March 16, 2006

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

SUBJECT: SUPPLEMENTARY REQUEST FOR ADDITIONAL INFORMATION - "BWR VESSEL AND INTERNALS PROJECT REPORT, TECHNICAL BASIS FOR PART CIRCUMFERENCE WELD OVERLAY REPAIR OF VESSEL INTERNAL CORE SPRAY PIPING (BWRVIP-34)"

Dear Mr. Eaton:

By letter dated May 22, 1997, you submitted for NRC staff review, Electric Power Research Institute (EPRI) proprietary report, "Technical Basis for Part Circumference Weld Overlay Repair of Vessel Internal Core Spray Piping (BWRVIP-34)." This report was submitted for the purpose of evaluating the feasibility of applying weld overlay repairs underwater to affected welds in the core spray piping and to provide the design basis, design requirements, technical basis and methodology for a part circumference weld overlay repair for internal core spray piping.

By letters dated December 14, 1997, and October 7, 2004, the staff sent you a request for additional information (RAI) regarding the BWRVIP-34 report. You responded by letters dated March 30, 1998, and November 1, 2004. The NRC staff has completed its review of the BWRVIP-34 report and your responses to the RAIs. The staff has determined that additional information is needed to complete the review. It should be noted that a conference call was held with the Boiling Water Reactor Vessel and Internals Project (BWRVIP) on March 6, 2006, to discuss the supplementary RAIs that are attached to this letter.

Please contact Meena Khanna of my staff at 301-415-2150 if you have any further questions regarding this subject.

Sincerely,

/RA/

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

Enclosure: As stated

cc: BWRVIP Service List

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SUPPLEMENTARY REQUEST FOR ADDITIONAL INFORMATION
REGARDING THE REVIEW OF THE BWRVIP-34 REPORT,
"BWR VESSEL AND INTERNALS PROJECT, TECHNICAL BASIS FOR PART
CIRCUMFERENCE WELD OVERLAY REPAIR OF
VESSEL INTERNAL CORE SPRAY PIPING"
EPRI PROPRIETARY REPORT TR -108198

Supplementary RAI 3-4

In response to Supplementary RAI 3-1(b), as provided by letter dated November 1, 2004, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) stated that all welding activities including weld design will be in accordance with the American Society of Mechanical Engineers (ASME) Code or with ASME Code Case N-516-1, "Underwater Welding Section XI, Div. 1" and ASME Code Case N-504-2, "Alternative Rules for Repair of Class 1, 2, and 3 Austenitic Stainless Steel Piping Section XI, Div. 1," as appropriate. However, instead of following the current version of the ASME Code and using the Z-factor approach for welds that are fabricated by the flux core arc welding (FCAW) process, the analysis in the BWRVIP-34 report takes some exceptions to the ASME Code based on the fact that measured material properties exceeded the strength parameters assumed by the ASME Code. Therefore, the staff requests that the BWRVIP provide further justification for why the Z-factor approach is not needed for the welds fabricated using the FCAW process. The justification may include details regarding the strength parameters assumed by the ASME Code and the measured material properties, including their reliability and applicability.

Supplementary RAI 3-5

In response to Supplementary RAI 3-1(c), as provided by letter dated November 1, 2004, the BWRVIP stated that the design tables (Tables 3-1 to 3-4) in the BWRVIP-34 report were developed without considering the Z-factor. The staff requests that the BWRVIP include this response in Section 3.3 of the -A version of the BWRVIP-34 report.

Supplementary RAI 3-6

In Section 3.0 of the report, it is not clear that the determination of required overlay length, according to the formula presented on Page 3-8 of the BWRVIP-34 report, is adequate to ensure "shear transfer between the overlay and the piping." In Supplementary RAI 3-1(e) of the staff's letter dated October 7, 2004, the staff requested that the BWRVIP provide additional information to support this argument. The BWRVIP's response to this RAI, in its letter dated November 1, 2004, did not adequately address the concern raised by the staff. The BWRVIP's response stated that Code Case N-504-2 or Section XI of the ASME Code does not explicitly address the manner in which shear transfer is calculated. However, the BWRVIP's response does not explain why the determination of required overlay length, as discussed on Page 3-8 of the BWRVIP-34 report, is appropriate to ensure "shear transfer between the overlay and the piping." Therefore, the staff requests that the BWRVIP provide this explanation.

