Docket File

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NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

April 11, 1996

Mr. Nicholas J. Liparulo, Manager
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SUBJECT: STATUS OF DRAFT SAFETY EVALUATION REPORT (DSER) OPEN ITEMS IN STANDARD SAFETY ANALYSIS REPORT (SSAR) SECTIONS 3.6.3 AND 3.12 FOR THE CIVIL ENGINEERING AND GEOSCIENCES BRANCH (ECGB) REVIEW OF THE AP600 REACTOR DESIGN

Dear Mr. Liparulo:

The Nuclear Regulatory Commission (NRC) ECGB, completed its review in the mechanical engineering area of the AP600 SSAR through Revision 5. As an aid to reinitiate this review, ECGB prepared a summary of the status of some of the DSER open and confirmatory items in the scope of review for Chapter 3, "Design of Structures, Components, Equipment, and Systems." The enclosed summary includes items in DSER Section 3.6.3, "Leak-Before-Break Evaluation," and 3.12, "Piping Design."

The summary contains the latest staff positions relative to open and confirmatory items that were in the DSER issued November 1994. Items in the sections listed above that are not in the summary are considered resolved based on SSAR revisions. The status of many issues do not agree with the Westinghouse AP600 Open Item Tracking System (OITS) database. In addition, there are several areas where technical differences have been identified that were not in the DSER. Please update the OITS database to reflect these changes.

This summary is intended to assist in communications between the NRC and Westinghouse, to inform Westinghouse of various staff positions, and can serve as an agenda for conference calls and/or meetings with the staff. Please contact me at (301) 415-8548 if you have any questions or when you are ready to discuss any of these issues.

A summary of the open items in DSER Section 3.9.6, "Testing of Pumps and Valves" which is also in the mechanical engineering scope of the review, will be submitted in a separate transmittal.

Sincerely,

original signed by:

Diane T. Jackson, Project Manager
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Office of Nuclear Reactor Regulation

Docket No. 52-003

Enclosure: As stated

cc w/enclosure:
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AP600

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Status of AP600 Remaining Open Items in
Chapter 3.6.3: Leak-before-break

(Up to SSAR Revision 5)

ITEM NO. & STATUS	DESCRIPTION
3.6.3.4-1 (608) Action W	LBB Bounding Analysis (A) Revise description of methodology and acceptance criteria of the LBB bounding analysis in SSAR Revision 4 to incorporate information provided in the March 15, 1995 handouts and in the July 25-26, 1995 meeting, and to address all LBB evaluation. Especially, how a margin of 2 between the leakage crack size and the critical crack size can be verified and were calculated under what loads respectively are not clearly stated. SSAR Subsection 3.6.3.2 and Appendix 3B should be revised to ensure compliance of LBB methods and acceptance criteria with guidelines stated in NUREG-1061, Volume 3 and SRP 3.6.3. (B) The proposed load combination for the LBB evaluation for the FW line is unacceptable. SRP 3.9.3 does not permit load combinations to be developed based on probabilistic arguments. (See evaluation of Open Item 3.6.3.5-5) (C) As indicated in the July 25-26, 1995 design review meeting, the staff has been unable to verify the leak rate in the Westinghouse LBB evaluation of the 4 inch ADS line (See DSER Open Item 3.6.3.6-4). The staff utilized the PICEP computer code in its verification analysis. A further meeting is needed to review the details of Westinghouse LBB bounding analyses to resolve this issue.
3.6.3.4-2 (609) Action W	COL applicant to verify LBB bounding analyses (same as COL Action Item 3.6.3.4-1) on materials, as-built analyses, and acceptance parameters. Newly added SSAR Section 3.6.4.2, Revision 4 is partly acceptabe. Only COL actions regarding reconciliation of as-built piping materials were addressed. Additional COL actions regarding reconciliation of as-built piping design parameters, in addition to verification that as-built stresses are within the limits of bounding analyses, such as pipe diameter, configurations, characteristics of supports, etc. were not included. Thus new Section 3.6.4.2 needs to be revised. DSER COL Action Item 3.6.3.4-1 and DSER Open Item 3.6.3.4-2 remain open and further Westinghouse action is needed.

