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July 30, 2010

Subject: AP1000 Response to Request for Additional Information

Westinghouse is submitting the following responses to the NRC open item (OI) on Chapter 3. These proposed open item responses are submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in these responses is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

Enclosure 1 provides the response for the following proposed Open Item(s):

RAI-TR09-008

Questions or requests for additional information related to the content and preparation of this response should be directed to Westinghouse. Please send copies of such questions or requests to the prospective applicants for combined licenses referencing the AP1000 Design Certification. A representative for each applicant is included on the cc: list of this letter.

Very truly yours,

D.A. Lindgren /FOR

Robert Sisk, Manager
Licensing and Customer Interface
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/Enclosure

1. Response to request for additional information (Chapter 3)

D063
NRO

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ENCLOSURE 1

AP1000 Response to Request for Additional Information (Chapter 3)

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR09-008
Revision: 6

Question:
In TR-9, starting on p. 4, Westinghouse presents a justification for reducing the design external pressure from 2.9 psid to 0.9 psid, and states that "the extreme conservatism in the above analyses was reduced and an estimate of the external pressure was provided in the response to DSER Open Item 3.8.2.1-1." The staff reviewed the AP1000 SER and could not establish that this reduction has been specifically reviewed and accepted by the staff. The staff also reviewed AP1000 DCD, Rev. 15, and found that the design external pressure is specified to be 2.9 psid on page 3.8-1. Since there is no evidence that the reduction in design external pressure has been reviewed and accepted by the appropriate staff reviewers, and a determination of acceptability cannot be made by staff structural reviewers, Westinghouse must use the design external pressure of record (i.e., 2.9 psid) in demonstrating the adequacy of the containment penetration designs. Therefore, the staff requests the applicant to

- Demonstrate the design adequacy of the containment penetrations for a design external pressure of 2.9 psid.
- Confirm the design adequacy of the steel containment vessel (other than penetrations) for a design external pressure of 2.9 psid.

Revision 2

According to Westinghouse, the "inadvertent actuation of the containment coolers" event controls both the minimum service temperature and the external pressure loading for the steel containment shell. The Containment Performance reviewers must evaluate the hypothetical scenario, and either agree or disagree with Westinghouse's predicted minimum containment shell temperature, and the predicted external pressure loading. The structures and materials reviewers cannot resolve their technical issues until the "inadvertent actuation of the containment coolers" event is resolved. Refer to RAI-SRP 6.2.1.1-SPCV-07. A teleconference took place between W and staff reviewers responsible for structures, materials, and containment performance, in order to clarify for W what the issues are, related to each review area. W has an action to address these issues.

Revision 3

Resolution of RAI-TR09-008 is tied to the resolution of RAI-SRP6.2.1.1-SPCV-07. Explain inconsistencies in DCD Section 3.8.2.6, Table 3.8.3-1, and Tech Spec Bases B 3.6.4.

Revision 5

10 CFR 50, Appendix A, General Design Criterion (GDC) 50, requires that nuclear power plant containment structures be designed with a sufficient margin of safety to accommodate appropriate design loads. Per the guidance in SRP 3.8.2 II.3 (acceptance criteria), the

structural staff has reviewed the Revision 4 response to RAI TR09-08, and requires additional clarifications. Please address the following:

a. In Table 1, the results show a trend of higher external pressure as the outside temperature goes up. However, the analysis is limited to ≤ 19 degrees F, for which the external pressure is 0.98 psi. The staff requests the technical basis for limiting the analysis to 19 degrees F for the outside temperature.

b. After reviewing the RAI response and the proposed revision to DCD Table 3.8.2-1, it is not clear what temperature gradient/external pressure combination is used in the Service Level A load combination notated by footnotes 3 and 5. Describe in detail the pressure and temperature condition used in this Service Level A load combination, and the technical basis for concluding it is the worst case. Include this information in DCD 3.8.2 and TR-09. Revise the DCD Table 3.8.2-1 footnotes to reference the DCD 3.8.2 section that describes this loading condition.

c. The staff noted a number of inconsistencies between proposed DCD Table 3.8.2-1 and the latest TR-09 Table 2-4, both of which identify the applicable load combinations for design of the containment structure. Please make these tables consistent, or provide the technical basis for the inconsistencies.

d. The maximum external pressure is no longer listed as 0.9 psi in the proposed revision to DCD Table 3.8.2-1. For consistency, ensure that all references to the 0.9 psi external pressure in both the DCD and TR-09 are appropriately revised.

