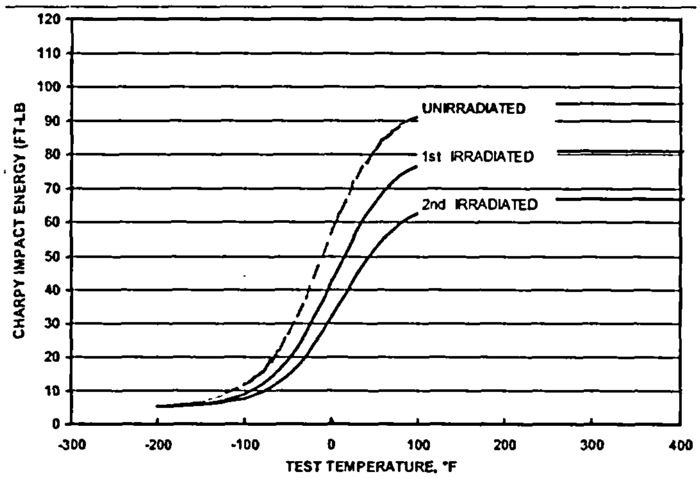

Figure 2-1
Representative Data Set

3 STATUS OF EXISTING BWR SURVEILLANCE PROGRAMS

3.1 Overview of BWR Surveillance Data

As part of the development of the ISP implementation plan, the BWRVIP conducted a survey of U.S. BWRs. The purpose of the survey was to document the current (pre-ISP) status of capsule testing, i.e., number of capsules remaining, current withdrawal schedule, intentions to seek deferrals, and related information. The survey was distributed to BWRVIP members in June 2000 requesting verification of plant specific surveillance capsule information, confirmation of licensing commitments in plant Technical Specifications or UFSARs, explanation of unique aspects of surveillance monitoring to address issues other than reactor vessel integrity, determination of the basis and EFPY for current pressure-temperature limit curves, and understanding the status of vessel fluence calculations. The data gathered from this survey was used to substantiate or update the plant data in the BWRVIP-78 report. Applicable results of the survey are presented below.

3.1.1 BWR Capsules and Vessel Materials

For existing (pre-ISP) surveillance programs, each plant has established a withdrawal schedule for its capsules consistent with 10CFR50 Appendix H [8]. BWR vessels were built with at least three capsules provided near the RPV wall. Several plants (e.g., Browns Ferry 2, Dresden 2 and 3) were provided with a complement of more than three surveillance capsules. Four plants (Dresden 2 and 3 and Quad Cities 1 and 2) have near-core capsules as well as wall capsules. As discussed in the BWRVIP-78 report, near-core capsules are not included in the ISP.

In general, the first two capsules are scheduled for removal during the plant life and are used for monitoring radiation embrittlement. The third capsule is scheduled for removal at End-of-License (EOL) and may be held without testing or used for the purpose of license renewal.

In addition to the typical allotment of three surveillance capsules, at least eight plants have reconstituted previously-tested surveillance specimens and reinserted the capsules: Duane Arnold, FitzPatrick, Hatch 2, Nine Mile Point 1, Perry, Susquehanna 1 and 2, and Columbia Generating Station (formerly WNP-2). The ISP regards these reconstituted/reinserted capsules as Standby capsules.

The status of existing (pre-ISP) programs is summarized in Table 3-1. The table shows actual and planned withdrawal dates (in Effective Full Power Years [EFPY]) together with the fluence of the capsule withdrawn and planned EFPY for future capsule withdrawals. In general, third (e.g., 32 EFPY), fourth and reconstituted/reinserted capsules (where applicable) are shown as Standby (SB) capsules, unless the utility survey response indicated a definitive intention or commitment to withdraw a third or fourth capsule at a specific EFPY prior to 32 EFPY.

A total of 42 capsules are scheduled for future withdrawal and testing under the existing surveillance programs. Thirty-six capsules have been tested and 49 are available as Standby capsules. Therefore, there is a total set of 127 tested, future and Standby capsules. The identities of all surveillance materials contained in the capsules are provided in Tables 3-2 (plate surveillance materials) and 3-3 (welds).

As discussed in BWRVIP-78, the ISP team also confirmed the limiting beltline materials for each BWR vessel – i.e., the limiting beltline weld heat and limiting beltline plate heat. For each vessel, a short list of candidate limiting materials were evaluated to identify the heat(s) with the highest Adjusted Reference Temperature (ART) using the embrittlement correlations of Regulatory Guide 1.99, Revision 2 for the end of license embrittlement condition (EOL fluence). The ISP team's results were then confirmed or reconciled with the utility's calculation. The limiting plate and weld materials for each BWR vessel are shown in Tables 3-4 and 3-5, respectively.

