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Your ref: Docket No. 52-006
Our ref: DCP/NRC2261

September 15, 2008

Subject: AP1000 Response to Request for Additional Information (TR09)

Westinghouse is submitting a revised response to the NRC requests for additional information (RAI) on AP1000 Standard Combined License Technical Report (TR) 09, APP-GW-GLR-005, Containment Vessel Design Adjacent to Large Penetrations. This RAI response is submitted in support of the AP1000 Design Certification Amendment Application (Docket No. 52-006). The information included in the response is generic and is expected to apply to all COL applications referencing the AP1000 Design Certification and the AP1000 Design Certification Amendment Application.

A revised response is provided for RAI-TR09-001,-003,-004,-005,-006, and 008. This response completes all requests received to date for TR 09. A revised response for RAI-TR09-008 was submitted under letter DCP/NRC2132 dated May 12, 2008. A revised response for RAI-TR09-001,-004,-005, and -006 was submitted under letter DCP/NRC2131 dated May 2, 2008. A Revision 0 response for RAI-TR09-001 through -008 was submitted under letter DCP/NRC1986 dated September 7, 2007.

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,

Robert Sisk

Robert Sisk, Manager
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/Enclosure

1. Response to Request for Additional Information on Technical Report 09



D063
NRO

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ENCLOSURE 1

Response to Request for Additional Information on Technical Report 09

# AP1000 TECHNICAL REPORT REVIEW

## Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR09-001
Revision: 2

***Question:***

The Main Steam and Feedwater penetrations are not addressed in TR-9. These are important major penetrations, which potentially induce cyclic thermal and mechanical loading in the steel containment vessel, around the periphery of the penetrations. The staff requests the applicant to include the design and analysis details for the Main Steam and Feedwater penetrations in TR-9.

**Westinghouse Response:**

Westinghouse calculation APP-MV50-S2C-012, Design of Containment Vessel (CV) Penetration Reinforcement, includes the CV reinforcement design for containment penetrations. Section 2.6 was added to the TR09 Rev 1 report describing the design of the Main Steam and Feedwater penetration reinforcement. It was clarified that the penetration assemblies are connected to the vessel by expansion bellows thus preventing significant cyclic thermal and mechanical loading in the steel containment vessel.

When APP-MV50-S2C-012 was reviewed by the NRC in May 2008 audit in the Westinghouse offices in Pittsburgh, it included the design of penetration reinforcement for the main steam, feedwater, and the start-up feedwater penetrations. Subsequently, the NRC staff asked the information related to the design of CV reinforcement for other CV penetrations.

To close this RAI, a proposed revision to TR09 (see Attachment 'A') was agreed.

- The proposed revision has been incorporated in TR09 Revision 2 (APP-GW-GLR-005, Revision 2).
- The proposed revision has also been incorporated in Westinghouse Calculation APP-MV50-S2C-012.

**Design Control Document (DCD) Revision:**

None

**PRA Revision:**

None

**Technical Report (TR) Revision:**

See Attachment 'A' below

**Attachment"A"**

Proposed Revisions to TR09

Renumber section 2.7 ("ASME Code Design Specification and Design Report") to 2.8

Add a new section 2.7 as follows:

2.7 Other Mechanical and Electrical Penetrations

This section describes the design procedure for the penetration reinforcement for containment penetrations except the equipment hatches, personnel airlocks, main steam, feedwater and start up feedwater, which are addressed in previous sections. It includes the piping and electrical penetrations, and the fuel transfer tube. The containment vessel includes the sleeve through the shell and the thickened insert plate. Other portions of the assemblies are designed as piping and equipment.

Typical design information for the penetrations is provided in the DCD. The mechanical penetrations are listed in DCD Table 6.2.3-1. Typical details are shown in DCD Figure 3.8.2-4. Penetration assemblies, such as those shown in the upper figure on DCD Figure 3.8.2-4 (sheet 4 of 6) are ASME Class 2. Expansion bellows and guard pipes are ASME Class 2 or Class MC. The penetration assemblies are welded to sleeves that are ASME Class MC. Process piping welded directly to the vessel, such as shown in the lower figure in DCD Figure 3.8.2-4 (sheet 4 of 6) is ASME Class 2.

