May 10, 2007

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

SUBJECT: REQUEST FOR ADDITIONAL INFORMATION - BWRVIP-158: BOILING WATER REACTOR (BWR) VESSEL AND INTERNALS PROJECT, FLAW PROXIMITY RULES FOR ASSESSMENT OF BWR INTERNALS

Dear Mr. Eaton:

By letter dated September 28, 2006, the Boiling Water Reactor Vessel and Internals Project (BWRVIP) submitted for the Nuclear Regulatory Commission staff review, Electric Power Research Institute Technical Report 1014387, "BWR Vessel and Internals Project, Flaw Proximity Rules for Assessment of BWR Internals (BWRVIP-158)." The BWRVIP-158 report provides revised guidelines for evaluating adjacent cracks in the same plane, and parallel cracks in different planes for the core shroud and the internal core spray piping. These guidelines are based on the results of work to validate the American Society of Mechanical Engineers Code, 2004 Edition flaw proximity rules for application to stainless steel BWR internals. The revised guidelines to the flaw proximity rules will reduce the conservatism currently used in the existing guidance.

The staff has determined that additional information is needed to complete the review. The staff's request for additional information (RAI) regarding the BWRVIP-158 report is enclosed. In order to complete the staff's review of the report in an efficient and effective manner, your complete response to the attached RAIs are required no later than six months from the date of this letter. If you cannot provide a complete response within six months, please contact John Honcharik at (301) 415-1157 to discuss the withdrawal of the BWRVIP-158 report and its future resubmittal when you are prepared to respond to the RAIs. In addition, if you have any other questions regarding the enclosed RAIs, please contact Mr. Honcharik.

Sincerely,

R/A

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

Project No. 704

Enclosure:
Request for Additional Information

cc: BWRVIP Service List

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DATE	5/8/2007	5/9/2007	5/10/2007

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REQUEST FOR ADDITIONAL INFORMATION
BWRVIP-158 REPORT
BOILING WATER REACTOR (BWR) VESSEL AND INTERNALS PROJECT
FLAW PROXIMITY RULES FOR ASSESSMENT OF BWR INTERNALS

MAJOR ISSUES:

RAI 158-1

On page 3-3 of the BWRVIP-158 report, Figure 3-2 shows the normalized stress intensity factors for the four surface crack tips of two adjacent semi-elliptic cracks under three-point bending for five carbon-manganese steel specimens. The purpose of the experiment is to study the proximity effect of two adjacent cracks. Submit Reference 6 (the source document for Figure 3-2) to the Nuclear Regulatory Commission, and justify the applicability of the data plotted in Figure 3-2 to the current application for adjacent cracks in the same plane. It is not clear that the typical BWRVIP internal material would exhibit the similar behavior as that of Figure 3-2. In addition, the BWRVIP should address the following staff concerns about Figure 3-2 itself:

- Figure 3-2 did not show a consistent trend regarding crack interaction for all specimens. For example, the S4 specimens of Figure 3-2 showed that crack interaction was observed even when s/d (distance between two cracks/crack depth) is twice the value of what you proposed.

- It is not clear whether the fatigue crack growth equation used in generating the plots in Figure 3-2 is the American Society of Mechanical Engineers curve for carbon and low alloy ferritic steels, and whether the same crack growth equation (same constant and exponent) was used for all specimens.

RAI 158-2

Concerning pages 5-3 through page 5-16 of the BWRVIP-158 report, the test specimen materials used by Miller, Connors, Hasegawa, and Battelle are different from the BWRVIP internal materials. Compare the mechanical properties of the test specimens used by Miller, Connors, Hasegawa, and Battelle with the mechanical properties of BWRVIP internals. Justify the applicability of the test data mentioned above to the current application for adjacent cracks in parallel planes.

RAI 158-3

On pages 5-4 and 5-16, the BWRVIP-158 report proposed an empirical equation, Equation 5-1, to estimate the load capability of parallel cracks on different planes. BWRVIP-158 has applied this equation to Miller's test data, and the staff has confirmed the validity of the values reported on page 5-4 regarding the calculated load capability based on Equation 5-1. However, when the same calculated values are reproduced in Figure 5-4 (on page 5-16), they assume different values. Please clarify.

