June 16, 2003

Mr. W. E. Cummins, Director
AP600 & AP1000 Projects
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355

Dear Mr. Cummins:

The potential open item letter for draft safety evaluation report (DSER) Chapter 3, "Design of Structures, Components, Equipment, and Systems," was issued on May 29, 2003. Enclosed for your information is an amendment to Open Item 3.6.3.4-2 concerning leak-before-break (LBB) and the analysis Westinghouse Electric Company (Westinghouse) should perform to ensure that all AP1000 LBB candidate piping systems can meet their bounding analysis curves at the combined license phase. The staff expects to issue the final version of this open item in a supplemental DSER to Chapter 3. The staff may hold a public meeting prior to the issuance of the Chapter 3 supplemental DSER to discuss this issue further with Westinghouse.

Please contact one of the following members of the AP1000 project management team if you have any questions or comments concerning this matter: Mr. John Segala (Lead Project Manager) at (301) 415-1858 or jps1@nrc.gov, Mr. Joseph Colaccino at (301) 415-2752 or jxc1@nrc.gov, or Ms. Joelle Starefos at (301) 415-8488 or jls1@nrc.gov.

Sincerely,

/RA/

James E. Lyons, Director
New Reactor Licensing Project Office
Office of Nuclear Reactor Regulation

Docket No. 52-006

Enclosure: As stated

cc: See next page

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OFFICE	PM:NRLPO	(A)DD:NRLPO	D:NRLPO
NAME	JColaccino	JWilliams	JLyons
DATE	06/16/03	06/16/03	06/16/03

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Westinghouse AP1000
Draft Safety Evaluation Report
Potential Open Items
Chapter 3
Design of Structures, Components, Equipment, and Systems

Open Item Number: 3.6.3.4-2

Original RAI(s): 251.005

Summary of Issue: In GDC 4 [Criterion 4 of 10 CFR Part 50, Appendix A, “General Design Criteria for Nuclear Power Plants”], “Environmental and Dynamic Effects Design Bases,” the NRC states, in part, that "dynamic effects associated with postulated pipe ruptures in nuclear power units may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping."

The analyses referred to in GDC 4 should be based on specific data such as piping geometry, materials, and piping loads. For past generic and plant-specific LBB [leak-before-break] reviews, the staff reviewed the LBB analyses for piping systems with specific piping designs. However, applicants seeking design certification for ALWRs [advanced light water reactors] under 10 CFR Part 52 are allowed to incorporate preliminary stress analysis results in their LBB analyses, provided bounding limits (both upper and lower bound) are determined to establish assurance that adequate margins are available for leakage, loads, and flaw sizes. These bounding values and preliminary analyses can be verified when as-built and as-procured information becomes available during the COL [combined license] phase. Verification of the preliminary LBB analysis should be completed at the COL phase based on actual material properties and final, as-built piping analysis as part of ITAAC associated with 10 CFR Part 52 prior to fuel loading. The preceding staff position on LBB application is stated in SECY-93-087 and was approved by the Commission in its SRM dated July 21, 1993.

RAI [request for additional information] 251.009 sought additional clarification on the construction of BACs [bounding analysis curves], including the meaning of the horizontal part of the BACs. The applicant’s response showed that for the leftmost point of the horizontal segment of a BAC, its critical flaw size was obtained using a flow stress as the maximum stress. Corresponding normal stress was determined using a leakage flaw size of one half the critical flaw size. Further, a stress point to the right of the leftmost point of the horizontal segment will provide higher LBB margin since the leakage flaw size will be smaller with a higher normal stress. The NRC staff accepts this interpretation and

determined that using a horizontal segment for the right portion of BACs is conservative. RAI 251.009 also requested that the applicant construct design curves considering all ASME [American Society of Mechanical Engineers] Code requirements on piping stresses and to perform traditional LBB analyses for lines whose design curves exceed their corresponding BACs by 25 percent. The applicant's response to RAI 251.009 states that due to the difference in loading combinations and acceptance criteria between ASME piping qualification vs. LBB BAC, it is difficult to construct such a design curve requested by the staff. The response further states:

> [T]hat's why for all thirteen AP1000 candidate Leak-Before-Break piping systems..., both ASME stress criteria and LBB stress criteria need to be satisfied as defined in the appropriate AP1000 Piping Analysis Criteria documents. The corresponding AP600 piping systems have all been evaluated for both ASME criteria and LBB criteria and found to be acceptable.

