

U.S. NUCLEAR REGULATORY COMMISSION
OFFICE OF NUCLEAR REACTOR REGULATION SAFETY EVALUATION OF
"BWR VESSEL AND INTERNALS PROJECT, REACTOR PRESSURE VESSEL
AND INTERNALS EXAMINATION GUIDELINES (BWRVIP-03) REVISION 1

1.0 INTRODUCTION

1.1 Background

By letters dated November 22, 1994, and April 21, 1995 (References 1 and 2), the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted the reports, "BWR Core Shroud Inspection and Evaluation Guidelines, Revision 1," and the "BWRVIP Core Shroud NDE Uncertainty and Procedure Standard," respectively, for NRC staff review. The staff, with technical assistance from Brookhaven National Laboratory (BNL), assessed these reports in its safety evaluation (SE), dated June 16, 1995, (Reference 3). The BWRVIP then submitted the EPRI proprietary report TR-105696, "BWR Vessel and Internals Project, Reactor Pressure Vessel [RPV] and Internals Examinations Guidelines (BWRVIP-03)," by letter dated November 10, 1995, (Reference 4). The BWRVIP-03 report superseded References 1 and 2. It contained sections not in the original document, including Section 5, "Shroud Support," and Section 6A, "Standards for Visual Inspection of Core Spray Piping, Spargers, and Associated Components." The BWRVIP-03 report was supplemented by letters dated April 16, 1996, and March 12 and July 7, 1997, (References 6, 13, and 15, respectively).

The BWRVIP-03 report proposed guidelines for NDE techniques and inspection standards intended for voluntary implementation by BWR licensees in order to effectively examine and ensure the integrity of safety-related RPV internal components. The BWRVIP-03 report was structured to eventually address the examination of all components under the charter of the BWRVIP. The BWRVIP plans to update the BWRVIP-03 report twice a year to incorporate the results of ongoing NDE demonstrations and the inspection of the remaining internal components. The BWRVIP intended, in submitting the BWRVIP-03 report, to provide proven, documented NDE techniques and inspection standards to effectively examine susceptible BWR internal components to ensure their structural integrity.

By letter dated June 8, 1998, (Reference 17), the Staff forwarded its initial SE of the BWRVIP-03 report to the BWRVIP. This SE had several open items, repeated below, and requested that the BWRVIP address these issues in a timely manner. In response, the BWRVIP submitted EPRI Report TR-105696-R1, "BWR Vessel and Internals Project: Reactor Pressure Vessel and Internals Examinations Guidelines (BWRVIP-03) Revision 1," dated March 30, 1999, (Reference 18), which addressed the open items in the staff's June 8, 1998, SE.

1.2 Purpose

The staff reviewed the BWRVIP-03, Revision 1, report to determine whether its amended guidance would provide adequate NDE techniques and inspection standards to effectively examine susceptible BWR internal components to ensure their structural integrity.

1.3 Organization of this Report

The BWRVIP-03, Revision 1, report is proprietary; therefore, this SE was written to ensure that proprietary information was not compromised. Because of proprietary information concerns, this SE does not discuss in any detail the provisions of the guidelines nor the parts of the guidelines that the staff finds acceptable.

This SE gives a brief summary of the general contents of the report in Section 2.0 and the detailed evaluation in Section 3.0, below. In Section 3.0, the staff evaluates relevant parts of the BWRVIP-03, Revision 1, report, and associated documentation, to determine if items documented in the staff's June 18, 1998, SE (Ref. 17) have been satisfactorily addressed. It then compares the BWRVIP-03, Revision 1, report (Ref. 18) to the original BWRVIP-03 report (Ref. 4), to determine whether new material had been added that had not been previously evaluated or differed from the information upon which the Ref. 17 SE was based. The staff's conclusions are summarized in Section 4.0.

2.0 SUMMARY OF BWRVIP-03, REVISION 1

The BWRVIP-03, Revision 1, report addresses the following topics in the following order:

- o General Procedure: defines the process for BWRVIP member utilities and their vendors to use mockups developed by the BWRVIP. Details a consistent and formal manner that demonstrations of inspection tooling and NDE techniques on realistic mockups are performed, documented and reported.
- o Visual Examination Accuracy Demonstration: describes the protocol for determining uncertainties in visual inspections, including NDE uncertainty measurements and evaluation factors, and standards for visual examinations (VT).
- o Inspection Considerations and Technique Demonstrations: details the inspection considerations that are to be used in examining the various BWR internals. Describes applicable mockups, delivery systems for the inspection tooling, and the technique demonstrations to be used for the various examination methods (e.g., ultrasonic (UT), eddy current (ET), and VT) for the core shroud, shroud support, core spray piping and sparger, top guide, core plate, low pressure coolant injection (LPCI) coupling, jet pump assemblies, standby liquid control, vessel attachments, components located in the lower plenum, and instrument penetrations.

