Westinghouse

Westinghouse Electric Company
Nuclear Power Plants
P.O. Box 355
Pittsburgh, Pennsylvania 15230-0355
USA

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

Direct tel: 412-374-5355
Direct fax: 412-374-5456
e-mail: corletmm@westinghouse.com

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SUBJECT: AP1000 Containment Vessel Design

The purpose of this letter is to describe the additional level of design detail that we plan to develop for the structural design of the AP1000 containment vessel. This is provided in response to discussions during the structural audit that was held at the Westinghouse offices between April 2-5, 2003 and subsequent telephone discussions.

In the current Revision of the AP1000 DCD, the design of the containment vessel is described in subsection 3.8, and an ITAAC commitment is provided requiring the final containment vessel design be documented in an ASME Code Section III design report. Westinghouse believed that the conclusions of the AP1000 pre-application review that were published in SECY-02-0059 affirmed that this approach was acceptable for AP1000 Design Certification.

Based on the discussions held at the structural audit, we understand that the NRC staff deems it necessary for Westinghouse to provide additional design information to demonstrate that the vessel can satisfy the acceptance criteria identified in the ASME Design Specification and in the AP1000 Design Control Document (DCD).

To accommodate this request, Westinghouse has initiated additional design work by our subcontractor to demonstrate that the AP1000 containment vessel can be designed to satisfy the acceptance criteria documented in the DCD. Analyses have been completed for dead load and internal pressure and results are shown in the DCD. Analyses are in progress for equivalent static seismic loads, and for polar crane wheel loads. These loads are asymmetric and result in stresses that vary around the circumference. Results of the individual load cases at representative elevations and locations around the circumference will be combined following the load combinations shown in the DCD as modified below. The following load combinations for AP1000, which for AP600 were determined to be controlling, will be compared to the ASME Code acceptance criteria:

- Dead load plus internal design pressure with polar crane in the parked position for comparison against Level A stress intensity criteria
- Dead load plus internal design pressure plus Safe Shutdown Earthquake (SSE) with polar crane in the parked position for comparison against Level C stress intensity criteria

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- Dead load plus SSE with polar crane in the parked position for comparison against Level C buckling criteria
- Dead load plus external pressure plus SSE with polar crane in the parked position for comparison against Level D buckling criteria

In Revision 5 of the DCD, Westinghouse will revise the description of the load combinations contained in section 3.8 to be consistent with the above approach. In addition due to the very low probability of the combination of external design pressure (due to a reactor trip and loss of offsite power concurrent with the minimum outside air temperature) concurrent with the SSE, we will re-specify that this load combination be analyzed to Service Level D limits. Attachment 1 to this letter provides a justification for this approach.

The additional containment design analysis results for key locations will be compared against the stress intensity and buckling criteria, and these results will be included in a Table 3.8.2-5 that will be added to the DCD in Revision 6. DCD Revision 6 will be issued in June 2003. The results of this additional design analysis will demonstrate the feasibility of the AP1000 containment vessel design, and in combination with the other information presented in the DCD, will allow the staff to reach their final safety determination for AP1000 Design Certification.

Please contact me if you have further questions on this subject.

Very truly yours,

M. M. Corletti

M. M. Corletti
Passive Plant Projects & Development
AP600 & AP1000 Projects

/Attachments:

1. Combination of Containment Vessel External Pressure with Safe Shutdown Earthquake
2. Table 3.8.2-1, Load Combinations and Service Limits for Containment Vessel

Attachment 1

Combination of Containment Vessel External Pressure with Safe Shutdown Earthquake

The combination of external design pressure of 2.9 psi and the SSE will be revised in the DCD from Service Level C to Service Level D as shown in the attached proposed revision to Table 3.8.2-1. Additionally, the DCD will also be revised to specify that SSE load alone will be evaluated against Service Level C limits.

It is appropriate to classify this load combination to be analyzed to Service Level D limits due to the very low probability of the combination of external design pressure (due to a reactor trip and loss of offsite power concurrent with the minimum outside air temperature) concurrent with the SSE. This reclassification is appropriate based on the very low probability of the combination of events necessary to achieve this extreme loading condition (simultaneous high temperature and humidity inside containment, minimum outside air temperature, severe wind, reactor trip, loss of offsite power, SSE at instant of minimum containment pressure).