3.6.3.5-2 (611) Action W — Class 1 vs. Class 2 differences in analysis, fabrication, and inspection - RAI 252.5

(1) Perform fatigue crack growth analyses for each ASME Code Class 2 system for which LBB is demonstrated; (2) Include the two terminal end welds to the steam generator nozzles for the MS and FW lines in the PSI and ISI program; and (3) Provide explanation of the significance of differences in analysis, fabrication, and inspection requirements between Class 1 and 2 systems, as requested in Q252.5, should be provided.

3.6.3.5-5 (614) (2422 to 2428) Action W — Justification of LBB for MS and FW - RAI 252.13

In a letter dated May 2, 1995, the staff requested the following additional information about the feedwater lines:

(A) Discuss the steps taken to ensure that waterhammer is not a concern in feedwater line.

During the meeting, W described various design and operating features to address water hammer concerns on the FW system. The staff observed that these features would serve to minimize, but not necessarily eliminate, water hammer occurrences in the AP600 FW system. In addition, the staff also observed that there was no operating experience for the AP600 FW design, and consequently the application of the LBB methodology to the AP600 FW system may not be acceptable.

(B) Explain why thermal stratification is not a concern and what assurance is there that thermal stratification will not occur in the feedwater line.

(C) Commit to perform augmented ISI (100% volumetric inspection every inspection interval) at the feedwater nozzles connecting to the steam generator.

(D) In addition to performing ASME Code Class 1 stress and fatigue evaluation at the nozzle connecting to steam generator, perform a Class 1 equivalent fatigue evaluation for the Class 2 portion of the feedwater line.

(E) Discuss any significant differences in the ASME Code Class 1 ISI and fabrication requirements from the requirements applicable to the Class 2 portion of the feedwater line inside containment that affect LBB assumptions.

(F) Verify that the dynamic load used for design bounds the effects of feedwater pipe break outside containment (including isolation check valve slamming) and the effects of a postulated water hammer event.

The staff reviewed W letter NTD-NRC-95-4564 on the subject of "AP600 Feedwater Line Load Combination." The letter requested that in load combinations for applying LBB to main feedwater lines, effects of dynamic loads due to feedwater line break in the turbine building need not be included, especially the break induced depressurization loads. The staff has the following concerns:

(a) In Enclosure 1 of the letter, W provided a probabilitic approach, which concludes that probability of a pipe break in nonsafety-related main feedwater pipe in the turbine building is negligibly small. Thus the depressurization transient loads induced by such a break is an event of low probability and should be excluded from LBB load combination considerations.

The staff has the following concerns:

a. General Design Criterion 4 requires that structures, systems, and components important to safety shall be designed to accomodate dynamic effects of pipe ruptures. The staff position to postulate pipe rupture is delineated in SRP 3.6.2. The Branch Technical Position MEB 3-1 is a deterministic criteria which governs pipe rupture postulation of high energy lines inside and outside the containment, either designed by the ASME Code or other than ASME Codes. The criteria should also be applicable to the feedwater lines.

b. Although the General Design Criterion 4 permits exclusion of dynamic effects associated with postulate pipe ruptures from design basis when analyses demonstrated that the probability of pipe rupture is extremely low, it is a general requirement without specific acceptance criteria. The staff position on an acceptable approach is as delineated in the NUREG-1061, Volume 3, which indicates that, for justifying such exclusion, a deterministic fracture mechanics evaluation should be performed for demonstrating sufficient margins against pipe failure.

c. Currently, piping design is based on deterministic Code rules with specified loads and load combinations, and the pipe stresses should be deterministically calculated for meeting specific limits under various defined plant operating conditions. No probabilistic approach is allowed in the piping design.

(b) W indicated that the feedwater line anchor located at the exterior auxiliary building wall will eliminate transfer of dynamic loads from the feedwater line break in the turbine building.