Westinghouse Response:

For consistency with Figure 6.2.1.1-11, the words 'at one hour' were deleted from the text in section 6.2.1.1.4 of the DCD, Revision 16. This change and all other DCD changes shown below were incorporated in Revision 5 of APP-GW-GLR-134 (Technical Report 134).

The description of the external pressure analysis in DCD subsection 6.2.1.1.4 will be revised as shown below. ~~This analysis concludes that the limiting case containment pressure transient is an inadvertent actuation of active containment cooling during extreme cold ambient conditions.~~

The limiting external pressure and associated thermal transient is considered conservatively as a normal event and is evaluated against ASME Service Level A criteria. It is also conservatively evaluated in combination with the safe shutdown earthquake occurring at the time of minimum pressure against ASME Service Level D criteria.

The external pressure analysis in DCD subsection 6.2.1.1.4 would permit a reduction in the design external pressure for the containment vessel from 2.9 psid to 0.9 psid. Westinghouse does not intend to change the design of the containment vessel and will retain the 2.9 psid as the design external pressure.~~ which is evaluated against ASME design conditions. Westinghouse will also retain the specification requiring evaluation of the combination of the 2.9 psid design external pressure and the safe shutdown earthquake.~~

The containment vessel, including the penetrations, is designed for a design external pressure of 2.9 psid. The design external pressure is the second "design" case in DCD Table 3.8.2-1 and also shown as "Des2" in Table 2-4 of this report.~~ The design external pressure plus SSE is considered in the first Service Level D case in DCD Table 3.8.2-1 and also shown as "D1" in Table 2-4 of this report. The lower external pressure of 0.9 psid is only used as part of the "inadvertent actuation of active containment cooling during extreme cold ambient conditions" event (cases A1 and D2 in Table 2-4).~~

Response Revision 3

To determine parameters and loading conditions for the structural evaluation of the containment pressure vessel shell for external pressure loading conditions, postulated accident scenarios are evaluated. These scenarios typically postulated a rapid temperature reduction in the containment atmosphere. These postulated accidents were defined in DCD Subsection 6.2.1.1. DCD Section 6.2 considers containment performance requirements and analyses. The placement of information about the external pressure transients in Subsection 6.2.1.1 has caused confusion in the review of Section 6.2. The resolution of RAI-SRP6.2.1.1-SPCV-07 is dependent on the removal of information on the external pressure analyses from Section 6.2.

Information on the external pressure analyses is added to DCD Subsection 3.8.2, as shown below, to replace information removed from Subsection 6.2.1.1. The service metal temperature in Subsection 3.8.2.6 is corrected. Conforming changes to Note 3 to Table 3.8.2-1 and Technical Specification Bases for B 3.6.4 are also shown below.

No additional changes to TR09 (APP-GW-GLR-005) are included in Revision 3 of this response

Response Revision 4

In Revision 2 of the response to RAI-SRP6.2.1.1-SPCV-07 Westinghouse has proposed revision of Subsection 6.2.1.1.4 to be similar to what was provided in DCD Revision 15 to support the Design Certification. This revised text supports the use of a value of 2.9 psi for a design external pressure. This design external pressure is used in a design pressure load combination that does not include a thermal load. The design external pressure is a bounding pressure determined using a scenario that is nonmechanistic with respect to credible temperature conditions.

To evaluate loading combinations that include external pressure and thermal load a more credible external pressure is used. These loading combinations are used to evaluate Service

Level A and Service Level D limits. Additional information on the development of the Service Level load combinations is provided in the DCD in Subsection 3.8.2 as shown below.

Westinghouse completed WGOTHIC runs of inadvertent actuation of the containment fan coolers, inadvertent actuation of the PCS, and Loss of AC (LOAC) transients. The inadvertent fan cooler cases were run at external ambient temperatures of -40°F, -30°F, -10°F, 0°F, and 19°F to determine the differential pressure across the containment shell. The inadvertent PCS cases were run with external temperatures of 33°F, 40°F, 70°F.The LOAC cases were run at -40°F and 19°F.

The analyses combine an initializing case to determine the initial containment atmospheric temperature with the appropriate fault condition transient into a single run.

