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Your ref: Docket No. 52-006
Our ref: DCP_NRC_002780

February 17, 2010

Subject: AP1000 Response to Request for Additional Information (TR 09)

Westinghouse is submitting responses to NRC requests for additional information (RAI) on Technical Report No. 09. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in this response 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 RAI(s):

RAI-TR09-008 R4

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
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/Enclosure

1. Response to Request for Additional Information on Technical Report No. 09

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NRO

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ENCLOSURE 1

Response to Request for Additional Information on Technical Report No. 09

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR09-008
Revision: 4

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.

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).

Design Control Document (DCD) Revision:

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 value of 2.9 psi differential pressure is used. The design external pressure is calculated 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, 50F. 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 external ambient 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. Inadvertent actuation of the containment fan coolers is the limiting event for external pressure at cold conditions. This event is evaluated at several initial ambient 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 protected by concrete mass to the portion exposed to the ambient external temperature condition.

Loss of ac power is evaluated using more realistic, mechanistic assumptions than for the design external pressure condition. 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.

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

External pressure is used in load combinations that include thermal loads and are used 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 cases of external pressure and external temperature.

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	W	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		
Design pressure	P_d			x			x		x			x	
Design External pressure ~~(2.9 psid)~~	P_e				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(5)	T_o				~~(4)~~	~~(5)~~x		~~(4)~~		~~(4)~~x	x(4)		~~(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. .
4. Temperature of vessel is 70°F.
5. Temperature distribution for 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.

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.

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.

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 revisions to Subsection 6.2.1.1.4 and Figure 6.2.1.1-11 were provided in Revision 2 of this response. Please see the response to RAI-SRP6.2.1.1-SPCV-07 Revision 1 and 2 for more recent revisions to this subsection. RAI-SRP6.2.1.1-SPCV-07 Revision 2 modifies Subsection 6.2.1.1.4 to be similar to the description in DCD Revision 15.

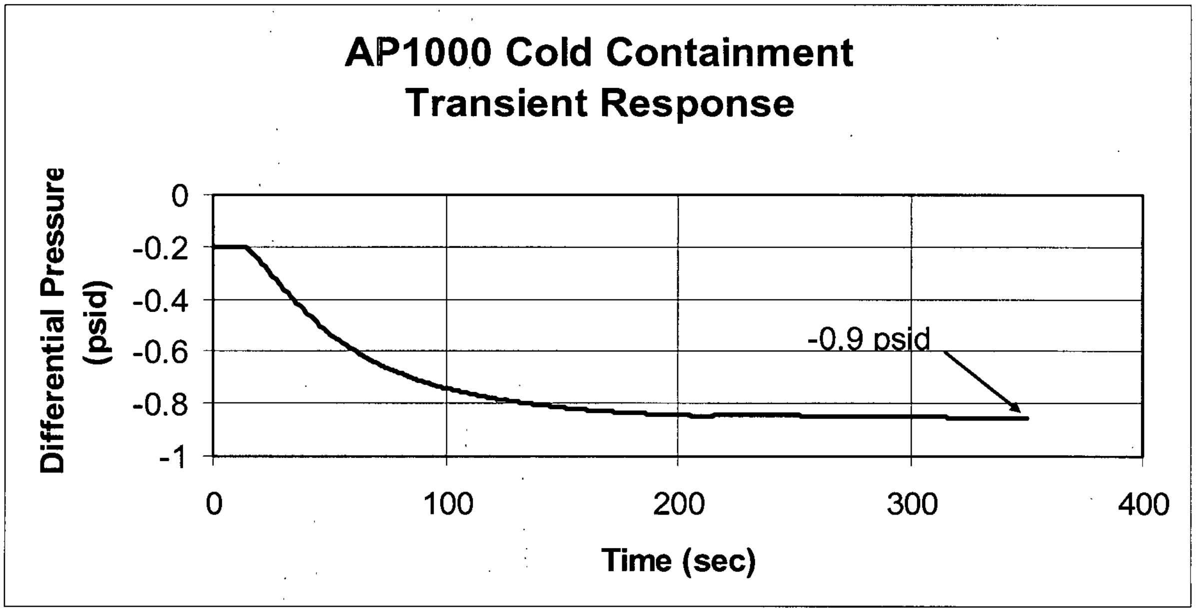
6.2.1.1.4 External Pressure Analysis

Certain design basis events and credible inadvertent systems actuation have the potential to result in containment external pressure loads. Evaluations of these events show that an inadvertent actuation of active containment cooling ~~a 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. Evaluations are performed to determine the maximum external pressure to which the containment may be subjected during a postulated actuation of the active containment cooling~~loss of all ac power sources~~.