The staff evaluation concludes that the anchor may be effective to prevent transfer of jet thrust loads due to a feedwater line break in the turbine building. However, the portion of feedwater line inside containment will still be affected by the break induced depressurization loads.

Based on the above discussion, the staff evaluation concludes that the bases and the probabilistic approach included in the W letter for justifying exclusion of dynamic effects of feedwater line break in the turbine building is unacceptable.

(G) Provide a discussion of the reduced thermal load effects in the feedwater line resulting from rerouting the auxiliary feedwater to a separate nozzle on the steam generator.

(H) Discuss how erosion-corrosion effects have been minimized or eliminated in the feedwater line inside containment.

(I) Discuss how fatigue effects due to dynamic operational vibration cycles have been minimized in the feedwater line.

(J) Commit to provide instrumentation for monitoring any unanticipated dynamic loads in the feedwater line inside containment.

In OITSD No. 614 on September 15, 1995, W committed to revise the SSAR Appendix 3B to address the above staff concerns to both the MS and FW lines. Thus DSER Open Item 3.6.3.5-5 remains open.

3.6.3.6-1 (615) Action W

Soil conditions for LBB analyses - RAI 210.10

During the meeting on July 27, 1995, W indicated that Appendix 3B will be extensively revised and that the worst case soils condition will be used in the bounding analyses. Thus closure of this open item is pending W action to implement its commitment in the bounding analyses, which will be verified at a future meeting.

3.6.3.6-2 (616) Action W

Staff piping design review - RAI 252.11
This item will be evaluated as a part of Open Item 3.6.3.4-1.

In Q252.11, the staff requested W to clarify whether the stresses in Tables 3B-3 and 3B-4 of the SSAR used in the LBB evaluation of the RCL, were from the analysis of routed or unrouted RCL piping. In the December 22, 1992 response to Q252.11, W indicated that the sample analysis for the RCL piping was based on routed RCL piping supported by primary equipment supports, but interconnected piping (e.g., the pressurizer surge line) was not included in the model. The staff intends to review these stresses in future piping design review meetings. Thus closure of this open item is pending further W action to complete the bounding analyses, which will be reviewed at a future meeting.

3.6.3.6-3 (617) Action W

0.5 gpm vs. 1.0 gpm leakage rate
The remaining portion of this issue will be resolved as a part of Open Item 3.6.3.4-1.

(A) Provide a commitment in SSAR that GW-N1-001 will be revised to make it consistent with the SSAR. (B) W committed to use a margin of 2.0 between the critical crack size and the leakage crack size as specified in the SSAR. According to guidance stated in NUREG-1061, Volume 3, paragraphs 5.2(e) and 5.2(h), the the leakage crack size should be calculated using normal loads and the critical crack size should be calculated using normal plus SSE loads. Verify its implementation in the SSAR and in the submitted bounding curves. (See also Open Item 3.6.3.4-1)

3.6.3.6-4 (618) Action W

Leakage rate evaluation methodology

This issue will be evaluated as a part of Open Item 3.6.3.4-1.

As discussed in the July 1995 meeting, the staff is concerned that the W leakage rate evaluation methodology may not be acceptable for calculating leakage rates in small size piping and especially in the single phase, low temperature flow state. As described in DSER Open Item 3.6.3.4-1, the staff was unable to verify the leakage rate in the W evaluation of the 4 inch ADS line.

3.6.3.6-6 (620) Action W

Waterhammer type loads in LBB analyses (Test results issue)

W has not yet responded to this open item. Preliminary results from small-break LOCA tests performed at Oregon State University indicate that rapid condensation events have the potential to cause unanticipated dynamic loads to occur in the AP600 RCS. These water hammer type loads have not been considered in the piping design loads to justify a LBB approach for the AP600 main coolant loop and attached piping. W was requested to address whether these water hammer type loads from condensation events need to be considered in its LBB analyses or, if not, justify why these loads can be excluded.