A humidity of 25% and 10% were analyzed for the -40°F and 0°F inadvertent fan cooler cases. A humidity of 25% was analyzed for the -30°F and -10°F cases. From sensitivity runs made during the development of the calculation it was determined the lower the humidity in containment the higher the containment temperature was allowed to rise prior to transient initiation. This makes sense as the specific heat of water vapor is 0.48 Btu/lbm-°F whereas the specific heat of air is ~ 0.24 Btu/lbm-°F. The higher the containment temperature the greater the calculated external pressure at transient initiation as this will result in the greatest ΔT. From sensitivity runs made at the cold conditions even at 100% and 50% humidity containment equilibrated to 25% and 10% humidity respectively. These values were used to minimize humidity in the various transients analyzed to maximize the calculated magnitude of external pressure. Table 1 depicts the results of the inadvertent fan cooler cases:

Table 1: Results of the Inadvertent Fan Cooler Cases

External Temp. (°F)	Humidity (%)	Min. Service Metal Temp (°F)	Calculated Ext. Pressure (psid)
-40	25	7.18	-0.59
-40	10	7.76	-0.70
-30	25	-0.61	-0.53
External Temp. (°F)	Humidity (%)	Min. Service Metal Temp (°F)	Calculated Ext. Pressure (psid)
-10	25	7.5	-0.54
0	25	17.5	-0.55
0	10	18.1	-0.79
19	10	33.75	-0.98

Table 2 depicts the results of the Loss of AC power cases. Based on the sensitivities to external pressure identified in the inadvertent fan cooler cases the LOAC cases were run at -40°F and 19°F as these were the most limiting cases identified for external pressure and minimum service metal temperature. The cases conservatively used 25% and 10% internal humidity to maximize the magnitude of the calculated external pressure.

Table 2: Results of the LOAC cases

External Temp. (°F)	Humidity (%)	Min. Service Metal Temp (°F)	Calculated Ext. Pressure (psid)
-40	25	4.16	-0.57
19	10	37.71	-0.58

Table 3 depicts the inadvertent PCS cases. The minimum service metal temperatures were not depicted for these cases since the minimum service metal temperature could not be challenged for these transients.

Table 3: Results of the Inadvertent PCS Cases

External Temp. (°F)	Humidity (%)	Min. Service Metal Temp (°F)	Calculated Ext. Pressure (psid)
40	10	N/A	-0.42
33	10	N/A	-0.37
70	10	N/A	-0.44

The scenario described in DCD Rev. 17 Subsection 6.2.1.1.4 to validate the external design pressure was also run to verify that the calculated pressure differential is less than 2.9 psid.

In the DCD revisions shown below the differentiation between the design external pressure and the more credible external pressure used for Service Level A and D load combinations is explained. How this more credible value of external pressure is determined is also explained.

In the revisions for Table 3.8.2-1 shown below, the reference to footnote (4) for the second design load combination is deleted. Footnote (4) identifies the thermal load at 70°F. This load is taken to mean a zero thermal load. Not including a thermal load in this load combination is consistent with the standard practice for vessel design to not include a thermal load for a design load combination. Typically the design load combinations include deadweight, pressure and design mechanical loads. The Standard Review Plan (SRP) for 3.8.2 does not include a design condition load combination that includes external pressure. The inclusion of this second design load combination provides for an evaluation beyond what is recommended by the SRP for 3.8.2.

In the revisions for Table 3.8.2-1 shown below two of the loading combinations are eliminated. For both the Service Level A and Service Level D combinations a case that includes a combination with the design external pressure and the thermal load at 70°F (footnote 4) was previously included. The thermal load at 70°is taken as a zero thermal load. These load combinations are not appropriate for the Service Level A and D load combinations and have been deleted. The load combinations that remain include cases with external pressure and a thermal load for both Service Level A and Service Level D. These cases are consistent with the guidance in Regulatory Guide 1.57 and the SRP for 3.8.2.

The footnote (4) remains for the load combination which includes the tornado load since tornados are not expected during extreme cold temperature conditions.

The footnote (6) for Table 3.8.2-1, which identifies the minimum metal service temperature, is deleted from the table since this information is included in the DCD text and there is no entry in the table that refers to footnote (6).

Response Revision 5

a. The explanation of results found in APP-MV50-Z0C-039 Rev. 0 clearly explains this. The pressure excursions are proportional to the temperature change in containment resulting from the various transients. For conservatism the inadvertent fan cooler transients were performed assuming the fan coolers were off to maximize the internal containment temperature prior to transient initiation. In reality the fan coolers will be running at all times, so an inadvertent actuation is not really a credible event but was analyzed at the staff's request. Additionally, the AP1000 Tech Specs State that if Containment Temperature is greater than 120 F then the plant can't operate. So, the 19 F case represents the case with the maximum containment internal temperature coupled with the minimum outside temperatures which maximizes the heat transfer gradient to the outside which results in the greatest containment internal temperature reduction at transient initiation.