3.2 Supplemental Surveillance Program (SSP) Data

The Supplemental Surveillance Program (SSP) is an important source of high-quality surveillance data for use in the ISP. Background information on the SSP and the reasons for including its materials in the ISP are discussed below.

The BWR Owners' Group (BWROG) initiated the Supplemental Surveillance Program (SSP) in the late 1980s to obtain additional BWR surveillance data [11, 12]. The purpose of the program was to supplement the available vessel embrittlement data so that an irradiation shift correlation could be developed specifically for BWR vessels as an alternative to Reg. Guide 1.99. Selecting materials that are suitable for a fleet-wide correlation also results in a selection of materials representing a broad range of BWR fleet chemistry. Although it was not the original intention of the SSP, this selection of materials is exactly what is needed to complement the existing plant surveillance programs to better match the BWR fleet limiting beltline materials. The SSP specimens are superior to the existing surveillance program specimens for several reasons:

1. Unirradiated data - Unirradiated Charpy specimens for each of the materials were fabricated from the same plate and under the same conditions as the irradiated specimens. The unirradiated specimens were tested at the initiation of the program.

2. Chemical composition - A broken unirradiated Charpy specimen half of each material was tested for carbon, manganese, phosphorus, sulfur, silicon, nickel, molybdenum, and copper.

3. Dosimetry – Neutron fluence monitors are included in each capsule so that fast flux and fast fluence of each specimen set can be individually determined. Each monitor is sensitive to a specific neutron energy range and increased accuracy in a flux-spectrum is achieved by the use of several monitors (up to eleven different types of flux wires).

4. Temperature Monitors – The inherent operating nature of the BWR, with temperature related directly to pressure according to the steam saturation relationship, makes the vessel wall temperatures quite constant, even from plant to plant. The annulus between the vessel wall and the core shroud in the region of the surveillance capsules contains a mix of water returning from the core and feedwater. Depending on the feedwater temperature, this annulus region is between 525°F and 535°F. Therefore, five (5) temperature monitors were designed to melt at temperatures within the range of 504°F and 580°F.

5. Flux/Fluence – The capsules were irradiated to target the BWR fleet mid- to end-of-license fluence ranges.

6. Standard Reference Material (SRM) – A SRM was added to the SSP to provide an independent check of the measurement of irradiation conditions for the surveillance materials. The material used in this program is HSST-02. This material could also be used to validate the assumptions regarding flux and fluence.

Twenty-five materials were selected for the SSP: 13 plate materials and 12 weld materials. A total of 84 sets of Charpy test specimens from these materials were inserted in nine capsules for irradiation in two host BWR reactors (Cooper and Oyster Creek). The nine capsules are identified as SSP-A through SSP–I. Table 3-6 provides an inventory of SSP materials by capsule.

All nine SSP capsules will be tested under the ISP. All six capsules that were in Oyster Creek – Capsules D through I - have been withdrawn and tested. Capsules A, B, and C (the Cooper capsules) are scheduled to be withdrawn and tested in 2003.

Although all SSP materials will be tested and added to the BWR material irradiation database, only ten of the 25 materials (4 plate heats and 6 weld heats) are formally used in the ISP Test Matrix as representative materials. Table 3-7 lists the ten SSP materials used in the ISP matrix and shows the specific SSP capsules in which these ten materials are located.

Table 3-1
Schedule of Existing BWR Surveillance Capsules

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Table 3-2
BWR Surveillance Capsule Plate Materials and Chemistry

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Table 3-3
BWR Surveillance Capsule Weld Materials and Chemistry

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Table 3-4
Limiting BWR Vessel Plate Materials

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Table 3-5
Limiting BWR Vessel Weld Materials

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Table 3-6
Supplemental Surveillance Program (SSP) Specimen Matrix

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Table 3-6
Supplemental Surveillance Program (SSP) Specimen Matrix (Continued)

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Table 3-6
Supplemental Surveillance Program (SSP) Specimen Matrix (Continued)

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Table 3-7
Capsule Locations of the SSP Materials Used in the ISP

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4 ISP CAPSULE IRRADIATION, WITHDRAWAL AND TESTING

4.1 ISP Test Matrix

Section 3 of this report identified the BWR vessel limiting materials; it also identified all available BWR surveillance materials. The next step in development of the ISP is to select the best representative surveillance material for each vessel limiting material (or "target" materials).

The initial process used to develop the ISP test matrix was described in Section 2.4 of BWRVIP-78. Criteria were established, based on a technical understanding of radiation damage mechanics, to identify surveillance materials that would best represent the limiting plate and weld materials. Criteria included chemical composition, material heat number, and fabricator. A list of candidates (usually six) best meeting these criteria was made for each target (vessel limiting material). Other factors were then considered, such as the availability of complete baseline (unirradiated) Charpy curve data and whether or not a candidate was a good representative for many other targets. Finally, from the list of candidates a single representative material was selected, based on all factors.

