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

ATTENTION: T. R. QUAY

SUBJECT: AP600 FEEDWATER LINE LBB LOAD COMBINATION

Dear Mr. Quay:

Westinghouse has had a number of meetings and discussions with the NRC staff on issues related to the application of leak-before-break criteria. One of the items as yet unresolved is definition of the load combinations to be used in the evaluation of the feedwater line. Because feedwater lines in operating plants have not been accepted for application of leak-before-break, there are no directly applicable precedents. The system design, layout, and material selection for the AP600 main feedwater lines in containment and in the break exclusion zone have addressed the issues of erosion-corrosion, water hammer, and fracture toughness that have precluded the application of leak-before-break criteria to feedwater lines in operating nuclear power plants.

Westinghouse has proposed load combinations for evaluation of the feedwater lines that do not include depressurization loads from a postulated break of the feedwater lines in the turbine building. This is similar to the evaluations of reactor coolant loop piping and branch lines that do not include the effects of a postulated pipe break in a connecting line not evaluated for leak-before-break criteria. The enclosed write-up provides a justification, based on probabilistic grounds, to exclude from the leak-before-break evaluation the effects of a feedwater line break in the turbine building . The design of the supports for the feedwater lines and the surrounding building structure preclude transfer of the effects of a postulated feedwater line break in the turbine building to the safety related portion of the feedwater piping. The pipe anchor located at the exterior auxiliary building wall eliminates transfer of loads and moments applied to the pipe in the turbine building. The auxiliary building wall eliminates consideration of pipe whip, jet impingement, and other dynamic effects.

Finalization of the feedwater line design and analysis is pending the resolution of the load combinations. Please review and ratify the use of the load combination without the break depressurization loads.

Please contact D. A. Lindgren at (412) 374-4856 with any questions. We will setup a phone call or meeting with the Westinghouse personnel technically responsible for leak-before-break evaluation to discuss the proposed load combination if necessary.

Brian A. McIntyre, Manager
Advanced Plant Safety and Licensing

/nja

Enclosure

cc: D. Terao, NRC
N. J. Liparulo, Westinghouse

Probability of Pipe Break in Main Feedwater Line Within Turbine Building and Load Combinations for Leak-Before-Break in the AP600 Plant

The following evaluation is provided to support the position that a failure of the nonsafety-related main feedwater line piping in the turbine building should not be included in the load combinations used to evaluate the leak-before-break characteristics of the feedwater line inside containment.

The 16 inch main feedwater piping inside the steel containment vessel is evaluated for leak-before-break to avoid unnecessary plant hardware and to increase plant safety. The load combinations used for leak-before-break exclude events of low probability. This is because the probability that these loading events will occur when a through wall crack exists in the 16 inch main feedwater piping inside containment is extremely low. Failure of the main feedwater line in the turbine building has the potential of causing an internal system depressurization transient to be induced in the portion of the piping system within the nuclear island structure (safety-related portion). The main feedwater line in the turbine building consists of 16 inch and larger diameter carbon steel piping. If the probability causing internal system depressurization loads due to a break in the main feedwater line in the turbine building is very small, then the loading transient can be considered unrealistic. Given below is the rationale that demonstrates that this probability is small given the occurrence of an earthquake equal to the safe shut down earthquake (SSE) level of 0.3 g.

Probabilities of pipe break within the safety portions of nuclear power plant piping systems have been studied by industry and regulatory agencies. The probability of a reactor coolant loop pipe break has been shown to be small, and has been demonstrated through evaluation programs and actual earthquake experience data. Examples of results considering earthquakes larger than the SSE are given in Table 1. As seen from the results given in the table, considering earthquakes larger than the safe shutdown earthquake, the probability of a direct or indirect double-ended, guillotine break (DEGB) is very low with the indirect DEGB about four orders of magnitude higher. Similar results are expected for the main feedwater piping within the containment.