   At higher external temperatures the fan coolers would have to be running prior to transient initiation, which would result in a lower containment initial temperature which would result in a smaller pressure excursion magnitude. Remember the fan cooler performances ramp from 40 F to max at 120 F. Starting the transient at a lower containment temperature would result in less heat removal due to the reduced performance of the fan coolers.

b. The external pressure to be analyzed in Service Level A1 is 0.9 psid combined with the thermal gradient based on an outside air temperature of -40°F. When the outside air temperature is -40°F, the metal temperature of the CV exposed to the cold air is -18.5°F. The metal temperature of the CV not exposed to outside air temperature will be 70°F, with a step change taking place at the location of the external stiffener at E.L. 131'-9".

   Based upon the results of analyzing several credible initiating events, it was determined that an external pressure of 0.9 psid combined with this thermal gradient provide the highest stress intensities in the CV. Because of this, these will be the pressure and temperature to be analyzed with the ASME Service Limits.

See DCD revision section of the RAI Response for DCD markup.

c. Once this RAI Response is accepted by the NRC, TR-09 will be updated to reflect the proposed DCD Table 3.8.2-1. See Technical Report Revision Section of this RAI Response for changes to TR-09.

d. Once this RAI Response is accepted by the NRC, TR-09 will be updated to reflect the proposed DCD Table 3.8.2-1. See Technical Report Revision Section of this RAI Response for changes to TR-09.

Response Revision 6

This RAI response is prepared based upon the addition of the containment vacuum relief system, which is integrated into the containment air filtration system (VFS). The containment vacuum relief system uses an actuation point of 0.8 psid. Based on the external pressure that the containment vacuum relief system can mitigate, a conservative containment external design pressure is defined as 1.7 psid. Design external pressure is evaluated in both design load combinations as well as the service limits of the Table 3.8.2-1. See DCD markups for changes to the load combinations table.

Due to the addition of containment vacuum relief based on the Section 6.2.1.1.4 safety analysis, and the CV design external pressure of 1.7 psid, much of the transient discussion in previous revisions of this RAI is now invalid. APP-MV50-Z0C-039 still confirms the lowest service metal temperature of the CV.

Revision 6 of this RAI response only covers the changes made to DCD Section 3.8.2. For DCD Section 6.2.1.1.4 changes see the Change Notice issued on the containment vacuum relief system. TR09 will be submitted to the NRC for review.

The Technical Specification (T.S. 3.6.5) changes that were provided in Rev. 5 of this response are now invalid and the Technical Specification 3.6.4 is not changed from that in Rev. 17 of the DCD.

Design Control Document (DCD) Revision: (thru Revision 6)

Note: Due to the complexity of the combined responses' changes, a "changes accepted" version of the markup is also attached.

Revise Subsection 3.8.2.1.1 as follows:

3.8.2.1.1 General

Diameter: 130 feet
Height: 215 feet 4 inches
Design Code: ASME III, Div. 1
Material: SA738, Grade B
Design Pressure: 59 psig
Design Temperature: 300°F
Design External Pressure: ~~2.9~~1.7 psid

Revise Subsection 3.8.2.4.1.1 as follows:

3.8.2.4.1.1 Axisymmetric Shell Analyses

The containment vessel is modelled as an axisymmetric shell and analyzed using the ANSYS computer program. A model used for static analyses is shown in Figure 3.8.2-6.

Dynamic analyses of the axisymmetric model, which is similar to that shown in Figure 3.8.2-6, are performed to obtain frequencies and mode shapes. These are used to confirm the adequacy of the containment vessel stick model as described in subsection 3.7.2.3.2. Stress analyses are performed for each of the following loads:

Dead load
Internal pressure
Seismic
Polar crane wheel loads
Wind loads
Thermal loads

The seismic analysis performed envelope all soil conditions. The seismic analysis is discussed in Section 3.7. The torsional moments, which include the effects of the eccentric masses, are increased to account for accidental torsion and are evaluated in a separate calculation.

The results of these load cases are factored and combined in accordance with the load combinations identified in Table 3.8.2-1. These results are used to evaluate the general shell away from local penetrations and attachments, that is, for areas of the shell represented by the axisymmetric geometry. The results for the polar crane wheel loads are also used to establish local shell stiffnesses for inclusion in the containment vessel stick model described in subsection 3.7.2.3. The results of the analyses and evaluations are included in the containment vessel design report.

Design of the containment shell is primarily controlled by the internal pressure of 59 psig. The meridional and circumferential stresses for the internal pressure case are shown in Figure 3.8.2-5. The most highly stressed regions for this load case are the portions of the shell away from the hoop stiffeners and the knuckle region of the top head. In these regions the stress intensity is close to the allowable for the design condition.