This process was originally documented in the Individual Vessel Evaluations (IVEs) in Appendix B of BWRVIP-78. During the regulatory review and approval process, some changes were made to the ISP test matrix. The attached Appendix A provides updated IVEs which reflect the ISP test matrix [6] approved by Reference 7. In a few IVE tables, an "associated material" has been added to the list of candidate representative materials. These "associated materials" address an NRC staff recommendation [5] to identify materials which, although they may not be the best chemistry match, are given consideration because they provide better fluence matches to the target RPV materials.

The ISP test matrix identifies the surveillance capsule set(s) that provide representative materials for each plant's limiting plate and weld materials. The ISP test matrix is shown in Table 4-1. Rows represent surveillance capsule sets and columns represent the vessel limiting plate and weld materials. The capsule set(s) chosen as representative for a vessel's limiting weld or plate is marked with a shaded box under the appropriate column. The identity of the representative capsule set can be read on the left column row headings.

Table 4-1 provides a general representation of the ISP test matrix that associates vessels to representative capsule sets. However, it is the association of a specific material heat number within each capsule set that defines the detailed ISP test matrix, which is provided in Table 4-2. The content of ISP test matrix in Table 4-2 is identical to that provided to the NRC in [6] and subsequently approved by the Safety Evaluation [7].

The ISP matrix will be re-evaluated periodically based on new information such as updated fluence evaluations, and, where changes to the matrix are warranted, they will be submitted to the NRC for approval prior to implementation.

Table 4-1
ISP Test Matrix

TARGET VESSEL WELDS AND PLATES

SURVEILLANCE CAPSULES	Brown Ferry 2 weld	Brown Ferry 2 Plate	Brown Ferry 3 weld	Brown Ferry 3 Plate	Brunswick 1 weld	Brunswick 1 Plate	Brunswick 2 weld	Brunswick 2 Plate	Clinton weld	Clinton Plate	Cooper Weld	Cooper plate	Dresden 2 weld	Dresden 2 Plate	Dresden 3 weld	Dresden 3 Plate	Duane Arnold weld	Duane Arnold plate	Enrico Fermi 2 weld	Enrico Fermi 2 plate	FitzPatrick weld	FitzPatrick plate	Grand Gulf Weld	Grand Gulf Plate	Hatch 1 weld	Hatch 1 Plate	Hatch 2 weld	Hatch 2 Plate	Hope Creek weld	Hope Creek plate	LaSalle 1 weld	LaSalle 1 Plate	LaSalle 2 weld	LaSalle 2 Plate	Limerick 1 weld	Limerick 1 plate	Limerick 2 weld	Limerick 2 Plate	Monticello weld	Monticello plate	Nine Mile Point 1 weld	Nine Mile Point 1 plate	Nine Mile Point 2 weld	Nine Mile Point 2 plate	Oyster Creek weld	Oyster Creek plate	Peach Bottom 2 weld	Peach Bottom 2 plate	Peach Bottom 3 weld	Peach Bottom 3 plate	Perry weld	Perry plate	Pilgrim weld	Pilgrim plate	Quad Cities 1 weld	Quad Cities 1 plate	Quad Cities 2 weld	Quad Cities 2 plate	River Bend weld	River Bend plate	Susquehanna 1 weld	Susquehanna 1 plate	Susquehanna 2 weld	Susquehanna 2 plate	Vermont Yankee weld	Vermont Yankee plate	Columbia weld	Columbia plate
Browns Ferry 2	■	■	■	■																																																																
Browns Ferry 3																																																																				
Brunswick 1																																																																				
Brunswick 2																																																																				
Clinton																																																																				
Cooper											■	■													■																					■																						
Dresden 2																																																																				
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Duane Arnold						■		■									■	■																				■												■														■				■
Enrico Fermi 2																																																																				
FitzPatrick																																																																				
Grand Gulf																																																																				
Hatch 1																				■						■																																										
Hatch 2																											■	■													■				■																							
Hope Creek																													■	■																																						
LaSalle 1																						■									■	■																						■														
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Limerick 1																																																																				
Limerick 2																																																																				
Monticello																																								■																												
Nine Mile Point 1																																																																				
Nine Mile Point 2																																																																				
Oyster Creek																																																																				
Peach Bottom 2																																				■								■			■	■																				
Peach Bottom 3																																																																				
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River Bend									■	■																								■	■		■		■										■											■	■							■
Susquehanna 1																																	■																													■	■			■	■	
Susquehanna 2																																																																				
Vermont Yankee																																																																				
Columbia (WNP-2)																																																																				
SSP					■	—	■	—	—					■		■	—	—	■		■		—	■	—										—		—	—	—			■	—						—	—	—			■			■		■	—				■	—		—	—