The material of construction is SA738 Grade B for the vessel shell, insert plates and nozzle necks of penetrations with inside diameters greater than 24". For penetrations less than 24" inside diameter and greater than 2" nominal diameter, forgings of SA350 LF2 material are used for the nozzle neck.

Penetration reinforcement is designed by the area replacement method in accordance with the requirements of ASME Section III, Division 1, Subsection NE, Paragraph NE3330. Area is added to the shell by the addition of an insert plate that is thicker than the shell or by increasing the thickness of the nozzle neck or a combination of both. This piping penetration design is then evaluated for external loads on the penetration imposed by the piping system as follows:

- The penetrations are grouped together based on configuration and size. For each group, a spread sheet is provided by CV supplier to the piping analyst.
- The piping analyst uses the spread sheet to assure that the CV nozzle capacity satisfies the ASME stress criteria
- (Note: Loads on the nozzle are limited, if necessary to satisfy ASME stress criteria, by adjusting the support locations and flexibility of the piping)

..

The penetration reinforcement and local region of the vessel shell have been analyzed for unit external loads, for selected typical nozzle configurations, by finite element analyses. A typical finite element model is shown in Figure 2-6.1. Corresponding stresses were determined at selected points of interest, such as every 10 degrees around the circumference of the nozzle at the attachment fillet weld toe and at a distance of $.5\sqrt{(Rt)}$ from the nozzle wall.

Note: External loads on the penetrations are obtained from detailed piping and equipment analyses and are generally not available for inclusion in initial issues of the containment vessel design specification. The finite element models of each penetration are used to develop guidance on acceptable loading to the piping and equipment designer. Once the detailed piping and equipment loads are available, they are provided to the containment vessel designer as an addendum to the design specification, to document the adequacy of the penetrations designs in the CV Design Report.

It may be noted that many of the penetrations include expansion bellows which limit the load on the nozzle. Others are less than 2" in diameter where the strength will be limited by the piping.