Table 3.8.2-1 includes a second design load combination to address external pressure. For the design external pressure load combination a conservatively large magnitude of 1.7 ~~2.9~~ psi differential pressure is used. Design external pressure is defined as a value greater than the external pressure the containment vacuum relief system can mitigate. This is a part of the containment air filtration system (See DCD Section 9.4.7). Upon actuation, the external pressure transient is immediately controlled and the external pressure is relieved. This design external pressure is combined with a coincident -40°F outside air temperature which corresponds to a -18.5°F metal temperature for the CV shell not insulated from ambient conditions. The portions of the CV shell which are below the external stiffener are insulated from the cold outside air conditions and result in a metal temperature of 70°F. ~~This design external pressure is validated by assuming that the containment is operating at the maximum temperature, 120°F, with 100% relative humidity, and experiences a step change to the minimum operating temperature, 50°F. The assumptions used to validate the 2.9 psi differential pressure are discussed in Subsection 6.2.1.1.4. These assumptions are nonmechanistic because the outside air temperature conditions to result in an operating temperature of 50°F are inconsistent with an initial containment atmosphere temperature of 120°F. The calculation of the differential pressure using this nonmechanistic approach results in a value of external pressure less than the 2.9 psid design external pressure. The design external pressure provides a bounding value for the design conditions. The load combination for the external pressure design condition includes deadweight, design external pressure, and reaction loads. Thermal loads are not included.~~

~~Several events are evaluated for the potential to result in an external pressure load. A more credible value for external pressure is evaluated by assuming an inadvertent actuation of the active containment cooling during cold weather conditions. The net external pressure for this event is less than 1.0 psid. For this event tevent conservatively results in~~

~~Loss of AC power is evaluated using more realistic, mechanistic assumptions than for the design external pressure analysis. The more credible determination of the external pressure for the loss of AC power results in a value smaller than the inadvertent actuation of the active containment cooling and considerably smaller than the design external pressure (2.9 psid).~~

~~Inadvertent actuation of the containment fan coolers is the limiting event for external pressure at cold conditions;However, this event was evaluated at several initial outside air temperature conditions to determine the maximum differential pressure. The thermal load associated with~~

this event is due to the thermal gradient in the containment shell from the portion insulated by the external stiffener to the portion exposed to the outside air.

For AP1000, the passive containment cooling system (PCS) provides heat removal from the containment shell to the environment via natural circulation air flow. Since the passive containment cooling system water is relatively warm (minimum of 40°F) compared to the outside air temperature; for extreme cold conditions inadvertent actuation of this system results in a less limiting external pressure and shell temperature.

Inadvertent actuation of the containment spray is not credible since the AP1000 containment spray requires significant local operator action to align the system.

Design Eexternal pressure and thermal loads are used in load combinations to evaluate Service Level A and D stress limits. These external pressure conditions are included in the loading combinations in Table 3.8.2-1. The load combinations that include external pressures and thermal loads are evaluated for several cases of initiating event and external temperature to determine the limiting case of external pressure and external temperature.

Operating pressures range from -0.2 psig to 1.0 psig, which are then combined with an ambient temperature for the CV. Design internal pressure is 59 psig combined with a CV metal temperature of 300°F to be evaluated in the ASME service limits as well as the design conditions.

A load combination which combines design wind plus internal design pressure is not included in the Table 3.8.2-1 because the wind loads are small (within the normal operating range for containment pressure) and because the combination of the design wind and accident pressure is a lower probability than either the design wind or the accident pressure acting alone.

Major loads that induce compressive stresses in the containment vessel are internal and external pressure and crane and seismic loads. Each of these loads and the evaluation of the compressive stresses are discussed below.

- Internal pressure causes compressive stresses in the knuckle region of the top head and in the equipment hatch covers. The evaluation methods are similar to those discussed in subsection 3.8.2.4.2 for the ultimate capacity.
- Evaluation of external pressure loads is performed in accordance with ASME Code, Section III, Subsection NE, Paragraph NE-3133.
- Crane wheel loads due to crane dead load, live load, and seismic loads result in local compressive stresses in the vicinity of the crane girder. These are evaluated in accordance with ASME Code, Case N-284.

- Overall seismic loads result in axial compression and tangential shear stresses at the base of the cylindrical portion. These are evaluated in accordance with ASME Code, Case N-284.