The staff agrees with the applicant's response in principle. However, AP600 experience is not a guarantee that all AP1000 LBB candidate piping systems will meet their respective BACs. Since this concern is covered by the staff's concerns regarding validation of the BACs under Open Item 3.6.3.4-2, the staff considers RAI 251.009 closed.

As discussed in Section 3.6.3.2 of this report, the staff determined that potential degradation mechanisms such as erosion-corrosion induced wall thinning, water hammer, fatigue, thermal aging, and thermal stratification, have been appropriately addressed. Since the V.C. Summer main coolant loop weld cracking event involving Alloy 82/182 weld material, the staff has considered the effect of PWSCC [primary water stress corrosion cracking] on Alloy 82/182 piping welds as an operating-plant issue, potentially affecting piping with or without approved LBB applications.

In RAI 251.004, the staff requested that the applicant address the following: (1) clarify whether Alloy 600 material, which is susceptible to PWSCC as indicated by the V.C. Summer primary loop leakage, will be used in any of the AP1000 LBB candidate piping systems, (2) provide test and plant operational data demonstrating that the proposed weld material, Alloy 52/152, is not susceptible to PWSCC, and (3) provide an inspection plan licensees would perform to address additional inspection techniques for detecting tight flaws that might exist in LBB piping welds.

The applicant's response to RAI 251.004 states the following: (1) Alloy 600 will not be used for any of the AP1000 LBB candidate piping systems; (2) Alloy 52/152 weld material (for Alloy 690 base material) has been used in various applications such as steam generator welds and safe end-nozzle welds for 9 plants (7 years in one application) without any reported instances of environmental degradation, and although

laboratory data for Alloy 52/152 in simulated primary water is limited, they indicated no environmentally-related crack propagation was observed for periods up to 4122 hours; and (3) since Alloy 52/152 weld material has better crack resistance than Alloy 82/182, augmented inservice inspection using eddy current testing (ET) to supplement ASME Code required ultrasonic testing (UT) should not be necessary for the AP1000 applications.

The staff considers the information provided for (1) to be complete and that no further information is required. Regarding (2), although the chrome content of Alloy 52/152 is approximately twice the chrome content of Alloy 82/182, making Alloy 52/152 more resistant to PWSCC, the test and plant operational data for Alloy 52/152 are for periods less than 7 years. This is not long enough for the NRC staff to consider the question of PWSCC for Alloy 52/152 material in the AP1000 LBB candidate piping to be resolved, considering the licensing period for AP1000 facilities.

To address this issue for currently operating plants, the industry has undertaken an initiative to (1) develop overall inspection and evaluation guidance, (2) assess the current inspection technology, and (3) assess the current repair and mitigation technology. An interim industry report, "PWR [pressurized-water reactor] Materials Reliability Project Interim Alloy 600 Safety Assessment for U.S. PWR Plants (MRP-44), Part 1: Alloy 82/182 Pipe Butt Welds," was published in April 2001 to justify the continued operation of PWRs while the industry completes the development of the final report. The final industry report on this issue has not yet been published. Subsequent to staff review and evaluation of the final report and receipt of additional Inconel UT inspection data from the industry, the staff will determine if additional regulatory actions will need to be imposed to address the potential for PWSCC to occur in lines with currently approved LBB analyses in operating plants. To address this issue for the AP1000 application, the applicant needs to modify its DCD Tier 2 Section 3.6.4 on COL information to indicate that COL holders should implement inspection plans, evaluation criteria, and other types of measures imposed on or adopted by operating PWRs with currently approved LBB applications as part of the resolution of concerns regarding the potential for PWSCC in those units. This is Open Item 3.6.3.4-1.

In RAI 251.005, the staff requested that the applicant provide values of crack morphology parameters, e.g., surface roughness, number of 45 degree and 90 degree turns, etc., that were used in generating the BACs for LBB. The NRC staff also asked for a comparative study, using the values of crack morphology parameters associated with transgranular stress corrosion cracking (TGSCC). This information and the study were requested to evaluate the BACs and to understand the sensitivity of the AP1000 LBB analyses to a crack morphology similar to PWSCC. In its response to RAI 251.005, the applicant provided the values of crack

morphology parameters used in generating the BACs. However, since chlorides will be controlled at minimum levels in the AP1000 LBB candidate piping systems water environment and the hydrogen overpressure will keep the oxygen levels to near zero, the applicant discounted the possibility of TGSCC and considered the comparative study using the crack morphology parameters associated with TGSCC not necessary. The applicant's argument does not address the intent of RAI 251.005. The NRC staff performed an independent sensitivity study to assess the impact on the BACs due to a consideration of a TGSCC type of crack in the LBB analysis as a surrogate for PWSCC. The NRC staff's independent sensitivity study shows that the BACs might not be easily met by the most limiting piping. DCD [design control document] Tier 2 Appendix 3B.3.3.4 does not rule out the possibility of a LBB candidate piping system not meeting the BAC limit either, as evidenced by the statement: "[i]f the point falls above the bounding analysis curve, the leak-before-break analysis criteria are not satisfied and the pipe layout or support configuration needs to be revised to meet the leak-before-break bounding analysis."