3.0 NRC STAFF EVALUATION

3.1 Evaluation of the BWRVIP-03 Report and Associated Documentation to Determine If Staff Concerns Documented in the SE Dated June 16, 1995, Have Been Satisfactorily Addressed.

The staff's June 8, 1998, SE, provided a list of nine items that were the subject of the staff's June 16, 1995, SE. The BWRVIP, in its letters of May 17 and June 6, 1996, (Ref. 7 and 8) addressed the majority of these items, except for Item 6, which expressed the staff's concern regarding the completion and evaluation of full size mockups for assessing the performance of NDE techniques for core shroud evaluations. The BWRVIP responded that two mockups of

ring segment welds have been fabricated (BWRVIP-G and BWRVIP-H) and were being evaluated by NDE. A report for these evaluations was planned for summer of 1996; however, at the time the staff provided its initial SE (Ref. 17), the BWRVIP had not provided the results of these evaluations for staff review. The BWRVIP-03, Revision 1, report addressed this item. The staff reviewed the subject information and finds that the BWRVIP activities adequately addressed this item.

3.2 Evaluation of the BWRVIP-03 Report with Respect to New Material and Differences from Original Documents.

The staff compared the original BWRVIP-03 report (Reference 4) to the original documents (References 1 and 2) to determine whether new material had been added that had not been previously evaluated or differed from the information upon which the staff's June 16, 1995, SE was based. The staff issued a request for information dated March 12, 1997, (Ref. 13), to which the BWRVIP responded in its letter of June 30, 1997, (Ref. 14). Having evaluated the BWRVIP's response, the staff identified several items for resolution. These are repeated below, along with the BWRVIP's response to the items as provided in Reference 18, dated March 30, 1999, and the staff's disposition of the BWRVIP's responses.

Item 3.2-1 Paragraph 4.1 specifies that personnel evaluating inspection data be certified in the VT-1 method (as required by the American Society of Mechanical Engineers (ASME) Code, Section XI) only. The staff believes that this certification is not sufficient to show the competence of the personnel evaluating inspection data with enhanced visual testing (EVT-1) and the visual inspection of core spray components (CS-VT-1). EVT-1 and CS-VT-1 are more demanding examinations; i.e., they are performed underwater, in radiation environments, and require more specialized equipment. The personnel must also be able to resolve finer targets, 1/2- and 1-mil, underwater, versus the 1/32-inch, in air, required by VT-1. Therefore, the staff concludes that the personnel also need to be certified in (1) EVT-1 and (2) CS-VT-1.

Response: The BWRVIP agrees that there is a need for the additional training and/or experience and has prepared the required guidance to assess the qualifications of those inspection personnel. The "Generic Standards for Visual Examination of Reactor Pressure Vessel Internals, Components, and Associated Repairs" is included in Revision 1 to BWRVIP-03. This Generic Standard combines the previous Shroud and Core Spray Visual Standards and provides the minimum requirements and recommendations for the performance of underwater in-vessel visual inspections (IVVI) of reactor pressure vessel (RPV) internals. The standard establishes additional training and experience requirements for those individuals performing the inspections. Utilities review personnel certifications and training documentation to assure the additional BWRVIP training and experience requirements are met.

NDE industry practice calls for a single certification for each NDE method (e.g. magnetic particle, penetrant, and ultrasound) as specified in ASNT-TC-1A. There may be additional training and *qualifications* required for personnel performing various techniques within a method – such as solvent removable, post-emulsified, visible, or fluorescent techniques within the dye penetrant

method – but there is only one *certification*. Since VT-1 allows both the direct and remote application, the EVT-1 is just an extension of remote visual. The remote and direct visual techniques are different in application, however ASME Section XI does not require an additional certification. The BWRVIP feels that the different visual techniques are analogous to the different techniques for other NDE methods, and thus, only additional training and experience are required but not additional certifications. Although the BWRVIP may recommend additional training or experience for specific activities, certification of nondestructive testing personnel is the domain of the ASME Boiler and Pressure Vessel Code and the ASNT. BWRVIP does not believe it should alter the present consensus process for certification of NDE personnel in the nuclear industry, and feels that the certification, experience, and training recommendations contained in the Generic Standard provide adequate assurance of EVT-1 personnel capability.

Evaluation: The staff finds that the BWRVIP's response adequately addressed this item.