The bottom head is embedded in the concrete base at elevation 100 feet. This leads to circumferential compressive stresses at the discontinuity under thermal loading associated with the design basis accident. The containment vessel design includes a Service Level A combination in which the vessel above elevation 107′-2″ is specified at the design temperature of 300°F and the portion of the embedded vessel (and concrete) below elevation 100 feet is specified at a temperature of 70°F. The temperature profile for the vessel is linear between these elevations. Containment shell buckling close to the base is evaluated against the criteria of ASME Code, Case N-284.

Revision 1 of Code Case N-284 is used for the evaluation of the containment shell and equipment hatches.

~~Negative pressure is evaluated by assuming an inadvertent actuation of the active containment cooling. For AP1000, the passive containment cooling system provides heat removal from the containment shell to the environment via natural circulation air flow during normal operation. Since the passive containment cooling system water is relatively warm (minimum of 40°F) compared to the outside air temperature, actuation of this system results in a less limiting external pressure and shell temperature. The net external pressure for this event is approximately -0.9 psid. Inadvertent actuation of the containment fan coolers is the limiting event for external pressure at cold conditions. Inadvertent actuation of the containment spray is not credible since the AP1000 containment spray requires significant local operator action to align the system.~~

~~The bounding external pressure can be calculated by assuming that the containment is operating at the maximum temperature, 120F, with 100% relative humidity, and experiences a step change to the minimum operating temperature, 50F. The calculated pressure change for this transient is -2.9 psid. This value is bounding and is based on a nonmechanistic condition.~~

~~These external pressure conditions are included in the loading combinations in Table 3.8.2-1~~

Revise Table 3.8.2-1 as follows:

Table 3.8.2-1

LOAD COMBINATIONS AND SERVICE LIMITS FOR CONTAINMENT VESSEL

Load Description		Load Combination and Service Limit											
		Con	**Test**	**Des.**	**Des.**	**A**	**A**	**A**	**C**	**D**	**C**	**D**	**~~D~~**
Dead	D	x	x	x	x	x	x	x	x	x	x	x	~~x~~
Live	L	x	x	x	x	x	x	x	x	x	x	x	~~x~~
Wind(5)	W	x				~~x~~		x					
Safe shutdown earthquake	E_s								x	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	
Design External pressure ~~(2.9 psid)~~	P_e				x	x		~~x~~		x			
~~External pressure (0.9 psid)(3)~~	~~P_e~~					~~x~~				~~x~~			~~x~~
Normal reaction	R_o				x	x		x		x	x		
Normal thermal(~~4~~5)	T_o				x~~(4)~~	~~(5)~~x		(34)		~~(4)~~x	~~x~~(34)		~~(5)~~
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 to be taken as zero, unless it can be demonstrated that the load is always present or occurs simultaneously with the other loads.
3. ~~Reduced External pressure of 0.9 psid at one hour in loss of all ac transient based on evaluation of credible initiating events in cold weather or inadvertent PCS actuation. .~~

34. Temperature of vessel is 70°F.

45. Temperature distribution for normal operation in cold weather. ~~credible initiating event inadvertent actuation of active containment cooling in cold weather or inadvertent PCS actuation. Evaluation of load combination cases including external pressure and thermal combine the coincident external pressure with thermal load for same temperature.~~

6. ~~The "lowest service metal temperature" corresponding to -40°F outside temperature is -18.5°F.~~

5. Wind load for the construction load combination is based on a 70 mph wind. Wind load for the Service Level A load combination is analyzed as a reduction in external pressure.

The following paragraphs are added to subsection 3.8.2.4.1.1 in Revision 3 of this response. This DCD revision is superseded by the DCD revision for Revision 4 of the response. These paragraphs are deleted in Revision 6 of this response.

> ~~Negative pressure is evaluated by assuming an inadvertent actuation of the active containment cooling. For AP1000, the passive containment cooling system provides heat removal from the containment shell to the environment via natural circulation air flow during normal operation. Since the passive containment cooling system water is relatively warm (minimum of 40°F) compared to the outside air temperature, actuation of this system results in a less limiting external pressure and shell temperature. The net external pressure for this event is approximately -0.9 psid. Inadvertent actuation of the containment fan coolers is the limiting event for external pressure at cold conditions. Inadvertent actuation of the containment spray is not credible since the AP1000 containment spray requires significant local operator action to align the system.~~
>
> ~~The bounding external pressure can be calculated by assuming that the containment is operating at the maximum temperature, 120F, with 100% relative humidity, and experiences a step change to the minimum operating temperature, 50F. The calculated pressure change for this transient is -2.9 psid. This value is bounding and is based on a nonmechanistic condition.~~
>
> ~~These external pressure conditions are included in the loading combinations in Table 3.8.2-1~~