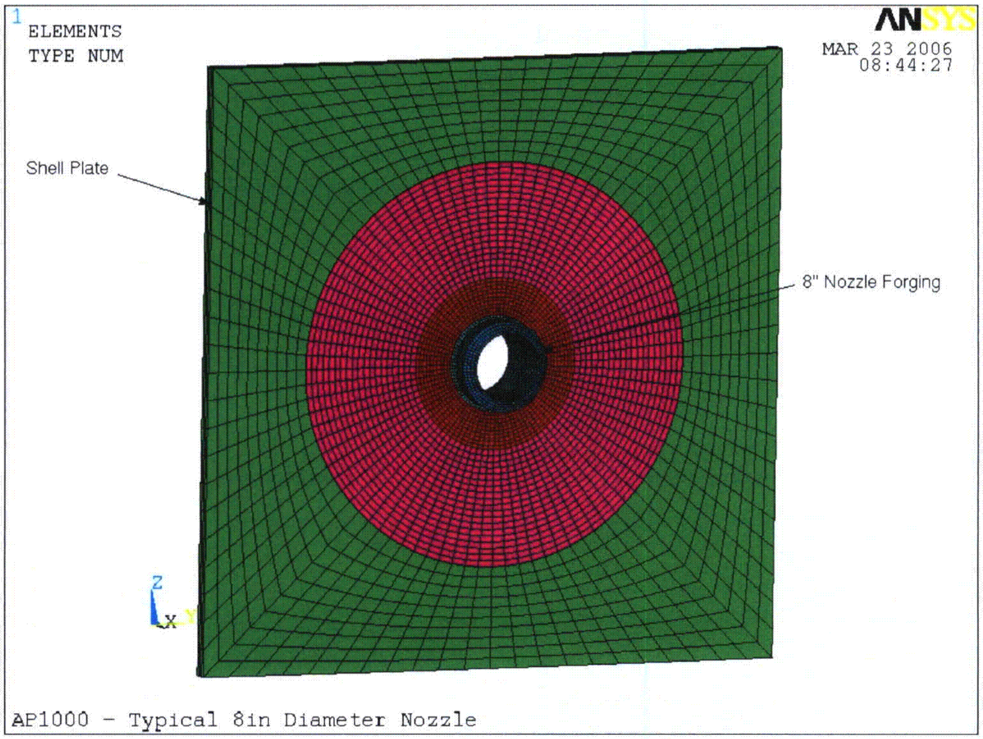



**Figure 2-6.1 Typical Nozzle FEA Model**

# AP1000 TECHNICAL REPORT REVIEW

## Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR09-003
Revision: 1

***Question:***

There are no design details for the penetrations in TR-9. The staff requests the applicant to include design information (geometry, material and material properties, dimensions and wall thicknesses) for each penetration in TR-9. Also specify the ASME Code, Class MC jurisdictional boundaries for each penetration.

**Westinghouse Response:**

Typical design information for the penetrations is provided in the DCD. This material has now been included in Appendix A of the report. Penetration assemblies, such as those shown in the upper figure on DCD Figure 3.8.2-4 (sheet 4 of 6) are ASME Class 2. Expansion bellows and guard pipes are ASME Class 2 or Class MC. The penetration assemblies are welded to sleeves that are ASME Class MC. Process piping welded directly to the vessel, such as shown in the lower figure in DCD Figure 3.8.2-4 (sheet 4 of 6) is ASME Class 2.

The material of construction is SA738 Grade B for the vessel shell, insert plates and nozzle necks of penetrations with inside diameters greater than 24". For penetrations less than 24" inside diameter and greater than 2" nominal diameter, forgings of SA350 LF2 material are used for the nozzle neck.

Design requirements for the mechanical penetrations are as follows:

- Design and construction of the process piping follow ASME, Section III, Subsection NC. Design and construction of the remaining portions follow ASME Code, Section III, Subsection NE. The boundary of jurisdiction is according to ASME Code, Section III, Subsection NE.

- Penetrations are designed to maintain containment integrity under design basis accident conditions, including pressure, temperature, and radiation.

- Guard pipe assemblies for high-energy piping in the containment annulus region between the containment shell and shield building that are part of the containment boundary are designed according to the rules of Class MC, subsection NE, of the ASME Code.

- Bellows are stainless steel or nickel alloy and are designed to accommodate axial and lateral displacements between the piping and the containment vessel. These displacements include thermal growth of the main steam and feedwater piping during plant operation, relative seismic movements, and containment accident and testing conditions. Cover plates are provided to protect the bellows from foreign objects during construction and operation. These cover plates are removable to permit in-service inspection.

NRC staff had indicated that TR-09, Rev 1, includes a significant amount of new information on the design of penetrations; and they needed to review applicable design calculations.

The CB&I Containment Vessel Design Report (APP-MV50-S3R-003) and the calculation 'Design of Containment Vessel Penetration Reinforcement' (APP-MV50-S2C-012) were reviewed by the NRC staff in detail during the May 2008 audit in Pittsburgh.

- The staff noted a few discrepancies related to the applicable ASME Code year, and an ASME Code Case, referenced in these documents.

- The staff also noted that a note at the bottom of load combination tables in these documents, related to the -40F temperature condition, needs to be updated.

It was explained to the staff that these changes would have no impact on the design, or the analysis results, contained in these documents.

However, in accordance with the Westinghouse Quality procedure, a 'Supplier CAR' issue (#08-163-M005) was opened. The corrections have been incorporated in the documents.

**Design Control Document (DCD) Revision:**

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 fluid 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.

