Westinghouse Electric Corporation
Energy Systems
Box 355
Pittsburgh Pennsylvania 15230-0355

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Document Control Desk
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555

ATTENTION: T. R. QUAY

SUBJECT: STATUS OF DSER OPEN ITEMS RELATED TO PIPING ANALYSIS

Dear Mr. Quay:

In a letter dated April 11, 1996 from Diane T. Jackson, NRC to Nicholas J. Liparulo, Westinghouse, a summary of open items related to Section 3.12 of the DSER for which the NRC staff required additional information was provided. This letter is provided in response to that NRC letter and identify the information required for closure of the items. The attachment to this letter provides the information required for closure.

In addition to the items addressed in the April 11 letter, proposed changes to the SSAR are provided to address confirmatory item 3.12.5.5-1.

The meeting scheduled with the NRC staff for review of the piping analysis is scheduled for June 25 and 26, 1996. Closeout of these items can be discussed at that meeting.

Revision 7 of the SSAR introduced a change in the approach of the evaluation of pipe break hazards. The high energy pipe break hazard evaluation is performed during Design Certification. This includes the following activities.

1. identify the high energy line break locations and rooms on the nuclear island and in the turbine building adjacent to the main control room.

2. for each room with a high energy break, determine if there are essential systems, structures or components that are needed to mitigate the break.

3. for each room with essential systems, structures or components, identify the regions that are affected by pipe whip and jet impingement associated with the pipe breaks.

4. for each room, ensure that there is no adverse interaction between the essential items and the whipping pipe or jet. If necessary, identify the locations of pipe whip restraints and jet shields that are needed to protect the essential systems, structures and components.

These activities are available for NRC audit. Westinghouse will be ready to discuss the pipe break hazards evaluation and schedule for NRC review and audit during the review of the piping analysis

If you have any questions, please contact Donald A. Lindgren at (412) 374-4856.

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

/nja

Attachments

cc: D. Jackson, NRC
G. DiGrassi, BNL
N. Liparulo, Westinghouse (w/o attachments)

The following are the responses to the most recent NRC review of status of open items associated with the piping analysis in the AP600. The revision of subsection 3.7.3 included in SSAR Revision 7 addresses the majority of these items.

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

Item No. & NRC Status	Description Response, W Status
3.12.3-1 (822)	Piping analysis methods
Action W	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)

Response:

(1) The 100-40-40 method is not used for piping-SSAR 3.7.3.6, revision 7. This item is closed.

(2) For the PS+CAEPIPE program, the time history analysis is linear and the integration time step does not need to be smaller than the time step that defines the input loads. For WECAN and GAPPIPE programs the analysis may be linear or non-linear to account for support nonlinearities. For nonlinear analysis, the integration time step is varied to ensure a convergent solution, that is, that a smaller time step does not have a significant effect on the calculated response. SSAR 3.7.3.17, revision 7. This item is closed.

Time history broadening is accounted for in two ways. First, the SSE analysis covers a wide range of frequencies based on the four different soil cases. Second, when the

building model is coupled to the piping model, the stiffness of the building is varied by + or - 30 percent to account for uncertainties. SSAR 3.7.3.17, revision 7. This item is closed.

Westinghouse is not aware of any limitation on the use of composite modal damping with respect to the size of the pipe. The damping values are described in Table 3.7.1-1. This item requires more input from the NRC staff. The status for this item is Action N.

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.

Response:

The rigid region is defined in SSAR 3.7.3.13.4.2, revision 7. This item is closed.

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.

Response:

Westinghouse is working with Brookhaven to resolve the differences between the computer programs and the input models. This item is open. (Action W and N)

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.

Response:

(1) See response for item 3.12.4.4-2. (2) Changes to the SSAR were incorporated in Revision 7. This item is closed

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.

Response:

The benchmarking of the piping analysis programs will be completed during design certification. See response to open item 3.12.4.1-1 for a discussion of the independent confirmatory piping analysis. The Combined License applicant will implement the NRC benchmark program using AP600 specific problems if a piping analysis computer program other than PS+CAEPIPE, GAPPIPE, or WECAN is used. The first paragraph in subsection 3.9.1.2 will be revised as follows:

A number of computer programs that are used in the dynamic and static analyses of mechanical loads, stresses, and deformations, and in the hydraulic transient load analyses, of seismic Category I components and supports are listed in Table 3.9-15. A complete list of programs will be included in the ASME Code Design Reports. The Combined License applicant will implement the NRC benchmark program using AP600 specific problems if a piping analysis computer program other than those used for design certification (PS+CAEPIPE, GAPPIPE, and WECAN) is used.