Item 3.2-2 Paragraph 4.3 addresses personnel training. The staff questioned the amount of facility specific training for performing the inspections recommended by the BWRVIP. The BWRVIP responded that it has no recommendation for site-specific training. This answer is inadequate. There needs to be some minimum amount of site-specific training required of even the most easily inspected plants since each plant is unique and has certain characteristics that could affect the validity of an inspection.

Response: The BWRVIP originally intended that the training in Paragraph 4.3 be given prior to the inspections for each refueling outage. However, this was not clear as written in this document, and as submitted to the NRC. This is clarified in Revision 1 to BWRVIP-03. The obvious advantage of this is that the inspections will be performed shortly after a refresher orientation covering the plant-specific configuration, equipment, and procedures.

The mix of visual examination data evaluators at a particular refueling outage can range from the use of only utility personnel to the use of only contractor personnel, or it could be a combination of both. The evaluators could be the same people that have been there for many refueling outages, or it could be their first time at that plant. It can be seen then, that the previous plant-specific experience has a large effect on the amount of training necessary to meet this requirement.

Additionally, the scope of inspections will vary from outage to outage. The components to be inspected and the complexity of those inspections, along with previous inspection results, may vary widely. A specific plant may have many components scheduled for inspection, whereas another plant may only have a few components. It can also be seen that as inspection history grows, the amount of necessary training may increase.

As stated in the NRC concern, each plant is unique and the amount of plant-specific training will vary. This is not only because of the uniqueness of the plant, but it is also affected by the outage scope, previous experience of

evaluation personnel with the plant, and previous inspection results. To accommodate this wide array of scenarios, the BWRVIP does not believe that specifying a minimum amount of time is appropriate. If a minimum amount of time were to be specified, it may be inadequate for plants with large scopes of work and inspection personnel without previous plant-specific experience, regardless of plant configuration complexity. *A minimum specified time may not require the utility to make a realistic assessment of the amount of training hours actually needed.* In light of this clarified interpretation of Paragraph 4.3 as it relates to a pre-inspection orientation rather than a one-time training function, it can be seen why the BWRVIP recommends additional site-specific training, but lets the utility determine at their discretion the duration of the training. The BWRVIP clarified Paragraph 4.3 to state that this orientation training will be conducted prior to inspections at each refueling outage, and the length of the training will be based on the outage inspection scope, the inspection history, and the familiarity of data evaluators with the plant.

Evaluation: The staff finds that the BWRVIP's response adequately addressed this item.

Item 3.2-3 Subsection 8 of Section 4E concerns the documentation of results. The staff questioned whether the amount of training time in the use of equipment used for visual inspection and in aspects of inspection specific to a given site was specified and documented. The BWRVIP responded that training time and other details of personnel qualification and certification are not considered a necessary part of the documentation of an examination. This answer is inadequate for the following reasons:

- Visual inspection is relied upon as a primary method of inspection of internals.
- The qualification of personnel performing visual inspections is important as discussed in Item 3.2-1.
- To the staff's knowledge, this information would not be documented elsewhere.
- This information would be important for possible future evaluations.

Response: The BWRVIP agrees that the amount of training time and experience is important to the examination. Therefore, "Generic Standards for Visual Examination of Reactor Pressure Vessel Internals, Components, and Associated Repairs" requires documentation of all specified experience and training.

Evaluation: The staff finds that the BWRVIP's response adequately addressed this item.

Item 3.3-1 Paragraph 4.1 specifies the certification of personnel evaluating inspection data. See discussion under Item 3.2-1.

Response: See Response to 3.2-1.

Evaluation: The staff finds that the BWRVIP's response adequately addressed this item.

Item 3.3-2 Paragraph 4.3 addresses personnel training. See discussion under Item 3.2-2.

Response: See Response to 3.2-2.

Evaluation: The staff finds that the BWRVIP's response adequately addressed this item.

Item 3.3-3 Subsection 9 concerns the documentation of results. See discussion under Item 3.2-3.

Response: See Response to 3.2-3.

Evaluation: The staff finds that the BWRVIP's response adequately addressed this item.

Item 3.3-4 Upon cross-referencing the recommendations of Reference 10 to the BWRVIP-03 report, the staff finds that the scope of Section 6A is limited to EVT-1. The scope needs to cover standards for all the types of visual examinations specified in Reference 10. These include CS-VT-1, VT-1 and VT-3. (In contrast, the staff found no such limitation of scope in Section 4B).

Response: The BWRVIP has consolidated its visual inspection guidance into one standard (as previously noted in Response 3.2-1), "Generic Standards for Visual Examination of Reactor Pressure Vessel Internals, Components and Associated Repairs." This standard addresses all types of visual examination techniques employed by the BWRVIP program. This change is documented in Revision 1 of BWRVIP-03.