1 ■ Selected to be in final ISP text matrix

2 — Capsule(s) which contain the same heat as the Representative Material and whose results will also be considered

Table 4-2
Summary of ISP Surveillance Material Assignments

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Table 4-2
Summary of ISP Surveillance Material Assignments (Continued)

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Table 4-2
Summary of ISP Surveillance Material Assignments (Continued)

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Table 4-2
Summary of ISP Surveillance Material Assignments (Continued)

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4.2 ISP Test Schedule

The ISP capsule test schedule for the 13 ISP host plants and nine SSP capsules is illustrated in Table 4-3. Test schedules for ten capsules have been deferred for periods varying from three to twenty-one years, as compared to the current schedule for testing those capsules. In Table 4-3, arrows show the schedule shifts, with the bold "X" indicating the ISP test schedule for the capsule.

There are two reasons for deferring the testing of most of the ISP host plant capsules. The first reason is to avoid overlap with SSP capsule testing. Nine SSP capsules will be tested under the ISP during next two years. It is desirable to allow time for evaluation of SSP test data before performing additional testing of valuable ISP plant capsules. Delaying the testing of the nine ISP host plant capsules that would have otherwise been scheduled through 2007 will provide time for evaluation of all SSP data. The second reason for the deferrals is the NRC Staff request [5] that the ISP delay testing in order to obtain better consistency between the capsule fluences and the Target RPV 1/4T EOL fluences. The deferrals will increase the fluence of the plant capsules and thereby increase the shifts and improve the quality and applicability of test results.

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A comparison of the current testing schedule versus the ISP testing schedule for the 13 ISP plants is provided in Table 4-4.

4.3 Detailed ISP Test Plan

The previous sections have described the ISP matrix from the fleet perspective, which is useful for describing the structure and organization of the program. ISP implementation is ultimately performed at the plant level, however. Therefore, this section provides a detailed presentation of the ISP from the perspective of the individual plant.

Table 4-3
ISP Capsule Test Schedule

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Table 4-4
Comparison of ISP Capsule Testing Schedule to Current Schedule

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Table 4-5 is a detailed ISP test plan by plant. Each row addresses one BWR plant. In columns from left to right, the ISP representative materials for the plant's limiting weld and plate materials are identified, along with the names of source capsules. Next, the table identifies any ISP capsules containing the representative material that have already been tested. Finally, future ISP capsule testing is detailed. From this table, a plant can determine what data is already available for its representative material and when future surveillance data will become available.

Each plant has at least two capsules listed for each limiting material. Data from two irradiated capsules, together with the baseline data, provide the representative data set for the surveillance material. In many cases, three or four capsules are listed, because representative materials are often in more than two capsules.

Table 4-5 also shows applicable fluence data for both the target vessel (limiting materials) and the surveillance capsules. The plant names in bold type in Table 4-5 indicate the plant capsules that are in the ISP. For the vessel limiting materials (weld and plate), the end-of-license (EOL) fluence (E>1.0 MeV) at the 1/4T position is shown. For each capsule, the actual capsule fluence (if already tested) or target capsule fluence is provided. Inspection of the fluence data in Table 4-5 shows that, for the fleet as a whole, the target capsule fluences provide reasonable coverage of the EOL fluences. The ISP provides a significant improvement over the capsule fluence representativeness of the current programs for the following reasons:

- The higher-fluence SSP surveillance data will be included in the ISP (it would not have been available under the existing surveillance programs without the ISP);
- Testing of most ISP host plant capsules has been deferred by three or more years to increase fluence, as discussed above; and
- An additional capsule will be tested from Duane Arnold and Hatch 1 in order to obtain higher fluence data even though their individual surveillance programs would not have required it and representative data sets have already been obtained.

Table 4-5
Detailed Test Plan by Plant

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Table 4-5
Detailed Test Plan by Plant (Continued)

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Table 4-5
Detailed Test Plan by Plant (Continued)

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4.4 Results

The results of the ISP Test Plan discussed above are shown in Table 4-6. The table shows the disposition of all BWR surveillance capsules under the ISP. Plants that are not selected as ISP hosts are shaded.

Table 4-6 shows that there are 15 ISP capsules remaining to be withdrawn and tested. This total includes the ISP host plant capsules only and does not include the 9 SSP capsules. Sixteen ISP capsules have already been tested. Testing of 62 capsules will be deferred indefinitely, and 13 ISP plant capsules are designated for use in license renewal.