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.

Response:

Branch line mass and flexibility is described in SSAR 3.7.3.8.1, revision 7. This item is closed.

3.12.4.4-2 (830) Action W

Decoupling 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.

Response:

The amplification of the run pipe is considered when significant as described in SSAR subsection 3.7.3.8.2.1, revision 7. This item is closed.

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.

Response:

The peak shifting method is described in SSAR subsection 3.7.3.9, revision 7. This item is closed.

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 $\pm15\%$ peak broadening and with not more than 5% damping.

Response:

(A) All loads classified as DML meet the Design stress limits of the ASME Code. Loads classified as DU meet the Level B stress limits. The ASME Design Specification will identify if RVOT is classified as DN, DU, or DE. RVOS is classified as DML. Table 3.9-3, revision 7. This item is closed.

(B) SSE loads are always combined with pipe break loads based on GDC 2. SSE combination with other event is based on a causal relationship with SSE occurring at 100 percent power. Table 3.9-5, revision 7. SSAR 3.9.3.1.1, revision 7. This item is open. (Action W and N)

(C) Table 3.9-5, revision 7, along with the 1989 ASME Code, establishes the requirements for Equation 9, 15, 16, and 17. The SSAR does not need to repeat the Code requirements. Table 3.9-6, revision 7. This item is open. (Action W and N)

(D) Table 3.9-5, revision 7, along with the 1989 ASME Code, establishes the requirements for Equation 8 and 9. The SSAR does not need to repeat the Code requirements. Table 3.9-7, revision 7. This item is open. (Action W and N)

(E) Table 3.9-5, revision 7, along with the 1989 ASME Code, establishes the requirements for Equation 9. The SSAR does not need to repeat the Code requirements. Based on NUREG-1367, the deadweight moment stress shall be limited to 0.25 Sy. The only nonreversing load in the NUREG is fluid hammer-slug flow loads. Section 7 of this NUREG states: "No increase in Code Equation (9) can be defended." No recommendation is given to reduce the current stress limit of 2.0 Sy for this load. Since AP600 is not increasing the stress limit for Equation (9), a distinction between reversing and nonreversing loads is not required. Table 3.9-11, revision 7. This item is open. (Action W and N)

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.

Response:

For seismic analysis of piping systems, RG 1.84 does not require the use of RG 1.61 damping values for equipment that is included in the couple piping model. This is the standard Westinghouse practice on operating plants. For seismic analysis of the equipment, the damping values are summarized in SSAR Table 3.7.1-1, revision 7. The 5 % damping for the Primary Coolant Loop piping is only used with the uniform envelope response spectra analysis. For other analysis methods, 4 % damping is used for the loop piping. This value is justified in Section 3.7, revision 7, Reference 22 for any analysis method. This item is open. (Action W and N)

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.

Response:

See response to open item 3.12.4.1-1 for a discussion of the independent confirmatory piping analysis.

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.

Response:

The methods used to assess thermal cycling are provided in the SSAR subsection 3.9.3.1.2 Revision 7. Calculations are available for NRC audit EPRI report TR-103581 has been submitted to NRC previously for use on the evaluation of operating

nuclear power plants. Westinghouse will provide a copy. This item is closed.

3.12.5.10-1 (837)
Thermal stratification evaluations

Action W

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 passive core cooling system 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.

Response:

Thermal stratification in the primary loop cold leg resulting from actuation of the passive core cooling system is discussed in SSAR subsection 3.9.3.12, Revision 7. For other systems, the effects of thermal stratification are considered when there is a potential temperature difference across the pipe diameter larger than 50°F. These loadings are defined n the ASME design specifications for ASME Code, Section III, Class 1, 2, and 3 piping systems. This item is closed.

3.12.5.12-1 (838)
Functional capability

Action W

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 $\pm 15\%$ 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.