Integral to the change is the elimination of the CS-VT-1 and MVT-1 methods. Thus the remaining visual examination methods will be the EVT-1, VT-1 and VT-3.

The definition of and requirements for VT-1 and VT-3 will continue to be the same as that in ASME Section XI. Members will perform the examinations that use these methods in accordance with their current written practice using each plant's existing procedures for these methods. This will eliminate confusion and contradictions between procedures implementing the BWRVIP inspections and existing procedures for code and other examinations.

As noted above, CS-VT-1 and MVT-1 are eliminated. BWRVIP through its assessment of the efficacy of the various methods concluded that there was not a meaningful difference between the EVT-1 and the MVT-1 (CS-VT-1 in BWRVIP-18). Examinations that previously were to be conducted using those methods will be performed using the EVT-1, VT-1 or VT-3 methods in the future. The EVT-1 method will be specified as the primary technique to be used when fine, tight IGSCC is a primary concern. In other locations, VT-1 or VT-3 will be used as appropriate.

The only real difference in the two methods was the resolution check (1/2 mil wire for EVT-1 vs. 1 mil wire for MVT-1) performed prior to the examination starting. This resolution check is used to demonstrate the resolution capabilities of the system in the environment and does not provide the complete means to determine the techniques detection capabilities. Rather, the detection capability of a particular visual technique is determined by important factors such as the surface condition, camera to object distance (or field of view for zoom type cameras) and camera lighting angles. These attributes are not controlled by the equipment/system resolution check. The more important aspects of the examination are those things that an examiner does after the simple system resolution check. BWRVIP members have complied with the existing BWRVIP recommendations, which already address these important factors.

As described in the previous paragraph, the resolution check of the system is essentially a quality assurance verification for the system. As such, the resolution check of a 1/2 mil wire vs. a 1 mil wire provides little difference to the overall sensitivity of the examination. Adequacy of the examination is controlled by the efforts of the examiner. Industry experience has shown that inspection personnel typically verify surface texture identifiers such as grinding and machining marks, weld beads and ripples, etc., before performing examinations to assure that proper visual resolution is attained. This leads one to conclude there is in fact little, if any, real difference between the examinations performed using EVT-1 versus the MVT-1 methods. Therefore, reassessment of previously performed examinations for the purpose of quality assurance verification is not required and the examinations previously performed using MVT-1 are deemed acceptable.

Evaluation: The staff finds that the BWRVIP's response adequately addressed this item.

Item 3.3-5 Unlike Subsection 6 of Section 4B, Subsection 6 of Section 6A does not require that the effectiveness of cleaning be demonstrated. The effectiveness of surface cleaning needs to be demonstrated for all visual examinations, not just for those affecting the core shroud.

Response: The NRC is correct in pointing out that the visual technique for the core spray should be consistent with the one for the shroud. The BWRVIP recognized this and incorporated this change into Revision 1 to BWRVIP-03. In Revision 1, the Core Shroud Visual Inspection Standard was replaced by the "Generic Standards for Visual Examination of Reactor Pressure Vessel Internals, Components, and Associated Repairs." The Generic Standard will be used when the BWRVIP Inspection and Evaluation Guidelines specify visual inspection.

A cleaning assessment will still be required by the Generic Standard prior to performing an EVT-1 inspection whether the area is inspected in the "as found" or cleaned state. The Generic Standard will provide guidance with objective criteria that has been obtained from industry experience on determining when the surface is suitable for inspection. The objective criteria for the cleaning assessment includes surface texture identifiers such as grinding and machining

marks, weld beads, ripples, etc. As an example, if a cleaning was performed in the previous outage, or components are in a high flow region, pre-inspection cleaning may not be necessary. However, the guideline provides means to assess this in all cases and does not provide for automatic exemption from cleaning when an EVT-1 inspection is to be performed. These changes will enhance the visual inspections currently being performed by the BWRVIP.

Evaluation: The staff finds that the BWRVIP's response adequately addressed this item.

Item 3.4 Concerning the guidance presented, this section [Section 5] appears to be incomplete. Mockups were made for just 3 of the shroud support welds, demonstrations were applicable to only one of those welds, and those demonstrations were for UT only. Qualification of UT and VT inspection methods for specific shroud support weld configuration remains to be completed. This item will be addressed in the staff's review of BWRVIP-38, "Shroud Support and Flaw Evaluation Guidelines," dated September 15, 1997.

