November 1, 2007

Rick Libra, BWRVIP Chairman
DTE Energy
Fermi Nuclear Plant (M/S 280 OBA)
6400 N. Dixie Highway
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SUBJECT: NRC APPROVAL LETTER WITH COMMENT FOR BWRVIP-100-A, "BWR VESSEL AND INTERNALS PROJECT, UPDATED ASSESSMENT OF THE FRACTURE TOUGHNESS OF IRRADIATED STAINLESS STEEL FOR BWR CORE SHROUDS"

Dear Mr. Libra:

By letter dated September 12, 2006, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted Proprietary Report BWRVIP-100-A, "Updated Assessment of the Fracture Toughness of Irradiated Stainless Steel for BWR Core Shrouds," for Nuclear Regulatory Commission (NRC) staff review.

The BWRVIP-100-A report was submitted as a means of exchanging information with the staff for the purpose of supporting the assessment of the integrity of core shrouds.
The BWRVIP-100-A report provides accurate methods for predicting fracture toughness of irradiated stainless steel and defines appropriate flaw evaluation methodologies for assessing the integrity of irradiated core shrouds.

The BWRVIP-100-A report presents a compilation of information from the BWRVIP-100 report and the NRC staff's final safety evaluation (SE) dated March 1, 2004, which includes the BWRVIP's associated responses to NRC staff requests for additional information.

The NRC staff has reviewed the information in the BWRVIP-100-A report and has found that the report accurately incorporates all of the relevant information which was submitted by the BWRVIP in the documents noted above to support NRC staff approval of the report. The staff found that minimal revisions were made to the BWRVIP-100 report in the production of the BWRVIP-100-A report. These revisions are discussed in detail below.

The first revision was that the BWRVIP revised Section 1.4 and added a new Section 1.5 to include the implementation requirements of Nuclear Energy Institute Guideline 03-08 (NEI 03-08), "Guideline for the Management of Materials Issues." This section states that the BWRVIP-100-A report is considered "needed" in accordance with the implementation requirements of NEI 03-08. The staff finds this revision acceptable because the NEI 03-08 requirements would provide adequate guidelines for implementing the BWRVIP-100-A report at each BWR unit.

The second revision was that the BWRVIP added recently available fracture toughness data related to the heat affected zone (HAZ) of the stainless steel welds to Table 2-1. The staff finds this revision acceptable because the new data can be used for the evaluation of flaws in the HAZ of stainless steel welds.

The third revision consisted of a revision to Table 2-1 to include recently available data on the power fit coefficient (C), and power exponent (n) variables, which are used to determine the material resistance to fracture when stainless steel materials are subject to exposure to neutron radiation. The staff finds this revision acceptable because the new data can be used for the evaluation of flaws in core shroud stainless steel welds.

The fourth revision included an updated version of Figure 2-1 in which new data indicating a correlation between the neutron fluence and fracture toughness was added. The staff finds this revision acceptable as this data can be used by licensees for the evaluation of flaws in core shroud stainless steel welds.

In the fifth revision, the BWRVIP, in response to the staff's RAI 100-1 dated January 8, 2003, revised the first paragraph in Section 2.2.1 of the BWRVIP-100 report to indicate the method used for defining values of C and n as a function of neutron fluence. The staff determined that the BWRVIP adequately provided information on the definition of C and n.

The sixth revision addressed the staff's RAI 100-3(c) dated January 8, 2003, in which the BWRVIP revised the second paragraph in Section 2.2.1 of the BWRVIP-100 report to address the procedure used for the definition of HAZ toughness. The staff verified Section 2.2.1 of the report and concluded that the BWRVIP adequately addressed the HAZ toughness issue and, therefore, the staff's concern in RAI 100-3(c) is resolved.

The seventh revision, in response to the staff's RAI 100-3(a), the BWRVIP revised Figures 2-7 and 2-8 in which new toughness data values for HAZ, weld, and base material were added. In addition, Section 2.2.1 was revised to include the relationship between neutron fluence and fracture toughness for base metal and HAZ. The staff concluded that this revision provided adequate information regarding the relationship between neutron fluence and fracture toughness for base metal and HAZ and, therefore, the staff's concern in RAI 100-3(a) is resolved.