Table 1 - Recognized Reactor Coolant Loop Piping Failure Probabilities Given Seismic Events Larger than the SSE

Description	Upper Bound Probability (events/ plant-year)	Reference	Comments
Direct Double-Ended Guillotine Break (DEGB)	7.5×10^{-10}	NUREG-1061 Volume 3 11/84 (Table 3-1)	Based on Eastern and Midwestern Westinghouse PWR Plants Generic seismic hazard curves used
Leak	2.4×10^{-7}	NUREG-1061 Volume 3 11/84 (Table 3-1)	Based on Eastern and Midwestern Westinghouse PWR Plants Generic seismic hazard curves used
Indirect DEGB (Example - Induced by Support Failure)	7.0×10^{-6}	NUREG-1061 Volume 3 11/84 (Table 3-3)	Considers all Westinghouse PWR Eastern Plants Generic seismic hazard curves used

AP600 Specific Feedwater Line Probabilities

In order to reflect AP600 specifically, an estimate is given below of the probability, given the occurrence of the SSE (0.3 g), of a pressure boundary failure of the main feedwater lines in the turbine building.

To define the probability of a loss in pressure boundary of the AP600 main feedwater line in the turbine building, probabilities of events that can result in the pipe break are defined. The events considered are the following:

- o Probability of the SSE event occurring

  The probability is defined from the seismic hazard curves representing the rock and soil sites in the central and eastern United States.

- o Probability of a gross deformation (failure) of the turbine building

  The probability of large deformation of the turbine building is estimated by defining areas of design margin recognizing that the turbine building is designed for seismic levels of 0.3 g in accordance with the Uniform Building Code (UBC). Areas of reserve strength exist in material properties, ductility, redundancy, code allowables, and stress level. It is noted that from experience data of real earthquakes, piping has not failed (broken) when placed in structures of similar construction when subjected to large seismic events.

- o Probability of local failure within turbine building causing break in piping

  Piping is very robust even with loss of supports; however, a local failure within the turbine building could cause impact resulting in a break of the piping within the turbine building causing internal system depressurization loads. The probability used reflects a conservative 5% local failure probability and a 10% probability that sufficient loads would be induced in the pipe at a flaw causing loss of pressure boundary.

- o Probability of a significant flaw

  The main feedwater piping in the turbine building is ASTM A106 Grade B carbon steel piping. Fabrication is performed with good industry practice. A probability of a significant flaw that would cause the pipe to break given turbine building local failure or gross deformation is expected to be small. It is conservatively considered to be 20%. However, it is probably much less than one percent. It is noted that local failure impact and/or pipe break could occur at a location away from a flaw, however the probability of pipe break would be much less than 20% at this location.

The probabilities of each event are given in Table 2.

Table 2 - Event Probabilities Associated with Main Feedwater Break Within the Turbine Building

Description	Conservative Estimate of Probability	Comments
Probability of an SSE	1×10^{-4}	The probability of the SSE obtained from mean seismic hazard curves for rock and soil sites in the central and eastern United States.
Failure Probability of Turbine Building (Gross Deformation)	1×10^{-1}	Seismic loads are defined in accordance with the Uniform Building Code for Zone 3 with an Importance Factor of 1.0.
Probability of Local Failure of Turbine Building impacting main feedwater piping	5×10^{-3}	Reflects the probability of having a local failure in turbine building such that it impacts the pipe at the location of flaw that results in the loss of pipe pressure boundary.
Probability of a Significant Flaw in Turbine Building Main Feedwater Piping	2×10^{-1}	Construction performed with good industry practice

In Figure 1 is shown the logic sequence. There are two paths that lead to failure. One path considers gross turbine building deformation, and the other local failures within the turbine building that impact the piping and cause a break.