Response:

See response to open item 3.12.5.3-1 for a discussion of load combinations. Also, Table 3.9-11, revision 7, provides stress limits for thermal expansion and steel containment vessel anchor motions. These limits are imposed since there is no ASME Code stress limits for Level C and D thermal conditions. This item is open. (Action W and N)

3.12.5.16-1 (839) Modal damping for composite structures

Action W

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 reactor coolant loop, the use of composite modal damping will be limited to account for variations of damping with pipe size.

Response:

See the response for open item 3.12.3-1 (2) for the response on modal damping. Westinghouse does not agree that the use of composite modal damping should be limited. Additional information is required from the NRC on this topic. The status of this item is Action N

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

Action W

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.

Response:

Westinghouse is not using 3.0 Sm for ASME Class 2/3 piping. This item is closed.

3.12.5.19-5 (845) Reversing dynamic loads

Action W

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

Resolved

See response to open item 3.12.5.3-1.

3.12.5.19-7 (847) Applicable ASME Code Edition

Action W & N

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.

Response:

See the response to open item 3.12.5.3-1 for a discussion of the load combinations to be used. SSAR subsection 5.2.1.1 identifies the 1989 ASME Code with 1989 Addenda as the baseline ASME Code for the AP600. Open item 5.2.1.1-1 is closed This item is open. (Action W and N)

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.

Response:

(1) 3.12.6.3-1: See response for open item 3.12.5.3-1.
3.12.6.5-1: See 3.7.3.8.4, revision 7. This item is closed.
3.9.3.3-1: This item is closed. See 3.6.2.3.2, revision 7. See 3.9.3.4, revision 7. See 3.10.1.3, revision 7. Permanent deformation of supports is allowed within the ASME Code stress limits.

(2) The ninth paragraph of SSAR subsection 3.9.3.4 will be revised as follows:

Friction forces induced by the pipe on the support must be considered in the analysis of sliding type supports, such as guides or box supports, when the resultant unrestrained thermal motion is greater than 1/16 inch. The friction force is equal to the coefficient of friction times the pipe load, and acts in the direction of pipe movement. A coefficient of friction of ~~0.30~~ 0.35 for steel-on-steel sliding surfaces shall be used. If a self-lubricated bearing plate is used, a 0.15 coefficient of friction shall be used. The pipe load from which the friction force is developed includes only deadweight and thermal loads. The friction force can not be greater than the product of the pipe movement and the stiffness of the pipe support in the direction of movement.

(3) The following paragraph will be added to SSAR subsection 3.9.3.4.

For standard component pipe supports, the manufacturer's functional limitations for example, travel limits and sway angles, should be followed. 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 the snubber travel. Some margin should be provided between the expected pipe movement and the maximum or minimum snubber-stroke to accommodate construction tolerance.

This item is resolved.

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 casuai 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.

Response:

See response for open items 3.12.5.3-1, and 3.12.6-1.

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.

Response:

See 3.7.3.8.4, revision 7. This item is closed.

Confirmatory item

3.12.5.5-1 The options specified in Section 3.7.3.7.2 of the SSAR, to combine closely spaced modes, are acceptable contingent on a positive finding in the confirmatory evaluations.

Response:

The SSAR will be revised as shown below to eliminate the need for confirmatory evaluation of alternate methods of combining low-frequency modes for piping analysis.

SSAR Revision:

Revise the first paragraph of subsection 3.7.3.7.2 as follows:

This subsection describes the method for combining modal responses in the seismic response spectra analysis. The total unidirectional seismic response for subsystems is obtained by combining the individual modal responses using the square root sum of the squares method. For subsystems having modes with closely spaced frequencies, this method is modified to include the possible effect of these modes. For piping systems, the methods in Regulatory Guide 1.92 are used for modal combinations. For other

subsystems, the methods in Regulatory Guide 1.92 or the following alternative methods may be used. The groups of closely spaced modes are chosen so that the differences between the frequencies of the first mode and the last mode in the group do not exceed 10 percent of the lower frequency.

Delete the last page of subsection 3.7.3.7.2 as shown below.

~~In addition to the above methods, any of the other methods in Regulatory Guide 1.92 may be used for modal combination.~~