Response: Revision 1 to BWRV P-03 includes additional demonstrations that have been completed, including additional mockups of the shroud support welds. The demonstrations for several techniques, including UT, VT and eddy current (ET), have been conducted satisfactorily. As future demonstrations are completed they will be added under subsequent revisions. As a note, demonstrations become valid as soon as they are documented by EPRI.

Evaluation: The staff finds that the BWRVIP's response adequately addressed this item.

3.3 Evaluation of Section 5, "Shroud Support"

The staff previously found in its June 8, 1998, SE (Ref. 17) that this section appeared to be incomplete. As described in the original BWRVIP-03 report (Ref. 4), mockups were made for just 3 of the shroud support welds, demonstrations were applicable to only one of those welds, and those demonstrations were for UT only. The qualification of UT and VT inspection methods for specific shroud support weld configurations remain incomplete.

The BWRVIP has significantly expanded this section of the BWRVIP-03, Revision 1, report. In addition, the staff is completing its review of BWRVIP-38, "Shroud Support and Flaw Evaluation Guidelines," dated September 15, 1997. As such, the staff finds that the BWRVIP has adequately addressed this item.

4.0 CONCLUSIONS

The staff has completed its review of the BWRVIP-03, Revision 1, report and finds that the licensee implementation of the guidelines in BWRVIP-03, Revision 1, will provide an acceptable level of quality for examination of the safety-related components addressed in the BWRVIP-03, Revision 1, document.

5.0 REFERENCES

1. BWRVIP letter to NRC dated November 22, 1994, submitting the "BWR-VIP Core Shroud NDE Uncertainty and Procedure Standard."
2. BWRVIP letter to NRC dated April 21, 1995, submitting the "BWR Core Shroud Inspection and Evaluation Guidelines, Revision 1."
3. NRC letter to the BWRVIP dated June 16, 1995, providing safety evaluation titled, "Evaluation of BWR Core Shroud Inspection and Evaluation Guidelines, GENE-523-113-0894, Revision 1, dated March 1995, and BWRVIP Core Shroud NDE Uncertainty and Procedure Standard, dated November 22, 1994."
4. BWRVIP letter to NRC dated November 10, 1995, transmitting EPRI Report TR-105696, "BWR Vessel and Internals Project, Reactor Pressure Vessel and Internals Examinations Guidelines (BWRVIP-03)."
5. BWRVIP letter to NRC dated February 2, 1996, "Electric Power Research Institute (EPRI) EPRI Topical Report TR-105747, BWR Vessel and Internals Project, Guidelines for Reinspection of BWR Core Shrouds (BWRVIP-07)."
6. BWRVIP letter to NRC dated April 16, 1996
7. BWRVIP letter to NRC dated May 17, 1996, titled "BWRVIP Response to NRC staff Concerns and Unresolved Items."
8. BWRVIP letter to NRC dated June 6, 1996, "Additional Response to NRC Staff Concerns and Unresolved Items."
9. BWRVIP letter to NRC dated July 17, 1996, titled "Clarifications to Core Shroud Reinspection Guidelines."
10. BWRVIP letter to NRC dated July 26, 1996, transmitting "BWR Vessel and Internals Project, BWR Core Spray Internals Inspection and Flaw Evaluation Guidelines (BWRVIP-18)," EPRI Report TR-106740, July 1996.
11. BWRVIP letter to NRC dated October 21, 1996, titled "BWRVIP Response to Request for Additional Information Regarding Proprietary Topical Report EPRI TR-105747."
12. BWRVIP letter to NRC dated January 8, 1997 titled "Modification to BWRVIP Response to NRC Request for Additional Information on BWRVIP-07."
13. NRC letter to the BWRVIP dated March 12, 1997, "Proprietary Request for Additional Information - Review of BWR Vessel and Internals Project Reports, BWR Vessel and Internals Project, Reactor Pressure Vessel and Internals Examination Guidelines."
14. BWRVIP letter to NRC dated June 30, 1997, titled "BWRVIP Response to NRC Request for Additional Information on BWRVIP-03."

15. BWRVIP letter to NRC dated July 7, 1997
16. NRC letter to the BWRVIP dated September 15, 1997, providing the NRC Staff's Safety Evaluation of EPRI Topical Report TR-105747 "BWR Vessel and Internals Project, Guidelines for Reinspection of BWR Core Shrouds (BWRVIP-07)."
17. NRC letter to the BWRVIP dated June 8, 1998, providing the Staff's initial safety evaluation of the BWRVIP-03 report.
18. BWRVIP letter to NRC dated March 30, 1999, EPRI Report TR-105696-R1, "BWR Vessel and Internals Project: Reactor Pressure Vessel and Internals Examinations Guidelines (BWRVIP-03) Revision 1."