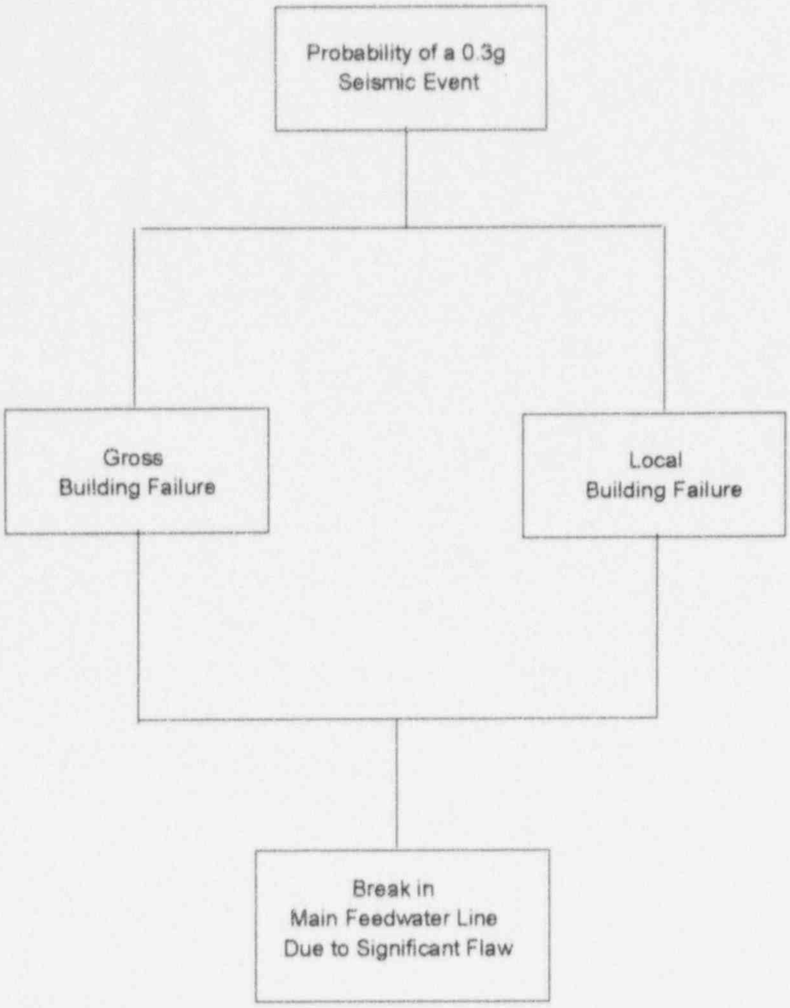

Figure 1 - Logic Flow Diagram of Seismic Turbine Building Failures Causing Internal System Depressurization Loads

Using the probabilities given in Table 2, and the logic flow diagram, the probability of having a break in the containment of the main feedwater line is calculated below.

$$\text{Probability} = \{1 \times 10^{-4} \times 1 \times 10^{-1} \times 2 \times 10^{-1}\} + \{1 \times 10^{-4} \times 5 \times 10^{-3} \times 2 \times 10^{-1}\}$$

$$\text{Probability} = \{2 \times 10^{-6}\} + \{1 \times 10^{-7}\}$$

$$\text{Probability} = 2.1 \times 10^{-6}$$

As expected, the failure probability is very small. The probability of internal system depressurization loads inside the containment building due to the rupture of the main feedwater piping within the turbine building is smaller than the probability of an indirect DEGB in the reactor coolant loop piping considering earthquakes larger than the SSE.

The first step in the leak-before-break (LBB) evaluations is the postulation of a large through-wall flaw. The combined probability reflecting the existence of such a large through-wall flaw, and a concurrent break of the pipe in the turbine building is extremely small and therefore the loads resulting from such a break need not be included in the LBB evaluations.

Conclusion

As shown above, the probability of a pipe break in nonsafety-related main feedwater pipe in the turbine building is negligibly small. The internal system depressurization transient due to a pipe break in nonsafety-related main feedwater pipe should be excluded from load combinations used for leak-before-break evaluation as an event of low probability.