Table 4-6
ISP Test Matrix Results

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5 PROJECT ADMINISTRATION AND IMPLEMENTATION

The integrated surveillance program is more than just a compilation of data from separate irradiation capsules and resultant sharing of the data. It is designed to address both the short- and long-term requirements for acquiring irradiation data to support the continued operability of the BWR vessels. This will be accomplished by systematically collecting the representative materials data from the selected capsules, consistently evaluating the Charpy test results and comparing the fitted test results to the predicted embrittlement behavior. The evaluated results from the ISP will be used to evaluate embrittlement in the limiting materials for each of the target BWR vessels.

5.1 Project Management Responsibilities

ISP project management responsibilities will be assigned to the BWRVIP. The BWRVIP will manage capsule withdrawal and testing in accordance with the schedule contained in this plan. Project management activities will include:

- Working with utilities to identify required capsule withdrawals so that the utility can make necessary plans and arrangements.
- Shipping and testing of ISP capsules and associated dosimetry per applicable standards.
- Reporting the results of the surveillance specimen testing in a report as required by 10CFR50 Appendix H within one year of the capsule withdrawal date.
- Distributing capsule reports to all plants that have representative materials in the capsule.
- Planning for changes and contingencies in the ISP testing matrix.
- Consideration of surveillance needs for plant license renewal.

5.2 ISP Capsule Data Evaluation

The surveillance capsules in the ISP program will be withdrawn according to the designated schedule. Testing will be performed in a timely manner to meet the requirements of 10CFR50, Appendix H, and ASTM E-185 [9]. The data from the testing of individual capsules will be summarized in a test report containing Charpy impact test results, tension test results (if applicable), dosimetry data from various locations within the capsule and chemistries of irradiated test specimens. An evaluation of the test data will be performed to determine the applicability to the BWR vessels. In particular, fitted curves will be developed for the irradiated transition temperature Charpy impact energy vs. temperature, lateral expansion vs. temperature, and percent shear vs. temperature data. The method of Charpy curve-fitting to be employed will be the hyperbolic tangent (TANH) function:

$$Y = A + B \times TANH[(T-To)/C] \qquad (1)$$

where

Y	=	the toughness response measurement (i.e., energy, lateral expansion, or percent shear) at a given temperature, T
A	=	the mid transition energy at a temperature To
B	=	the difference between the mid transition and the upper shelf energy levels
(A-B)	=	the asymptotic lower shelf energy level
(A+B)	=	the asymptotic upper shelf energy level
To	=	the mid transition temp. corresponding to the value A
C	=	a measure of the slope of the transition region (B/C is the actual slope)

These fitted Charpy curves will be evaluated together with the unirradiated data for the corresponding surveillance weld and plate materials. For both the unirradiated and irradiated transition temperature curves, the 30 ft-lb, 50 ft-lb and 35 mils lateral expansion values and upper shelf energies will be determined. The 30 ft-lb shift values (ΔT_{30}) will be calculated from the results of the fitted Charpy impact energy curves. The Charpy data from each capsule will be evaluated along with the unirradiated baseline data and any prior capsule test results for the same heats of weld or plate material. Data from both ISP and SSP capsules will be combined for the purpose of evaluation when the same heat of material is contained in multiple surveillance capsules. In particular, the surveillance data will be fitted as follows to obtain the best-fit chemistry factor (CF) per Reg. Guide 1.99, Rev. 2 [10]:

(a) Calculate the fluence factors for each data point from the measured fluence values

$$fluence\,factor_1 = f_1^{(0.28 - 0.10 \log f_1)}$$

$$fluence\,factor_2 = f_2^{(0.28 - 0.10 \log f_2)}$$

where f = fluence in units of 10^{19} n/cm^2.

(b) Calculate the best-fit CF from the least-squares fit equation

$$best\text{-}fit\ CF = \frac{(\Delta T_{30_1} x\ fluence\ factor_1 + \Delta T_{30_2}\ x\ fluence\ factor_2 + \ldots)}{(\ fluence\ factor_1^2 + fluence\ factor_2^2 + \ldots\ )} \quad (2)$$

The best fit CF is used to determine the measured RT_{NDT} shift in surveillance materials from the equation

$$\Delta RT_{NDT} = CF\, x\, f^{(0.28-0.1 \log f)} \quad (3)$$

The evaluated test results will be compared to the predicted behavior from Regulatory Guide 1.99, Revision 2 for the CF values from the known chemistries of the surveillance materials. The measured vs. predicted embrittlement response will be documented in the ISP surveillance capsule report.