ENCLOSURE

Supplementary RAI 3-7

In Supplementary RAI 3-2(b) of the staff's letter dated October 7, 2004, the staff requested that the BWRVIP provide the maximum shrinkage stress produced due to weld overlay repairs and ensure that welds and components of the "common" internal core spray system meet the applicable stress limits of ASME Code, Section III. In its response, by letter dated November 1, 2004, the BWRVIP stated that the maximum shrinkage stress is determined by the evaluation of the actual repair configuration, the measured shrinkage, the number of repairs applied to a specific piping system, and the actual configuration of the repaired piping system.

The BWRVIP further stated that the evaluation of the shrinkage stress will be performed after the repair application, as required by Supplement 1 of Generic Letter 88-01, "NRC Position on Intergranular Stress Corrosion Cracking (IGSCC) in BWR Austenitic Stainless Steel Piping." The staff finds the response acceptable because the licensee will be estimating the maximum shrinkage stress after the actual weld overlay repair. However, the staff requests that the BWRVIP provide a reference to Supplement 1 of GL 88-01 in Section 3 of the -A version of the BWRVIP-34 report.

Supplementary RAI 3-8

In Supplementary RAI 3-3(b) of the staff's letter dated October 7, 2004, the staff requested that the BWRVIP discuss whether any crevices may be introduced on the outside surface of the repaired core spray piping along the periphery of the weld overlay. Since IGSCC can be enhanced due to the presence of crevices, the staff issued Supplementary RAI 3-3(c) requesting that the BWRVIP provide an explanation for not performing crevice corrosion tests on weld coupons with a simulated crevice condition. In its response, by letter dated November 1, 2004, the BWRVIP stated that crevices may form on the outside diameter (OD) surface of the repaired core spray piping along the periphery of the weld overlay, but any IGSCC will be arrested at the structural overlay interface with the core spray pipe due to the high IGSCC resistance of the overlay material. The staff finds the response partially acceptable because the overlay weld material has low carbon content and adequate ferrite content and, therefore, it is IGSCC resistant. However, IGSCC could initiate at a crevice on the OD, if residual tensile stresses are present, and penetrate the core spray piping wall away from the repaired crack location without entering the structural overlay. In other words, the weld overlay repair could introduce new IGSCC-susceptible locations in the core spray piping. Therefore, the staff requests that the BWRVIP address this issue.

Supplementary RAI 6-5

In response to Supplementary RAI 6-1(a), in its letter dated November 1, 2004, the BWRVIP referred to the Argonne National Laboratory (ANL) research results for the long-term (>100,000 hours) thermal aging of cast stainless steel (SS) Grades CF-3 and CF-8 at 288 EC. The results show that thermal aging is expected to produce a 50% reduction in the room temperature Charpy impact energy of materials with 10% ferrite and an 80% decrease for material with 25%

ferrite. The BWRVIP further stated that because of the high initial values of the room temperature impact strength of Grades CF-3 and CF-8 materials, even a large decrease in this measure of toughness does not reduce the overall toughness of the overlay repair to unsatisfactory levels. In addition, the BWRVIP proposed to modify the BWRVIP-34 report to place an upper limit ferrite number (FN) of 17 for this underwater welding activity.