Status of AP600 Remaining Open Items in Chapter 3.12: Piping Design

(Up to SSAR Revision 5)

ITEM NO. & STATUS	DESCRIPTION
3.12.3-1 (822) Action W	Piping analysis methods Proposed response in Draft SSAR Revision 4 has not been incorporated into SSAR Revision 5. In addition, information relative to the modal response method and the time history analysis method is not completely acceptable: (1) For combination of response for the three directional components, although Section 3.7.3.9 states that the three directional responses are combined by the SRSS method, Section 3.7.3.6 provides an alternate method which allows combination of the responses from one direction with 40 percent of the responses from the other two directions (100 percent-40 percent-40 percent method). The staff has accepted this method in structural analysis due to evidence that the method is generally more conservative than using SRSS. However the staff has not accepted its application in piping analysis due to lack of evidence that similar conservatism also exist, because piping seismic response generally has narrower frequency bandwidth than response of structures. (2) The statement in Section 3.7.3.17 that the time steps are no larger than the time history input time steps is not sufficient. The SSAR should also include a description of the method to account for modeling uncertainties such as time history broadening. The use of composite modal damping with PS+CAEPIPE or WECAN is specified. The application of composite modal damping should be limited to account for variations of damping with pipe size. (See also Open Item 3.12.5.16-1)
3.12.3.7-1 (824) Action W	Non-seismic/seismic interaction (II/I) Response was proposed in Draft SSAR Revision 4. Information is acceptable with one exception, i.e., for the third method, W must provide a quantitative definition of the "rigid region" which is discussed in the Draft of SSAR Section 3.7.3.13.4.2. In addition, none of this information has been incorporated into the SSAR through Revision 5.
3.12.4.1-1 (825) Action W	Independent confirmatory piping analysis The independent confirmatory piping analyses have been completed. The comparison of the results of these analyses with the results of the W analyses did not meet the staff acceptance criteria. Further review and discussions with W are needed to resolve these differences.

3.12.4.2-1 (827) Action W — Dynamic piping model

Response was proposed in Draft SSAR Revision 4. Closing of this issue is pending (1) resolution of Open Item 3.12.4.4-2, and (2) incorporation of Draft Revision 4 into the SSAR.

3.12.4.3-1 (828) Action W — Commitment that COL will implement the benchmark program

This commitment has not been incorporated into the SSAR through Revision 5.

3.12.4.4-1 (829) Action W — Decoupling criteria - branch line mass and flexibility

The proposed response to this issue in Draft Revision 4 to the SSAR is acceptable. However, this response has not yet been incorporated into the SSAR through Revision 5.

3.12.4.4-2 (830) Action W — Decouplng criteria - Amplification at connection

W has not yet submitted an acceptable response to this issue. In order to limit significant amplification by the run pipe at the branch line connection point, W had proposed a one inch deflection limit on inertial displacement. This limit is technically inadequate, because the use of a deflection limit without consideration of branch line or run line frequencies cannot ensure against significant response spectrum amplification at the connection. The possibility of a frequency ratio criterion was discussed and Westinghouse agreed to give it further consideration. However, in Draft Revision 4 to SSAR Subsection 3.7.3.8.2.1, W included the same one inch deflection criterion which is unacceptable to the staff.

3.12.5.1-1 (831) Action W — Peak shifting method

The proposed response in Draft SSAR Revision 4 is acceptable. However, this response has not yet been incorporated into the SSAR through Revision 5.

3.12.5.3-1 (832) Action W — Loading combinations

The staff reviewed the response in SSAR Revision 4. Applicable tables in SSAR Section 3.9 were revised. However, the staff still has the following concerns:

(A) In Table 3.9-3, the relief/safety valve, open system, sustained load (RVOS) was still not included as a transient dynamic event (DU) associated with Level B (Upset) service conditions. It was instead included as a design mechanical load (DML). The safety/relief valve, open system, transient load (RVOT) was not included as either a DU or a DML load.

During the April 1995 design review meeting, Westinghouse had committed to clarify these classifications in the SSAR tables. This clarification and justification for the classifications is still needed.