Revise the first paragraph of Subsection 3.8.2.6 as follows: (Response Revision 3)

> Materials for the containment vessel, including the equipment hatches, personnel locks, penetrations, attachments, and appurtenances meet the requirements of NE-2000 of the

ASME Code. The basic containment material is SA738, Grade B, plate. The procurement specification for the SA738, grade B, plate includes supplemental requirements S1, Vacuum Treatment and S20, Maximum Carbon Equivalent for Weldability. This material has been selected to satisfy the lowest service metal temperature requirement of ~~-15~~-18.5°F. This temperature is established by analysis for the portion of the vessel exposed to the environment when the minimum ambient air temperature is -40°F. Impact test requirements are as specified in NE-2000.

Revise Note 3 to Table 3.8.2-1 as follows: (Response Revision 3) This revision is superseded by the revision for Response Revision 4 shown above. This note is deleted in Revision 6 of this response.

3. ~~Reduced pressure of 0.9 psid at one hour in event of inadvertent actuation of the containment fan coolers loss of all ac transient in cold weather~~.

The following revision is included as part of the Revision 6 Response:

Revise the third paragraph of APPLICABLE SAFETY ANALYSES in the Technical Specification Bases for B 3.6.4 Containment Pressure as follows:

> The containment was also designed for an external pressure load equivalent to 1.7~~2.9~~ psig. The limiting negative pressure transient is a loss of all AC power sources coincident with extreme cold weather conditions which cool the external surface of the containment vessel. The initial pressure condition used in this analysis was -0.2 psig. This resulted in a minimum pressure inside containment, as illustrated in Reference 1, which is less than the design load. Other external pressure load events evaluated include:
>
> Failed fan cooler control
>
> Malfunction of containment purge system

PRA Revision:
None

Technical Report (TR) Revision:
None

The 'accept changes' version of the DCD is shown below:

The following are DCD changes as a result of the response to RAI-TR09-008, R6. The DCD changes include sections 3.8.2.1.1 and 3.8.2.4.1.1

3.8.2.1.1 General

Diameter: 130 feet
Height: 215 feet 4 inches
Design Code: ASME III, Div. 1
Material: SA738, Grade B
Design Pressure: 59 psig
Design Temperature: 300°F
Design External Pressure: 1.7 psid

Revise Subsection 3.8.2.4.1.1 as follows:

3.8.2.4.1.1 Axisymmetric Shell Analyses

The containment vessel is modelled as an axisymmetric shell and analyzed using the ANSYS computer program. A model used for static analyses is shown in Figure 3.8.2-6.

Dynamic analyses of the axisymmetric model, which is similar to that shown in Figure 3.8.2-6, are performed to obtain frequencies and mode shapes. These are used to confirm the adequacy of the containment vessel stick model as described in subsection 3.7.2.3.2. Stress analyses are performed for each of the following loads:

Dead load
Internal pressure
Seismic
Polar crane wheel loads
Wind loads
Thermal loads

The seismic analysis performed envelope all soil conditions. The seismic analysis is discussed in Section 3.7. The torsional moments, which include the effects of the eccentric masses, are increased to account for accidental torsion and are evaluated in a separate calculation.

The results of these load cases are factored and combined in accordance with the load combinations identified in Table 3.8.2-1. These results are used to evaluate the general shell away from local penetrations and attachments, that is, for areas of the shell represented by the axisymmetric geometry. The results for the polar crane wheel loads are also used to establish local shell stiffnesses for inclusion in the containment vessel stick model described in subsection 3.7.2.3. The results of the analyses and evaluations are included in the containment vessel design report.

Design of the containment shell is primarily controlled by the internal pressure of 59 psig. The meridional and circumferential stresses for the internal pressure case are shown in Figure 3.8.2-5. The most highly stressed regions for this load case are the portions of the shell away from the hoop stiffeners and the knuckle region of the top head. In these regions the stress intensity is close to the allowable for the design condition.

Table 3.8.2-1 includes a second design load combination to address external pressure. For the design external pressure load combination a conservatively large magnitude of 1.7 psi differential pressure is used. Design external pressure is defined as a value greater than the external pressure the containment vacuum relief system can mitigate. This is a part of the containment air filtration system (See DCD Section 9.4.7). Upon actuation, the external pressure transient is immediately controlled and the external pressure is relieved. This design external pressure is combined with a coincident -40°F outside air temperature which corresponds to a -18.5°F metal temperature for the CV shell not insulated from ambient conditions. The portions of the CV shell which are below the external stiffener are insulated from the cold outside air conditions and result in a metal temperature of 70°F.