**DCD TABLE 3.2-3: AP1000 CLASSIFICATION OF MECHANICAL AND FLUID SYSTEMS, COMPONENTS, AND EQUIPMENT**

| Tag Number | Description | AP1000 Class | Seismic Category | Principal Construction Code | Comments |
|---|---|---|---|---|---|
| CAS-PY-C02 | Containment Instrument Air Inlet Penetration | B | I | ASME III, ~~MC~~ 2 | |
| CAS-PY-C03 | Containment Service Air Inlet Penetration | B | I | ASME III, ~~MC~~ 2 | |
| CCS-PY-C01 | Containment Supply Header Penetration | B | I | ASME III, ~~MC~~ 2 | |
| CCS-PY-C02 | Containment Return Header Penetration | B | I | ASME III, ~~MC~~ 2 | |
| CVS-PY-C02 | Letdown Line Containment Penetration | B | I | ASME III, ~~MC~~ 2 | |
| CVS-PY-C04 | Hydrogen Add Line Containment Penetration | B | I | ASME III, ~~MC~~ 2 | |
| DWS-PY-C01 | Containment Demineralized Water Supply Penetration | B | I | ASME III, ~~MC~~ 2 | |
| FPS-PY-C01 | Fire Protection Containment Penetration | B | I | ASME III, ~~MC~~ 2 | |
| PSS-PY-C03 | Containment Atmosphere Sample Line Penetration | B | I | ASME III, ~~MC~~ 2 | |
| PXS-PY-C01 | Nitrogen Makeup Containment Penetration | B | 1 | ASME III, ~~MC~~ 2 | |
| VFS-PY-C01 | Containment Supply Duct Penetration | B | I | ASME III, ~~MC~~ 2 | |
| VFS-PY-C02 | Containment Exhaust Duct Penetration | B | I | ASME III, ~~MC~~ 2 | |
| VWS-PY-C01 | Containment Chilled Water Supply Penetration | B | I | ASME III, ~~MC~~ 2 | |
| VWS-PY-C02 | Containment Chilled Water Return Penetration | B | I | ASME III, ~~MC~~ 2 | |
| WLS-PY-C02 | Reactor Coolant Drain Tank WLS Connection Penetration | B | I | ASME III, ~~MC~~ 2 | |
| WLS-PY-C03 | Containment Sump Pumps Combined Discharge Penetration | B | I | ASME III, ~~MC~~ 2 | |