The staff finds the response to Supplementary RAI 6-1(a) unacceptable because it does not address the concerns raised in RAI 6-1(a), as stated in the staff's letter dated October 7, 2004. The thermal aging results for Grades CF-3 and CF-8 materials are not applicable to overlay weldments because the ferrite morphology and distribution in weldments is different than those of the CF-3 and CF-8 castings. As stated in the RAI, unaged austenitic stainless steel weld metal, especially when welds are made using the submerged metal arc welding (SMAW) process, has a significantly lower resistance to stable crack growth than unaged cast stainless steel. The thermal aging results for Type 308 SS welds by Alexander et al. (1990) are relevant for the welds that were fabricated by the SMAW process with a ferrite content of 12% by volume. The results show that aging of these welds at 343 EC for 20,000 hours caused a significant increase in the ductile-to-brittle transition temperature measured at 68-J level, an increase from -25 EC to 60 EC. The staff notes that the weld overlay repair will be exposed to lower temperatures. However, the proposed upper limit of 17FN for the underwater welding activity could make the weld overlay repair susceptible to thermal aging. Therefore, the staff requests that the BWRVIP provide the results of thermal aging of weld overlay repair made with 17FN weld metal.

Supplementary RAI 6-6

In response to Supplementary RAI 6-4, the BWRVIP stated that all repairs to core spray piping (including the weld overlays described in the BWRVIP-34 report) are required to be designed and fabricated in accordance with relevant BWRVIP repair design criteria reports (in this case, BWRVIP-16 and BWRVIP-19) and the BWRVIP material guideline report (BWRVIP-84). The BWRVIP further stated that the requirements suggested by the staff are required by BWRVIP-84, Section 3.2. The staff finds the response acceptable because the BWRVIP has accepted the design requirements as recommended by the staff. Therefore, the staff requests that the BWRVIP include these responses to Supplementary RAI 6-4 in Section 6.0 of the -A version of the BWRVIP-34 report.

Supplementary RAI A-5

In response to Supplementary RAI A-3, the BWRVIP stated that the ferrite levels were not effected by depth or pipe wall thickness for underwater welding and, therefore, the constant extension rate testing (CERT) results at 30 feet could be used for welds that are to be made at a depth of 50 feet. The heat sink is basically the same based on the quantity of water that the test specimens were fabricated in and, therefore, the weld residual stresses would be the same. The BWRVIP further stated that the only reason tests were conducted on coupons fabricated at various depths was because of the level of difficulty in fabricating specimens at 50 feet (hyperbaric chamber) and 30+ feet (open dive tank). The BWRVIP's response to Supplementary RAI A-3 is partially acceptable but it raises some additional questions. The response does not address the staff's concern about the increase in the number of weld defects

with the increasing depth. The staff requests that the BWRVIP discuss how the increased number of weld defects would effect the CERT test results and the mechanical properties. In addition, the staff requests that the BWRVIP include guidelines about the use of dry and wet underwater welding for overlay repairs in the -A version of the BWRVIP-34 report.

Supplementary RAI D-1

The results presented in Appendix D.2 of the BWRVIP-34 report indicate that the SMAW welds that are fabricated and tested in water have inferior mechanical properties than those fabricated in water, but tested in air. Therefore, in Supplementary RAI A-2 (b), the staff requested that for the design of the weld overlay repair for internal core spray piping, the BWRVIP-34 report recommend the use of mechanical properties (i.e., yield strength and tensile strength) determined by the underwater tests of the welds that are also fabricated underwater. In response to Supplementary RAI A-2 (b), the BWRVIP stated that all requirements of Code Case N-516 will be met and, therefore, the mechanical property requirements used in the design would be representative of these weldments. However, Code Case N-516 refers to the determination of only Charpy energy for filler metal qualification but not for yield strength and tensile strength of the weldments. Therefore, the staff requests that the BWRVIP address the mechanical properties of yield strength and tensile strength with respect to the data because this information is needed to determine the design stress intensity, S_m, used for the determination of overlay thickness (see Section 3.4 of the BWRVIP-34 report). The staff also requests that the BWRVIP address whether the proposed high-ferrite contents (17FN) would effect the material properties of the FCAW and SMAW welds fabricated and tested underwater.