ENCLOSURE

RAI 158-4

On page 6-2, the BWRVIP-158 report proposed in Section 6.1.3 equations for effective crack length calculations based on measured crack lengths for adjacent flaws. Regarding the consideration of NDE uncertainties, it is stated in the last paragraph of Section 6.1.1 that , "If the inspection techniques do not meet the above criteria, the Evaluation Factors identified in the current edition of BWRVIP-03 [15] must be added to each flaw." The NDE uncertainty for BWRVIP internals is still under staff review. Therefore, to detach the staff determination on NDE uncertainty for BWRVIP internals from this staff review, please consider the following revision: "Depending on whether the inspection techniques meet the above criteria, Evaluation Factors identified in the current edition of BWRVIP-03 [15], as modified by the pending staff SE on the NDE uncertainty for BWRVIP internals, must be added to each flaw."

RAI 158-5

On page 6-2, the BWRVIP-158 report proposed in Section 6.1.3 Equations 6-1 through 6-4 for effective crack length calculations for adjacent flaws of different orientations. It is stated in the last paragraph of Section 6.1.1 that, "Since the NDE uncertainty includes location errors also, any uncertainty factor l_{NDE} should be added at each crack tip." Please confirm that, based on this statement, Equations 6-1 through 6-4 should be revised as follows (revisions are underlined):

- $L_{eff} = (L_1 + L_2 + 2CG + S + \underline{2\ l_{NDE}})$ Equation 6-1
- $L_{1\,eff} = (L_1 + 2CG + \underline{2\ l_{NDE}})$ Equation 6-2
- $L_{2\,eff} = (L_2 + 2CG + \underline{2\ l_{NDE}})$ Equation 6-3
- $L_{eff} = (L_1 + S + CG + \underline{l_{NDE}})$ Equation 6-4

<u>TYPOGRAPHIC ERRORS AND MINOR ISSUES:</u>

RAI 158-6

On page 5-22 of the report, confirm that the parameter for the horizontal axis of Figure 5-10 should be a/t instead of d/t.

RAI 158-7

On page 8-1 of the report, add the published year for Hasegawa's paper (Reference 6) and verify the Journal name and volume number.

RAI 158-8

On page 8-1 of the report, confirm that the page numbers for reference 6 should be 981-1000 instead of 1001-1020.

CONFIRMATION:

RAI 158-9

The staff independently derived Equations 5-2 to 5-4 and used them to validate the values in Table 5-4, as follows. Confirm these validations.

a) For test specimen 1D in Table 5-4

$a = 2.5$ mm
$d = 30$ mm
$t = 10$ mm
Using Equation 5-1:

$F = Fc + (Fs - Fc) \times (d/t - 1)/2$

where: $Fc = (1 - 2a/t)$ (Co-linear model)
$= 0.5$
$Fs = 2c/t + a/t - 1$ (Separate-crack model)
$= 2 \times 0.6453 + 0.25 - 1$
$= 0.5406$

when $a/t = 0.25$ then Equation 5-3 $\Rightarrow (c/t)^2 - 0.5\,(c/t) - 0.09375 = 0$

$c/t = [0.5 + \sqrt{(0.25 + 4 \times 1 \times 0.09375)}]/2$
$= 0.6453$

$F = 0.5 + (0.5406 - 0.5) \times (3 - 1)/2$
$= 0.5406$ (verified)

b) For test specimen 3D in Table 5-4

$a = 5$ mm
$d = 30$ mm
$t = 10$ mm
Using Equation 5-1:

$F = Fc + (Fs - Fc) \times (d/t-1)/2$

where: $Fc = (1 - 2a/t)$ (Co-linear model)
$= 0$
$Fs = 2c/t + a/t - 1$ (Separate-crack model)
$= 0.707 + 0.5 - 1$
$= 0.207$

when $a/t = 0.5$ then Equation 5-3 $\Rightarrow (c/t)^2 + 0\,(c/t) - 1/8 = 0$

$c/t = 0.3535$

$F = 0 + 0.207 \times 1$
$= 0.207$ (verified)