(B) In Table 3.9-5, note (6) states that timing and causal relationships that exist between SSE and other dynamic events are considered for determination of appropriate load combinations. The staff position on dynamic load combinations is that dynamic responses of piping loadings should be combined by the SRSS method.

(C) Table 3.9-6 does not include any Equation (9) load combinations or primary stress limits for Design or Service Level A, B, C, or D conditions. In addition, Equations (15), (16), and (17) for flanged joints which were included in a previous table were also not included. Two separate load combinations for Equation (13) were given. One combination included RVOS while the other combination included DU which should include RVOS. Westinghouse needs to clarify this.

(D) In Table 3.9-7, load combinations and stress limits for Design Condition Equation (8) and for Service Level A, B, C and D Equation (9) were not included.

(E) In Table 3.9-11, the table did not include any Equation (9) Level D load combinations or stress limits. In addition the table should include the following additional restrictions from NUREG-1367: steady state stresses shall not exceed $0.25S_y$, dynamic loads must be reversing, and dynamic moments must be calculated using an elastic response spectrum method with ±15% peak broadening and with not more than 5% damping.

3.12.5.4-1 (833) Action W — Use of 5% damping values

The proposed information in Draft SSAR Revision 4, Section 3.7.3.15, Appendix 3C, and Table 3.7.1-1 is not completely acceptable. W would apply the five percent damping to coupled equipment and valves as well as to the piping. This is inconsistent with RG 1.84 which states that for equipment other than piping, RG 1.61 damping should be used. In addition, an inconsistency was found in Table 3.7.1-1. The table specifies 5 percent damping for the primary coolant loop (with no restriction on analysis method) and also an alternative 4 percent damping for the primary loop if time history or independent support motion response spectrum analysis is performed. The staff also reviewed Draft Revision 4 to Appendix 3C, "Reactor Coolant Loop Analysis

Methods and Results," Subsection 3C.4, and found that for the reactor coolant loop analysis, W would use either 5 percent damping when the uniform envelope response spectrum method is used or 4 percent when the independent support motion response spectrum method is used. The staff had earlier accepted the use of 4 percent damping for time history analysis of the reactor coolant loop based on a W study. However, the application of this damping value to an independent support motion analysis would require additional justification. The use of 5 percent damping for the coupled reactor coolant loop piping and equipment model is inconsistent with the RG 1.84 limitation described above.

3.12.5.6-2 (835) Action W

High frequency modes

The resolution of this issue is pending the resolution of the independent confirmatory piping analysis in Open Item 3.12.4.1-1.

3.12.5.9-1 (836) Action W

Thermal cycling analyses

SSAR Section 3.9.3.1.2, Revision 5 is not completely acceptable. SSAR Subsection 3.7.3.1.2 did not have sufficient information to assess the adequacy of the methodology that Westinghouse applied to identify susceptible systems, the methods to define the thermal loading, or the methods to calculate the effects of the thermal loads on the susceptible systems. W needs to provide further justification for identifying only one system susceptible to thermal cycling. In that system, the stratification was associated with normal bypass flow around the pressurizer spray valves instead of valve leakage. W should explain why none of the piping systems in AP600 are susceptible to isolation valve leakage normally associated with thermal cycling as described in NRC Bulletin 88-08. The methods to define the thermal loads and to calculate the fatigue usage associated with these loads are described in EPRI Report TR-103581. However, this report has not been provided to the staff for the AP600 review, nor has the methodology described in the report been approved by the NRC for general use.

3.12.5.10-1 (837) Action W

Thermal stratification evaluations

The information in SSAR Section 3.9.3.1.2 through Revision 5 is not completely acceptable. W has still not addressed the broader thermal stratification issue. Aside from the surge line and feedwater line, other systems or locations susceptible to thermal stratification or the methods used to identify and evaluate these systems are not described. Specific AP600 issues should be addressed. In addition, initial thermal hydraulics tests have shown that following a small-break LOCA event, the slow injection of cold water from the PXS could result in severe thermal stratification. These areas may be addressed in the EPRI TASCS Program Report TR-103581, however, as noted in Open Item 3.12.5.9-1 above, this report is not available to the staff.