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. With no active cooling in use ~~T~~the initial internal containment temperature is conservatively calculated ~~assumed~~ to be 69~~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.

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. Inadvertent actuation of the containment spray is not credible since the AP1000 containment spray requires significant local operator action to alig~~h~~n the system. Inadvertent actuation of the containment fan coolers is the limiting event for external pressure at cold conditions.

Evaluations are performed using WGOTHIC with conservatively low estimates of the containment heat loads and conservatively high heat removal through the containment vessel consistent with the limiting assumptions stated above. Results of these evaluations demonstrate that ~~at one hour~~ after the event the net external pressure is approximately -0.9 psid which is within the capability of the containment vessel. The pressure changes very slowly after the initial decrease and there is ~~within the 2.9 psid design external pressure. This is~~ sufficient time for operator action to prevent the containment pressure from dropping below the -0.9 psid external pressure, based on the PAM's containment pressure indications (four containment pressure instruments) and the ability to mitigate the pressure reduction by opening either set of containment ventilation purge isolation valves, which are powered by the 1E batteries.



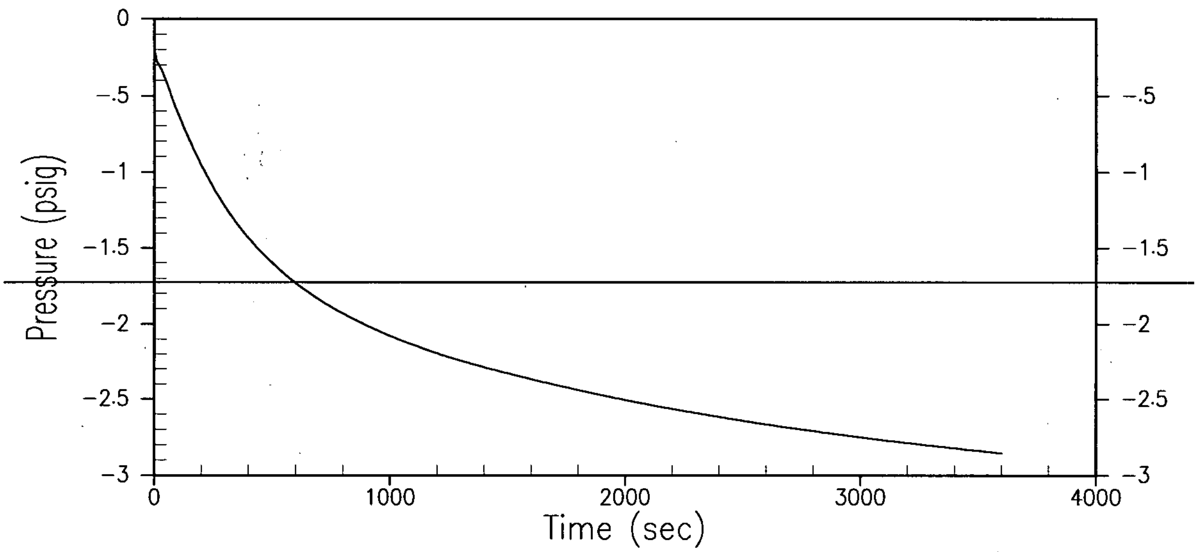


Figure 6.2.1.1-11 AP1000 External Pressure Analysis Containment Pressure vs. Time

The following revision is included as part of the Revision 3 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 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~~ based on a nonmechanistic step change in containment atmosphere at 120 degrees F, with 100% relative humidity, to the minimum operating temperature of 50 degrees F. 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:

The technical report revisions shown below were included in Revision 2 of the response. Revision 3 and 4 of the response does not include additional technical report revisions.

Revise section 2.4 as shown below.

2.4.1 External pressure and thermal loads

Design conditions for the containment vessel are specified as:

- Design Pressure 59 PSIG at design temperature of 280°F
- External Pressure 2.9 PSIG at design temperature of 70°F

Both the maximum external pressure and the temperature conditions are affected by the ambient temperature. Combinations of normal temperature and external pressure are evaluated as service conditions as follows:

Service Level A

- Dead load, uniform temperature of 70F, design external pressure of 2.9 psid
- Dead load, cold weather temperature distribution one hour after inadvertent actuation of active containment cooling, reduced pressure of 0.9 psid one hour after inadvertent actuation of active containment cooling in cold weather. This conservatively includes the low probability inadvertent actuation of active containment cooling in cold weather event as a normal operating condition.