5.3 Fluence and Dosimetry

An evaluation of capsule fluences will be performed for each of the ISP capsules as part of the testing and reporting of the capsule. The flux wires will be removed from each capsule and analyzed for radioactivity content by gamma spectrometry. The analysis of dosimeters will be performed using standard, benchmarked methods. ISP capsule fluence evaluations will be performed in a consistent manner using a RPV neutron fluence calculational methodology that will meet current NRC staff guidance in USNRC Regulatory Guide 1.190 [13].

5.4 Plan for Ongoing Vessel Dosimetry

Under the ISP, capsules from some plants will be tested and capsules from some other plants will not. For a plant that has one or more future capsules tested, dosimetry will be available from the capsule as an updated basis for the projected vessel fluence. For a plant that does not have a future capsule tested, there are several options:

1. If a plant has previously tested a capsule, the dosimetry from that capsule is generally the basis for its current fluence projection. This plant's fluence projection will continue to be based on its capsule dosimetry unless a major change to the core design or management is undertaken in the future.

2. If a plant has not previously tested a capsule, but has tested a first cycle dosimeter, the first cycle dosimetry is generally the basis for its current fluence projection. Comparisons of first cycle and first capsule dosimetry results have consistently shown that first cycle dosimetry results are conservative. Therefore, this plant's fluence projection will continue to be based on its first cycle dosimetry unless a major change to the core design or management is undertaken in the future.

3. Alternatively, if a plant has not had a previous capsule tested, a selective neutron transport recalculation could be performed for this vessel using a benchmarked fluence methodology, dosimetry data from plants with similar design and any related information (e.g., ex-vessel dosimetry) that could improve the calculation of fluence in the vessel beltline region.

5.5 ISP Capsule Data Sharing

The data exchange and data sharing will be coordinated with all participants under the ISP. A program plan to manage data sharing will be developed in the implementation phase of the ISP.

5.6 Data Utilization

There are two options for applying the measured surveillance data:

1. Under option 1, if the heat of material does not specifically match the limiting heat of beltline material for that vessel, the chemistry factor for the limiting beltline material will be determined by the tables in Reg. Guide 1.99, Rev. 2. The corresponding margin term as stated in Position C.1 will apply. Data from the representative material will be analyzed to confirm that the measured Charpy ΔT_{30} shift is within the normally expected scatter in the predicted shift. The same method (i.e., Position C.1) will be applied to calculate adjusted reference temperature (ART) for all weld and plate materials in the vessel beltline.

2. If two or more surveillance data sets with matching heat numbers are available for the limiting beltline material, Option 2 may be used to calculate adjusted reference temperature when the data has been determined to be credible. The chemistry factor and margin term are calculated using Reg. Guide 1.99, Rev. 2, Position C.2. This data will only be used for evaluating the ART for the limiting beltline materials in the vessel that is being represented. The ART for all other materials in the beltline will be evaluated according to the requirements of Reg. Guide 1.99, Rev. 2, Position C.1.

   Credibility of the surveillance data will be judged by the following criteria:

   a) Materials in the capsules should be those most likely to be controlling with regard to radiation embrittlement.

b) Scatter in the plots of Charpy energy vs. temperature for the irradiated and unirradiated conditions should be small enough to permit the determination of the 30 ft-lb temperatures and upper shelf energies unambiguously.

c) When there are two or more sets of surveillance data from one reactor, the scatter of ΔRT_{NDT} values about a best-fit line (given by Eq. 3) normally should be less than 28°F for welds and 17°F for base metal. Even if the fluence range is large (two or more orders of magnitude), the scatter should not exceed twice those values.

d) The irradiation temperature of the Charpy specimens in the capsule(s) should match the vessel wall temperature at the cladding/base metal interface within ±25°F.

e) If correlation monitor material is available in the capsules, the surveillance data for the correlation monitor material should fall within the scatter band of the data base for that material.

Data points falling outside the normal 2-sigma scatter band for welds or plates will be evaluated in detail and compared to similar material test results to understand the embrittlement behavior. Applicability to individual BWR vessels will be considered on a plant-specific basis.

5.7 Planning for ISP Changes

Throughout the term of the ISP, the BWRVIP will monitor the progress, coordinate future actions such as withdrawal and testing of future capsules and reporting of surveillance capsule test results, and identify additional program needs. A reevaluation of the ISP test matrix and capsule withdrawal schedule will be performed on a periodic basis or when a significant event occurs that may require special consideration. Contingency planning for the ISP will need to address any major interruptions in plant operation such as early, permanent plant shutdown or an extended outage of one of the host plants. As time progresses, actual plant operating experience will provide more accurate data about each plant for predicting end-of-life vessel fluences and target capsule fluence values. This information will be factored into the ISP planning and, if necessary, adjustments will be made to the remaining capsule test matrix and withdrawal schedule in order to maintain an optimized program. Minor reassessments in the ISP test matrix will 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 variation in capacity factor. For example, target fluences in the original plan assume a nominal capacity factor of 80 percent for all BWR plants, and actual plant operation may vary from this assumed value. An abnormal result from the testing of one or more ISP capsules could also be an event that causes a reevaluation of the ISP test plan.