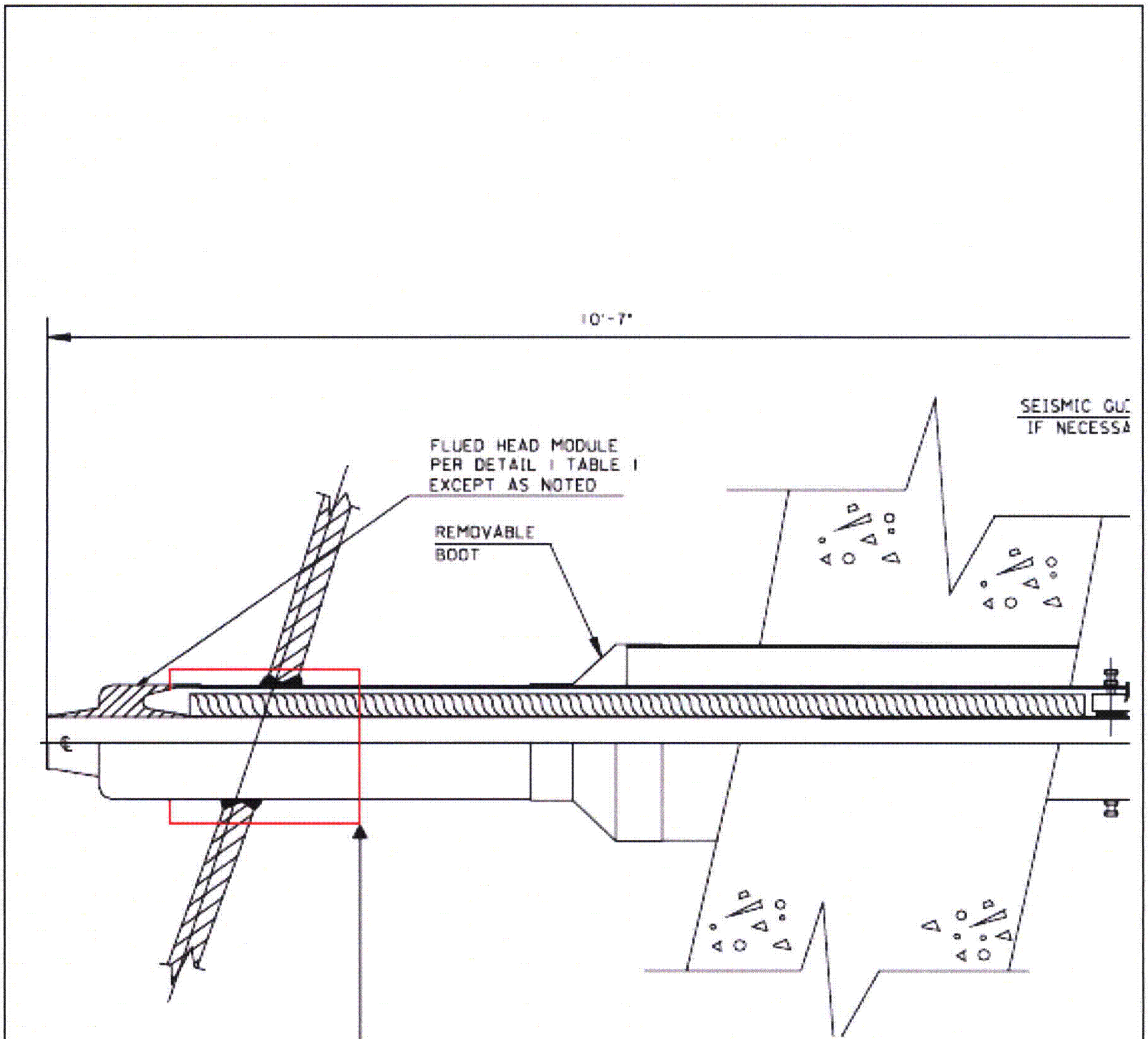



**Figure 3.8.2-4 (Sheet 2 of 6)**
**Containment Penetrations Startup Feedwater**

Thicken nozzle and add weld to guard pipe outside containment.

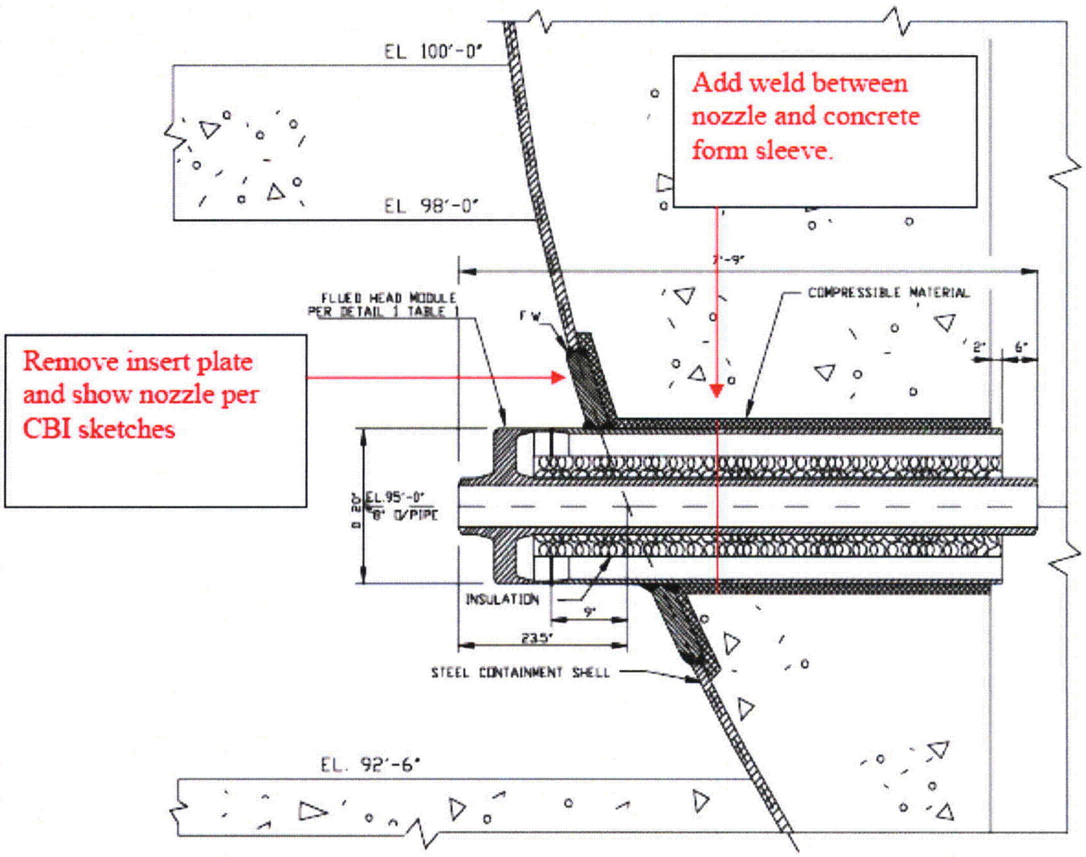



Figure 3.8.2-4 (Sheet 3 of 6)