3.12.5.12-1 (838) Action W — Functional capability

SSAR Table 3.9-11, which was revised in Revision 4 and was revised again in Revision 5, is still not consistent with NUREG-1367. The table did not include any Equation (9) Level D load combinations or stress limits. These load combinations and stress limits should be provided for both Class 1 and for Class 2 and 3 piping systems. The table also did not include the following additional restrictions from NUREG-1367: steady state stresses shall not exceed $0.25S_y$, dynamic loads must be reversing, and dynamic moments must be calculated using an elastic response spectrum method with ±15% peak broadening and with not more than 5% damping. Also, as noted above, W included load combinations and stress limits for Class 2 and 3 Equation 10a (single non-repeated anchor movement). The inclusion of these stress limits and their applicability to functional capability of piping should be clarified.

3.12.5.16-1 (839) Action W — Modal damping for composite structures

The SSAR, through Revision 5 has not yet been revised to incorporate the commitment made by W during the April 10-11, 1995 meeting, i.e, to revise the SSAR, Section 3.7 to state that, for piping systems other than the RCL, the use of composite modal damping will be limited to account for variations of damping with pipe size.

3.12.5.19-2 (842) Action W — Use of new code rules (S_h instead of S_m)

This is related to Open Item 3.12.5.12-1. W needs to provide another revision to the SSAR which provides functional capability limits that are consistent with all of the staff requirements, including the use of Equation (9) stress limits of $3.0S_h$ instead of $3.0S_m$ for Code Classes 2 and 3 piping.

3.12.5.19-5 (845) Action W — Reversing dynamic loads

This item will be resolved by Open Item 3.12.5.3-1.

3.12.5.19-7 (847) Action W & N — Applicable ASME Code Edition

This item will be resolved as a part of the resolution of Open Items 3.12.5.3-1 and 5.2.1.1-1

3.12.6-1 (848) Action W

Pipe support design criteria

This item will be resolved pending: (1) Resolution of Open Items 3.12.6.3-1, 3.12.6.5-1 and 3.9.3.3-1. (2) In Revision 4 to SSAR Section 3.9.3.4, W incorrectly reported a friction coefficient of 0.30 for steel-on-steel sliding surfaces. Correction of this coefficient to 0.35 is needed. (3) In the pipe support design criteria document, GW-P1-003, W states that for standard component supports, all manufacturer's functional limitations (travel limits, sway angles, etc.) must be strictly followed. Pipe movements for the normal condition should not result in support sway motion 4° from the support central position. Maximum sway for any loading combination should not exceed 5°. This criterion is applicable to limit stops, snubbers, rods, hangers and sway struts. Snubber settings should be chosen such that pipe movement occurs over the mid-range of snubber travel. Some margin shall be obtained between the expected pipe movement and the maximum or minimum snubber-stroke to accommodate construction tolerance. These requirements are acceptable and should be incorporated in the SSAR.

3.12.6.3-1 (850) Action W

Load combinations for pipe support design

In SSAR Revision 4, Table 3.9-8 was revised but it still contained a footnote stating that timing and casual relationships among SSE and other dynamic loads are considered to determine appropriate load combinations. Unless justification for this criteria is provided, this footnote should be replaced by the staff's position which requires earthquake loads to be combined with other dynamic loads by SRSS in accordance with NUREG-0484, Revision 1.

3.12.6.5-1 (851) Action W

Use of special engineered pipe supports (limit stops)

In response to this item, W submitted Draft SSAR Revision 4, Section 3.7.3.8.4, which included a description of the GAPPIPE methodology that will be used in the design and analysis of gapped supports (limit stops). The staff reviewed this information and found it acceptable. However, through SSAR Revision 5, Section 3.7.3.8.4 has not been revised to include this description.