The BWRVIP will identify and implement changes to the program as the need arises. When specific changes are identified to the ISP testing matrix, withdrawal schedule, or testing and reporting of individual capsule results, these modifications will be submitted to the NRC in a timely manner so that appropriate arrangements can be made for implementation.

5.8 Considerations for License Renewal

Although the primary focus of the ISP is to satisfy the requirements of 10CFR50 Appendix H for the BWR 40-year operating period, the needs of individual BWR utilities seeking plant license renewal could be factored into future planning of the ISP test matrix. The specific details of ISP changes depend on which plants intend to seek license renewal and the representative (host capsule) materials for those plants. A further consideration would be the timing of capsule withdrawal from the host plants and the achievable fluence levels in the remaining capsules. Close cooperation with the utilities seeking license renewal will be needed to accommodate the plant-specific needs and to modify the ISP as needed. A total of 13 ISP host plant capsules have been identified for application to license renewal, and an additional 65 deferred capsules may be available to satisfy unique needs of specific plants. The mechanism of planning for license renewal would be similar to the contingency planning described in Section 5.5. That is, a reevaluation of the test matrix will consider any additional capsules to be included in the test matrix and the schedule for testing these capsules to meet the utility needs for license renewal. Data generated from the capsules designated for license renewal will be evaluated in the manner described in Section 5.2.

6
LICENSING ASPECTS OF ISP IMPLEMENTATION

The ISP is designed as a replacement for the existing individual BWR material surveillance programs. From a licensing perspective, each utility will continue to demonstrate compliance with 10CFR50 Appendix H by reference to the ISP in Plant Technical Specifications or Updated Final Safety Analysis Reports. In the implementation phase, the program documents and capsule test reports will be submitted to NRC through the BWRVIP. Throughout the program, the BWRVIP will continue to review the ISP program and, if necessary, will implement revisions to meet the licensing needs of utilities.

6.1 Implementation of ISP in Plant Technical Specifications or UFSAR

Upon receiving approval of the ISP program and implementation plans, individual BWR plant owners will submit requests to NRC to replace their existing material surveillance monitoring program with the ISP. This will require referencing the ISP program and implementation plans in the individual plant Technical Specifications or Updated Final Safety Analysis Report (UFSAR), as appropriate. Details of the ISP test matrix to be included in plant Technical Specifications or UFSAR involve identifying the specific representative weld and plate materials from host reactor capsules, and specifying the associated testing schedule for these replacement capsules. In many cases the representative weld and plate materials may be contained in different reactors with staggered test schedules. In some cases, one or more of the representative material surveillance capsules may have already been tested, and the implementation will simply require adopting the results from these capsule tests in lieu of their own capsule data.

A second step in the implementation process is the plant-specific review of existing plant operating P-T limit curves. An initial review of the new/replacement surveillance data will confirm that the projections of ART used in developing the present curves are still valid, or are conservative, for each BWR vessel. The period of validity (EFPY) for the existing curves will be evaluated based on the available information for each vessel, and a reassessment of the date for revision will be determined if changes to the P-T curves are deemed to be necessary.

A reassessment of the validity of P-T limit curves will continue on an ongoing basis as new data becomes available from the ISP Program and as the data is evaluated for embrittlement behavior of the limiting weld and plate materials for specific BWR vessels.

6.2 Continuing Licensing Considerations

The BWRVIP will continue to monitor licensing needs of the BWR utilities related to surveillance program requirements. As changes to the ISP are warranted due to unanticipated shutdowns or outages, or as license renewal becomes a viable option for some utilities, the BWRVIP will develop the appropriate documentation for licensing submittal. The affected utilities will submit corresponding requests to adopt the revised ISP program as specified in the BWRVIP reports. It is anticipated that such requests would be coordinated through the BWRVIP to maintain consistency in the submittals.

7 REFERENCES

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3. "PROJECT NO. 704 – BWRVIP Response to NRC Request for Additional Information Regarding BWRVIP-78)," letter from Carl Terry (BWRVIP Chairman) to Document Control Desk (NRC) dated December 15, 2000.

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13. Regulatory Guide 1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence," March 2001.

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INDIVIDUAL VESSEL EVALUATIONS

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B
NRC FINAL SAFETY EVALUATION

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

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 conceming 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,

William H. Bateman

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

Attachment: As stated

cc: See next page

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.