**Containment Penetrations Normal RHR Piping**

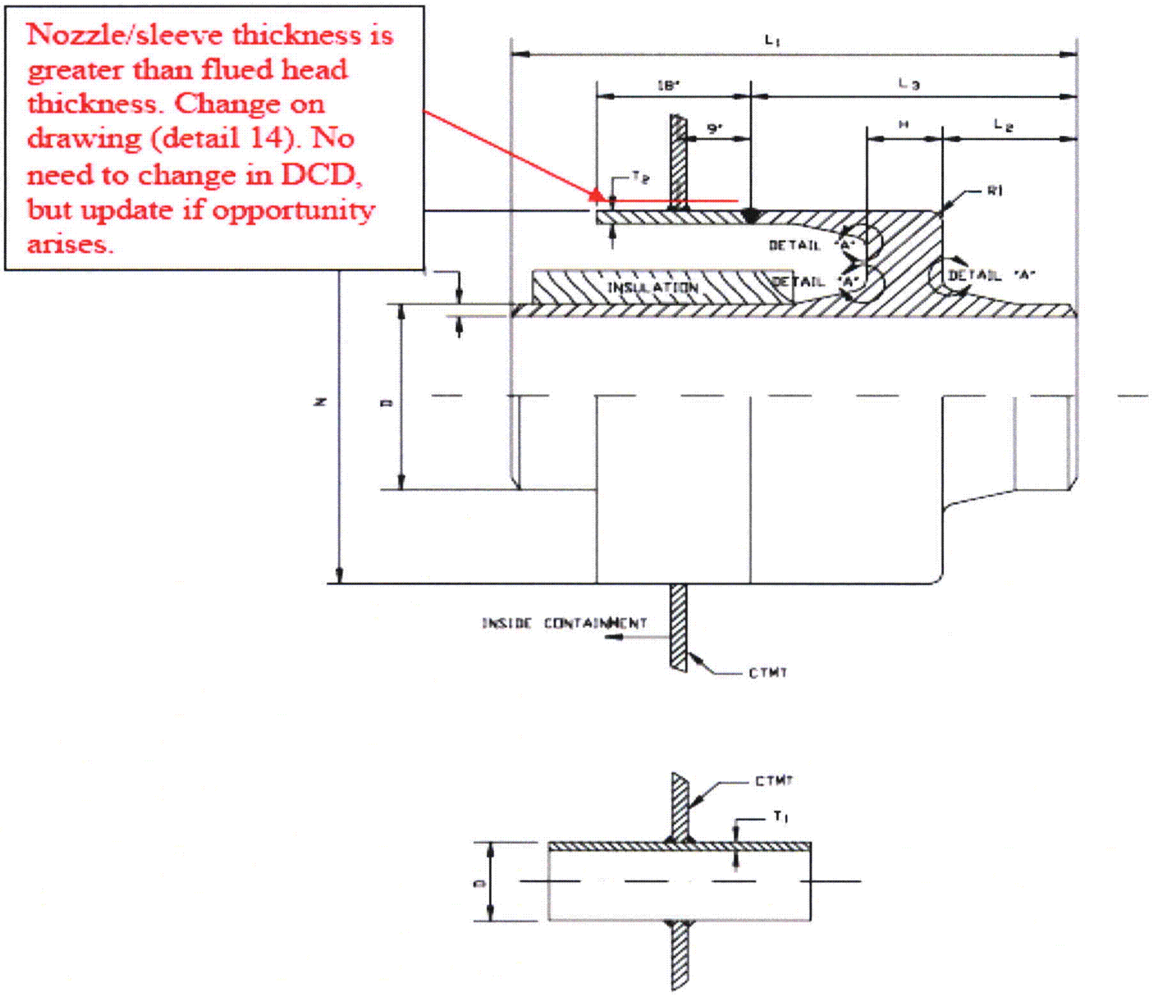



Figure 3.8.2-4 (Sheet 4 of 6)