In the eighth revision, in response to the staff's RAI 100-3(b) dated January 8, 2003, the BWRVIP added Section 2.3.1 and Figures 2-7 and 2-8 which included data related to the effect of neutron irradiation on the thermally aged stainless steel weld metal. This data was obtained from operating BWR plants and, therefore, represents thermal aging histories in stainless steel welds. However, data on delta ferrite contents of the weld metal specimens was not included in the BWRVIP-100-A report. Since delta ferrite affects thermal embrittlement, the staff concludes that an effective assessment of synergistic effects of neutron embrittlement and thermal embrittlement cannot be made at this time. Since this is an on-going study, delta ferrite contents should be included in future work so that an effective assessment of the synergistic effects of neutron embrittlement and thermal embrittlement on the austenitic stainless steel welds can be made. Therefore, the staff concludes the data in the BWRVIP-100-A report provides reasonable assurance that the material used is representative of operating BWR plants, but that the BWRVIP, in the future, needs to provide the delta ferrite content so that the effects of delta ferrite on neutron and thermal embrittlement in austenitic stainless steel welds can be assessed. In the ninth revision, in response to the staff's RAI 100-2 dated

January 8, 2003, the BWRVIP added Section 2.3.2 and modified Figures 2-2, 2-3, 2-7 and 2-8 to indicate the application of an appropriate flaw evaluation method for the stainless steel materials based on their exposure to neutron radiation. The staff reviewed the information that was submitted and concluded that by providing this information related to the proper application of a flaw evaluation methodology for the irradiated stainless steel materials, the BWRVIP adequately addressed the staff's concern in RAI 100-2.

The tenth revision addressed the staff's RAI 100-3(d) dated January 8, 2003, in which the BWRVIP added Section 2.3.3 to the BWRVIP-100-A report in which information related to the use of a fracture toughness value was provided. The BWRVIP provided a technical justification for using this fracture toughness value for evaluating flaws in stainless steel welds exposed to neutron fluence values equal to or greater than 3×10^{21} (E > 1 MeV). After reviewing the submitted information, the staff concluded that the BWRVIP adequately addressed the staff's RAI 100-3(d).

In the eleventh revision, in response to the staff's RAI 100-1 dated January 8, 2003, the BWRVIP added Section 2.3.4, Appendix A and Figures A-1 through A-2 to include recent experimental results related to fracture toughness values for stainless steel materials irradiated to various neutron fluences. The staff reviewed the data and concluded that predicted fracture toughness values for irradiated stainless steel materials addressed in the original BWRVIP-100 report are more conservative than the experimental results and, therefore, the staff's concern in RAI 100-1 is resolved.

In the final revision, the BWRVIP responded to the staff's RAI 100-4 dated January 8, 2003, by adding Section 3.2 and Appendix B in which a comparison was made between the experimental data and predicted values related to yield strength variation with neutron fluence. After the review, the staff concluded that the information presented in the original BWRVIP-100 report adequately represented irradiated yield strength values for application to the evaluation of flaws in core shroud welds. Therefore, the staff's concern in RAI 100-4 is considered closed.

Based on the discussion above, the staff has determined that the BWRVIP-100-A report is acceptable provided that the BWRVIP, in the future, provide the amount of delta ferrite in the stainless steel weld metal to facilitate an effective assessment of the synergistic effect of neutron embrittlement and thermal embrittlement on stainless steel welds. In addition, the staff reiterates the following issues that were stated in the staff's SE dated March 1, 2004, which require future actions, but which do not affect the acceptability of the BWRVIP-100-A report.

(1) A plant-specific flaw evaluation is necessary to determine inspection intervals for cracked core shroud welds exposed to a neutron fluence value greater than 1×10^{21} (E > 1 MeV) and must be submitted to the NRC staff for approval.

(2) The fracture toughness values (as a function of neutron fluence) shown in Section 2.0 of the BWRVIP-100-A report should be included in Appendix C of the BWRVIP-76 report, "BWR Core Shroud Inspection and Flaw Evaluation Guidelines."

(3) Due to limited availability of data concerning the effects of different parameters (i.e., orientation, temperature, etc.) on fracture toughness of irradiated stainless steel materials, the staff recommends that the BWRVIP-100-A report be updated

when new data becomes available. The BWRVIP should update the proposed fracture toughness curves for irradiated austenitic stainless steel to ensure consistency with the new data when it becomes available.

Please contact John Honcharik of my staff at (301) 415-1157 if you have any further questions regarding this subject.

Sincerely,

/RA/

William H. Bateman, Deputy Director
Division of Component Integrity
Office of Nuclear Reactor Regulation

Project No. 704

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