Design external pressure and thermal loads are used in load combinations to evaluate Service Level A and D stress limits. These external pressure conditions are included in the loading combinations in Table 3.8.2-1.

Operating pressures range from -0.2 psig to 1.0 psig, which are then combined with an ambient temperature for the CV. Design internal pressure is 59 psig combined with a CV metal temperature of 300°F to be evaluated in the ASME service limits as well as the design conditions.

A load combination which combines design wind plus internal design pressure is not included in the Table 3.8.2-1 because the wind loads are small (within the normal operating range for containment pressure) and because the combination of the design wind and accident pressure is a lower probability than either the design wind of the accident pressure acting alone.

Major loads that induce compressive stresses in the containment vessel are internal and external pressure and crane and seismic loads. Each of these loads and the evaluation of the compressive stresses are discussed below.

- Internal pressure causes compressive stresses in the knuckle region of the top head and in the equipment hatch covers. The evaluation methods are similar to those discussed in subsection 3.8.2.4.2 for the ultimate capacity.

- Evaluation of external pressure loads is performed in accordance with ASME Code, Section III, Subsection NE, Paragraph NE-3133.

- Crane wheel loads due to crane dead load, live load, and seismic loads result in local compressive stresses in the vicinity of the crane girder. These are evaluated in accordance with ASME Code, Case N-284.

- Overall seismic loads result in axial compression and tangential shear stresses at the base of the cylindrical portion. These are evaluated in accordance with ASME Code, Case N-284.

The bottom head is embedded in the concrete base at elevation 100 feet. This leads to circumferential compressive stresses at the discontinuity under thermal loading associated with the design basis accident. The containment vessel design includes a Service Level A combination in which the vessel above elevation 107′-2″ is specified at the design temperature of 300°F and the portion of the embedded vessel (and concrete) below elevation 100 feet is specified at a temperature of 70°F. The temperature profile for the vessel is linear between these elevations. Containment shell buckling close to the base is evaluated against the criteria of ASME Code, Case N-284.

Revision 1 of Code Case N-284 is used for the evaluation of the containment shell and equipment hatches.

Revise Table 3.8.2-1 as follows:

Table 3.8.2-1

LOAD COMBINATIONS AND SERVICE LIMITS FOR CONTAINMENT VESSEL

Load Description		**Load Combination and Service Limit**											
		Con	**Test**	**Des.**	**Des.**	**A**	**A**	**A**	**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[5]	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	
Design External pressure	P_e				x	x				x			
Normal reaction	R_o				x	x		x		x	x		
Normal thermal[4]	T_o				x	x		(3)		x	(3)		
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 to be taken as zero, unless it can be demonstrated that the load is always present or occurs simultaneously with the other loads.
3. Temperature of vessel is 70°F.
4. Temperature distribution for normal operation in cold weather.
5. Wind load for the construction load combination is based on a 70 mph wind. Wind load for the Service Level A load combination is analyzed as a reduction in external pressure.

The following paragraphs are added to subsection 3.8.2.4.1.1 in Revision 3 of this response. This DCD revision is superseded by the DCD revision for Revision 4 of the response. These paragraphs are deleted in Revision 6 of this response.

Revise the first paragraph of Subsection 3.8.2.6 as follows: (Response Revision 3)

> Materials for the containment vessel, including the equipment hatches, personnel locks, penetrations, attachments, and appurtenances meet the requirements of NE-2000 of the ASME Code. The basic containment material is SA738, Grade B, plate. The procurement specification for the SA738, grade B, plate includes supplemental requirements S1, Vacuum Treatment and S20, Maximum Carbon Equivalent for Weldability. This material has been selected to satisfy the lowest service metal temperature requirement of -18.5°F. This temperature is established by analysis for the portion of the vessel exposed to the environment when the minimum ambient air temperature is -40°F. Impact test requirements are as specified in NE-2000.

Revise the third paragraph of APPLICABLE SAFETY ANALYSES in the Technical Specification Bases for B 3.6.4 Containment Pressure as follows:

> The containment was also designed for an external pressure load equivalent to 1.7 psig. The limiting negative pressure transient is a loss of all AC power sources coincident with extreme cold weather conditions which cool the external surface of the containment vessel. The initial pressure condition used in this analysis was -0.2 psig. This resulted in a minimum pressure inside containment, as illustrated in Reference 1, which is less than the design load. Other external pressure load events evaluated include:
>
> Failed fan cooler control
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> Malfunction of containment purge system