The analyses for external pressure loads on the containment vessel are described in DCD subsection 6.2.1.1.4. Loss of all ac power sources during extreme cold ambient conditions has the potential for creating the worst-case external pressure load on the containment vessel. This event leads to a reduction in the internal containment heat loads from the reactor coolant system and other active components, thus resulting in a temperature reduction within the containment and an accompanying pressure reduction. The evaluations are performed with the assumption of a -40°F ambient temperature with a steady 48 mph wind blowing to maximize cooling of the containment vessel. The initial internal containment temperature is conservatively assumed to be 120°F, creating the largest possible temperature differential to maximize the heat removal rate through the containment vessel wall. A negative 0.2 psig initial containment pressure is used for this evaluation. A conservative maximum initial containment relative humidity of 100 percent is used to produce the greatest reduction in containment pressure due to the loss of steam partial pressure by condensation. It is also conservatively assumed that no air leakage occurs into the containment during the transient. The pressure transient shown in Figure 6.2.1.1-11 demonstrates that at one hour after the event the net external pressure is within the 2.9 psid design external pressure. The operator mitigates the low internal containment pressure by equalizing the internal and external pressures using the containment air filtration system (VFS).

The assumptions in the analyses for external pressure are specifically selected to ensure conservatism. The minimum air temperature of -40°F is specified in DCD Table 2-1 to be based on the minimum historical data (excluding peaks of less than 2 hours duration). In normal operation in extremely cold weather, cooling of the external surface of the containment vessel combined with the normal operation of the containment fan coolers (VCS) will match the heat input from the reactor coolant system and other active components and the internal containment temperature and humidity will be significantly lower than the 120°F and 100 percent humidity conservatively assumed in the analyses. Reactor trip, including the loss of offsite power event, does not result in an immediate reduction in heat input from the reactor coolant system and containment temperature will reduce slowly as the reactor coolant loop cools down. Thus, the reduction in internal pressure would be much slower than predicted by the conservative analyses.

The probability of the safe shutdown earthquake is in the order of 10^{-4} per year. The probability is very low that the earthquake would occur independently during the period of up to an hour when the internal pressure has been reduced by 2.9 psi due to the very rapid cooling of the containment atmosphere. This combination of independent events is sufficiently low that it does not need to be considered in the design basis.

The safe shutdown earthquake is conservatively assumed in the PRA analyses to lead to a loss of all ac power event. This may occur during cold weather. However, as shown by the analyses described in DCD subsection 6.2.1.1.4, it takes more than one hour after the loss of ac power for the pressure to reach the design external pressure even with the conservative initial conditions postulated in the external pressure analysis. Hence the safe shutdown earthquake loads are not concurrent with those due to external pressure. However, to provide margin and to allow for a potential aftershock at the most critical time, Westinghouse will conservatively consider the combination of the external design pressure and the safe shutdown earthquake and will evaluate it as a faulted condition against ASME Service Level D criteria.

Table 3.8.2-1

LOAD COMBINATIONS AND SERVICE LIMITS FOR CONTAINMENT VESSEL

		Load Combination and Service Limit										
Load Description		**Con**	**Test**	**Des.**	**Des.**	**A**	**A**	**A**	**C**	**~~C~~D**	**C**	**D**
Dead	D	x	x	x	x	x	x	x	x	x	x	x
Live	L	x	x	x	x	x	x	x	x	x	x	x
Wind	W	x				x						
Safe shutdown earthquake	E_s								x	x		x
Tornado	W_t										x	
Test pressure	P_t		x									
Test temperature	T_t		x									
Operating pressure	P_o					x					x	
Design pressure	P_d			x			x		x			x
External pressure (2.9~~3.0~~ psid)	P_e				x			x		x		
Normal reaction	R_o				x	x		x		x	x	
Normal thermal	T_o				x	x		x		x	x	
Accident thermal reactions	R_a			x			x		x			x
Accident thermal	T_a			x			x		x			x
Accident pipe reactions	Y_r											x
Jet impingement	Y_j											x
Pipe impact	Y_m											x

Notes:

1. Service limit levels are per ASME-NE.
2. Where any load reduces the effects of other loads, that load is be taken as zero, unless it can be demonstrated that the load is always present or occurs simultaneously with the other loads.