To provide assurance that all AP1000 LBB candidate piping systems can meet their BACs at the COL phase consistent with the staff position in SECY-93-087, the applicant needs to calculate preliminary piping stresses according to DCD Tier 2 Appendix 3B.3.3 for the five most limiting AP1000 LBB candidate piping subsystems and compare the resulting stresses to their respective BACs. Alternatively, the applicant may perform a traditional LBB analysis for the five most limiting AP1000 candidate piping systems and report the calculated ratio between the critical flaw size and the leakage flaw size. In this case, the applicant's preliminary analyses may utilize the crack morphology parameters provided by their response to RAI 251.005, however, the previously requested sensitivity study using a TGSCC morphology assumption should also be performed. This is Open Item 3.6.3.4-2.

AP 1000

cc:

Mr. W. Edward Cummins
AP600 and AP1000 Projects
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230-0355

Mr. H. A. Sepp
Westinghouse Electric Company
P.O. Box 355
Pittsburgh, PA 15230

Lynn Connor
Doc-Search Associates
2211 SW 1ST Ave - #1502
Portland, OR 97201

Barton Z. Cowan, Esq.
Eckert Seamans Cherin & Mellott, LLC
600 Grant Street 44th Floor
Pittsburgh, PA 15219

Mr. Ed Rodwell, Manager
Advanced Nuclear Plants' Systems
Electric Power Research Institute
3412 Hillview Avenue
Palo Alto, CA 94304-1395

Charles Brinkman, Director
Washington Operations
Westinghouse Electric Company
12300 Twinbrook Parkway, Suite 330
Rockville, MD 20852

Mr. R. Simard
Nuclear Energy Institute
1776 I Street NW
Suite 400
Washington, DC 20006

Mr. Thomas P. Miller
U.S. Department of Energy
Headquarters - Germantown
19901 Germantown Road
Germantown, MD 20874-1290

Mr. David Lochbaum
Nuclear Safety Engineer
Union of Concerned Scientists
1707 H Street NW, Suite 600
Washington, DC 20006-3919

Mr. Paul Gunter
Nuclear Information & Resource Service
1424 16th Street, NW., Suite 404
Washington, DC 20036

Mr. Tom Clements
6703 Guide Avenue
Takoma Park, MD 20912

Mr. James Riccio
Greenpeace
702 H Street, NW, Suite 300
Washington, DC 20001

Mr. James F. Mallay, Director
Regulatory Affairs
FRAMATOME, ANP
3315 Old Forest Road
Lynchburg, VA 24501

Mr. Ed Wallace, General Manager
Project Management
Lake Buena Vista Bldg., 3rd Floor
1267 Gordon Hood Avenue
Centurion 0046
Republic of South Africa
PO Box 9396 Centurion 0046

Mr. Vince Langman
Licensing Manager
Atomic Energy of Canada Limited
2251 Speakman Drive
Mississauga, Ontario
Canada L5K 1B2

Mr. Gary Wright, Manager
Office of Nuclear Facility Safety
Illinois Department of Nuclear Safety
1035 Outer Park Drive
Springfield, IL 62704

Dr. Gail H. Marcus
U.S. Department of Energy
Room 5A-143
1000 Independence Ave., SW
Washington, DC 20585

Mr. Edwin Lyman
Nuclear Control Institute
1000 Connecticut Avenue, NW
Suite 410
Washington, DC 20036

Mr. Jack W. Roe
SCIENTECH, INC.
910 Clopper Road
Gaithersburg, MD 20878

Patricia Campbell
Winston & Strawn
1400 L Street, NW
Washington, DC 20005

Mr. David Ritter
Research Associate on Nuclear Energy
Public Citizens Critical Mass Energy
and Environmental Program
215 Pennsylvania Avenue, SE
Washington, DC 20003

Mr. Michael M. Corletti
Passive Plant Projects & Development
AP600 & AP1000 Projects
Westinghouse Electric Company
P. O. Box 355
Pittsburgh, PA 15230-0355