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 also subsequently revised in response to NRC staff questions.

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

[1] C. Terry (BWRVIP) to U.S NRC Document Control Desk, "Project No. 704 - BWR Vessel and Internals Project, BWR Integrated Surveillance Program Plan (BWRVIP-78)," December 22, 1999.

[2] C. Terry (BWRVIP) to U.S NRC Document Control Desk, "Project No. 704 - BWRVIP-86: BWR Vessel and Internals Project, BWR Integrated Surveillance Program Implementation Plan," EPRI Technical Report 1000888, December 22, 2000.

[3] C. Terry (BWRVIP) to U.S. NRC Document Control Desk, "PROJECT NO. 704 - BWRVIP Response to NRC Request for Additional Information Regarding BWRVIP-78," December 15, 2000.

[4] C. Terry (BWRVIP) to U.S. NRC Document Control Desk, "PROJECT NO. 704 - BWRVIP Response to Second NRC Request for Additional Information on the BWR Integrated Surveillance Program," May 30, 2001.

[5] D.C. Trimble (USNRC) to C.S. Hinnant (Carolina Power and Light), "Request for Additional Information Regarding the Reactor Vessel Material Surveillance Program - Brunswick Steam Electric Plant (TAC No. M98710)," May 23, 1997.

[6] C.E. Carpenter (USNRC) to E.J. Sullivan (USNRC), "Meeting Summary for November 5 and 6, 1997, Meetings with Boiling Water Reactors Vessel and Internals Project Technical Chairs, Regarding BWRVIP-07 Safety Evaluation Report and to Discuss Issues Related to BWR Licensee Vessel Surveillance Programs, Relative to Monitoring Radiation Embrittlement at BWR Facilities," December 9, 1997. [Attachments proprietary.]

[7] General Electric Nuclear Energy Report GE-NE-523-93-0732, "BWR Supplemental Surveillance Program Phase 1 Report: Surveillance Data Collection and Evaluation," March 1989.

[8] General Electric Nuclear Energy Report GE-NE-523-99-0732, "Progress Report on Phase 2 of the BWR Owners' Group Supplemental Surveillance Program," January, 1992.

[9] USNRC Regulatory Guide 1.190, "Calculational and Dosimetry Methods for Determining Pressure Vessel Neutron Fluence," March 2001.

[10] S.A. Richards (USNRC) to J.F. Klapproth (GE), "Safety Evaluation for NEDC-32983P, 'General Electric Methodology for Reactor Pressure Vessel Fast Neutron Flux Evaluation' (TAC No. MA9891)," September 14, 2001.

C REVISION DETAILS

<table>
<tr><th>Revision Number</th><th>Revisions</th></tr>
<tr><td>BWRVIP-xx-?</td><td>Information from the following documents was used in preparing this document, which, although it carries a new report number, is an extensive update/revision of BWRVIP-86:

1. BWR Vessel and Internals Project: BWR Integrated Surveillance Program Plan (BWRVIP-78), EPRI, Palo Alto, CA and BWRVIP: 1999, TR-114228.
2. U.S. NRC (Bateman) Letter to BWRVIP (Terry), "Proprietary Request for Additional Information Regarding BWR Integrated Surveillance Program (BWRVIP-78) (TAC No. MA9111)," dated June 19, 2000.
3. BWRVIP Response to NRC Request for Additional Information Regarding BWR Integrated Surveillance Program (BWRVIP-78), December 2000.
4. BWR Vessel and Internals Project: BWR Integrated Surveillance Program Implementation Plan (BWRVIP-86), EPRI, Palo Alto, CA and BWRVIP: 2000, TR-1000888.
5. U.S. NRC (Bateman) Letter to BWRVIP (Terry) dated February 14, 2001; Subject: Proprietary Second Request for Additional Information Regarding BWR Integrated Surveillance Program (BWRVIP-78) (TAC No. MA9111).
6. BWRVIP Response to NRC RAI Regarding BWR Integrated Surveillance Program (BWRVIP-78), May 30, 2001.
7. Letter from William H. Bateman (NRC) to Carl Terry (BWRVIP Chairman), 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," dated February 1, 2002.
8. "Pressure-Temperature Curves for Entergy Operations Inc. (EOI), Using the K_{Ic} Methodology, River Bend," GE-NE-B13-02094-00-01, Revision 0, Class III, January 2001.
9. "Pressure-Temperature Curves for FirstEnergy Corporation, Using the K_{Ic} Methodology, Perry Unit 1," GE-NE-0000-0000-8763-01a, Revision 0, Class III, April 2002.

Details of the changes made to BWRVIP-86 in order to yield this report can be found in Table C-1.</td></tr>
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Table C-1
Details of Report Revisions

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