Service Level D

- Dead load, uniform temperature of 70F, SSE, design external pressure of 2.9 psid
- Dead load, cold weather temperature distribution one hour after inadvertent actuation of active containment cooling, SSE, reduced pressure of 0.9 psid one hour after inadvertent actuation of active containment cooling in cold weather

Two temperature conditions are considered corresponding to plant operation during cold weather with the outside air temperature at the minimum value of -40F and during hot weather with the outside air temperature at 115F. The cold weather operation results in a significant temperature differential in the vicinity of the horizontal stiffener at elevation 131' 9". The vessel above the stiffener is exposed to the outside air in the upper annulus. This cold weather condition is assumed concurrent with the pressure reduction resulting from inadvertent actuation of active containment cooling and is conservatively assumed as a normal operating condition. It is evaluated during normal operation as a Service level A event. It is also evaluated under Service level D in combination with the Safe Shutdown Earthquake.

~~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~~ The ~~design~~ external pressure of 02.9 psid is based on conservative analyses as described in DCD subsection 6.2.1.1.4 (see Section 5.2 of this Technical Report). ~~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 into the containment during the transient. Results of these evaluations demonstrate that at one hour after the event the net external pressure is within the 2.9 psid design external pressure.~~

~~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.~~

~~With the postulated low outside temperatures, it is physically very unlikely, if not impossible (due to air cooling on the surface of the containment vessel) that the initial containment temperature will ever be 120 degrees F. A WGOTHIC calculation was performed to determine the containment pressure response with the containment initial temperature at as high a value as possible, and with the environment temperature as low as possible. An analysis was performed that determined that the highest containment atmosphere temperature that could occur would be 75F while the reactor is operating and the environment temperature is -40F.~~

~~To determine the reduced pressure, the following assumptions were made:~~

~~1.Initial containment conditions from steady state analysis; 75F, 100% relative humidity~~
~~2. Internal heat sinks inside containment are assumed to be 75F.~~
~~3Fan coolers remove operating reactor heat so that no net heat load to containment is assumed.~~
~~4. Environment temperature assumed to be -40F.~~
~~5. Heat transfer coefficients to heat sinks and containment shell are nominal.~~

~~Without an internal heat load, the containment atmosphere will cool and the pressure will decrease. The pressure falls from 14.5 psia to 13.6 psia (0.9 psid) at 3600 seconds after the heat input to the containment atmosphere is terminated. This is sufficient time for operator action to prevent further pressure reduction, as discussed in AP1000 DCD Section 6.2.1.1.4. Thus the design value of 2.9 psid external pressure is very conservative.~~

~~Note that the 0.9 psid considered in this second case is also conservative since it assumes no net heat load into the containment. Immediately after reactor trip the reactor coolant loop stays hot and heat loads to the containment remain close to those during normal operation. The fan coolers cannot operate with the assumption of loss of all AC; nor would they be expected to be providing cooling when the exterior temperatures are so low.~~

Table 2-4 – Load Combinations for the Large Penetrations

Load			Design		Level A Service Limit			Level C Service Limit		Level D Service Limit		
	Con	Test	Des1	Des2	A1	A2	A3	C1	C2	D1	D2	D3
D	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
E_s								1.0		1.0	1.0	1.0
P_t		1.0										
T_t		1.0										
P_o									1.0			
P_i			1.0			1.0		1.0				1.0
P_e (2.9psid)				1.0			1.0			1.0		
P_e (0.9psid)					1.0						1.0	
T_o				(4)	(5)		(4)		(4)	(4)	(5)	
T_a			1.0			1.0		1.0				1.0

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 pressure of 0.9 psid at one hour in inadvertent actuation of active containment cooling ~~loss of all AC~~ transient in cold weather.
4. Temperature of vessel is 70F.
5. Temperature distribution for inadvertent actuation of active containment cooling~~loss of all AC~~ in cold weather.
6. The 'Lowest Service Metal Temperature' corresponding to -40 degree F outside temperature is -18.5 °F.

Revise section 5.1 as shown below.

5.1 DCD Changes from Rev 15 to Rev 16

The DCD changes from Rev 15 to Rev 16 were shown in Rev 0 and Rev 1 of this report. DCD Rev 16 has been issued so these changes have been deleted from this section of the Technical Report.

Revise section 5.2 as shown below.

5.2 DCD Changes to Rev 16

The following revisions are to DCD Rev 16.

Revise classification in Table 3.2-3 as shown below from MC to Class 2 for penetrations where the process pipe penetrates directly the containment vessel without the use of a flued head (see typical detail on lower half of Figure 3.8.2-4, sheet 4 of 6). In this case the sleeve is a boundary of the process fluid and is required by the ASME Code to be Class 2.

Revise sheets 2, 3, 4 and 6 of Figure 3.8.2-4 as shown on the following pages to reflect detail design of the penetration reinforcement.

Add text and figure showing changes to subsection 6.2.1.1.4, "External Pressure Analysis" as shown in the DCD Revisions in this RAI response (pages 2 and 3 in this RAI response).