**Containment Penetrations**

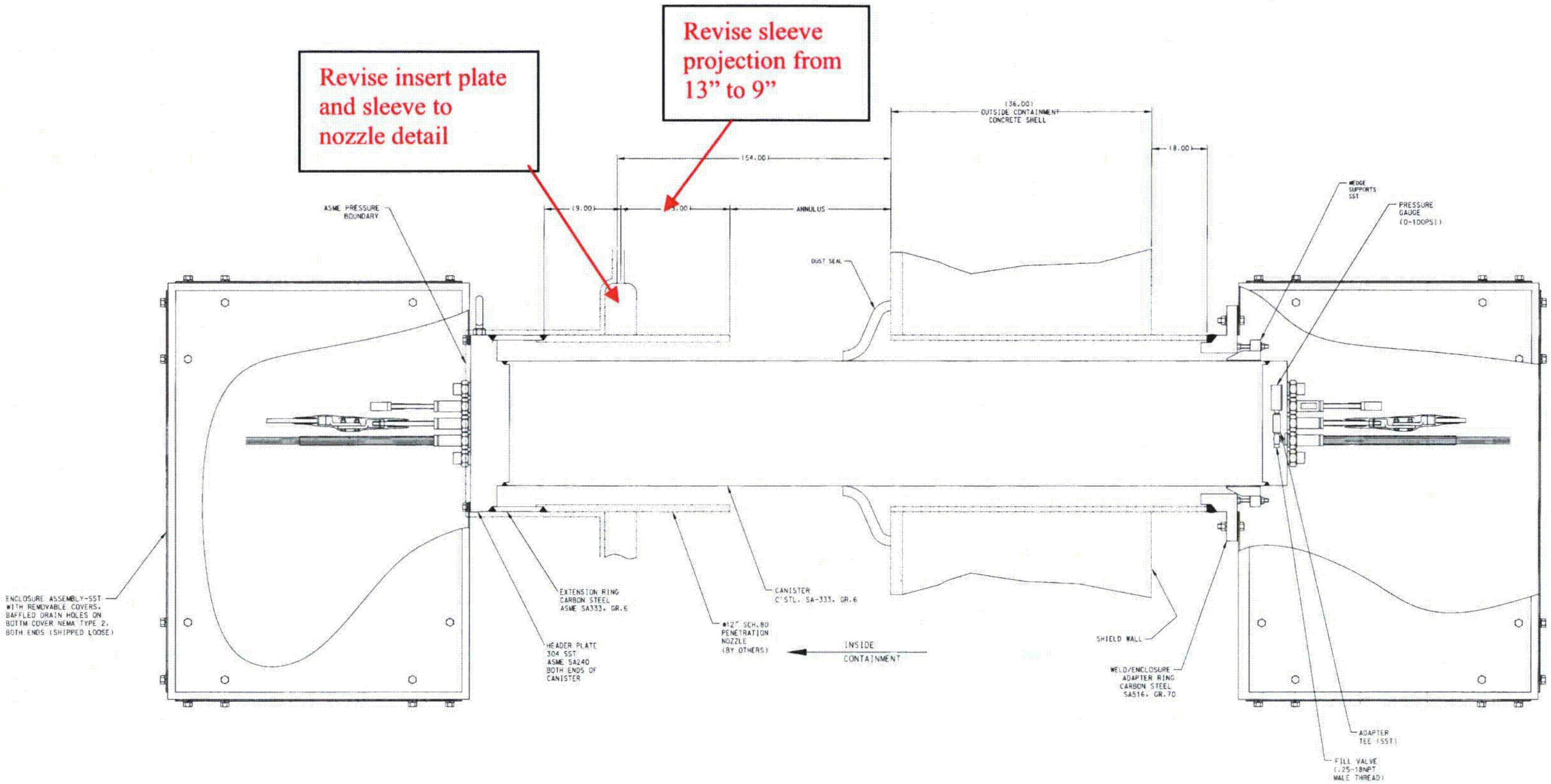



**Figure 3.8.2-4 (Sheet 6 of 6)**
**Containment Penetration Typical Electrical Penetration**

**PRA Revision:**

None

**Technical Report (TR) Revision:**

None

# AP1000 TECHNICAL REPORT REVIEW

## Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR09-004
Revision: 2

***Question:***

There is insufficient description in TR-9 of the local ANSYS models developed for the penetrations. For each penetration, the staff requests the applicant to address the following in TR-9:

- How is local thickening of the containment vessel modeled?
- How is the ANSYS output used to conduct the ASME Code stress checks?
- What ASME categories of stresses are directly obtainable from the ANSYS results: primary, primary + secondary, primary + secondary + peak?

**Westinghouse Response:**

The local ANSYS model for the upper equipment hatch is shown in Figure 2-6(b) of the report. This model is included as a refined part of the overall model. Elements are defined so that the local thickening is represented by the element thickness. The thicker portion around the upper equipment hatch is visible in Figure 2-6(b).

Hand calculations are used to check Primary General Membrane stresses (Pm). ANSYS output is used directly to make ASME Code stress checks for the following:

- Primary stresses - Local Membrane (PL)
- Primary and Secondary Stresses (Pb + PL + Q)

There are no loads causing primary bending stresses, Pb, or peak stresses, F, in the vicinity of the large penetrations.

Subsequent to the initial response to this RAI the NRC requested a revised Figure 2-6(b) in APP-GW-GLR-005 to show the thickened portion of the containment. An additional figure to supplement Figure 2-6(b) is shown below and will be added to the technical report.

After review of the initial response for this RAI the NRC requested explanation of the statement "There are no loads causing primary bending stresses, Pb, or peak stresses, F, in the vicinity of the large penetrations." The explanation for this statement is provided below.

A primary stress such as primary bending Pb is one that is necessary to satisfy the simple laws of equilibrium of external and internal forces and moments. A secondary stress Q is one that is developed by the constraint of adjacent parts or by self-constraint of a structure. The bending stresses in and around the large openings are not needed to satisfy equilibrium of the internal and external forces and moments acting on and around the large penetrations. These bending stresses are due to the restraint of adjacent parts caused by the abrupt changes in geometry.

Therefore, the bending stresses in the vicinity of the large penetrations are classified as secondary stresses only. None of it is classified as primary stress.

With reference to Section III, Div. 1, Subsection NE the stresses near a nozzle or other opening originating from external load or moment or internal pressure are classified as Local Membrane Pl and Secondary Bending Q stress in accordance with Table NE-3217-1. There are no Primary Bending Stresses Pb at the nozzle or large openings because Primary Bending Stresses are through thickness bending stresses such as are seen in the center of a flat head under internal pressure as noted in Table NE-3217-1.

As for the subject of peak stresses:
Para NE-3212.11 defines peak stress. It is noteworthy that stress concentrations are not necessary for the classification (the wording is including the effects, if any, of stress concentrations). Peak stress is objectionable only as a possible source of a fatigue crack or brittle fracture. The paragraph notes that it does not need to be highly localized if it is of a type which cannot cause noticeable distortion and cites four examples. Example c) states "the stress at a local structural discontinuity".

Also, FEA results can pick up some peak effects depending on the element size and other modeling details. Generally the portion of the stress above the equivalent linear stress (that obtained by linearizing the stress through the thickness) can be considered peak. But this is not necessarily all the peak stress that can be present. For example, peak stress due to notches or stress concentrations can also be calculated using fatigue strength reduction factors.

In any case, we did not determine peak stresses in and around the openings and did not classify any stresses as peak stresses because a fatigue evaluation is not required by the design specification. The ASME evaluation of peak stress is performed as part of a fatigue evaluation. ~~None was required~~ Fatigue evaluation was not required (because the CV Design Specification Section 3.10 states that analyses are not required for cyclic operation); so we did not classify any stresses as peak.

The statement in question read, "There are no loads causing primary bending stresses, Pb, or peak stresses, F, in the vicinity of the large penetrations." Regarding the peak stresses, we did not classify any stresses in the vicinity of the large penetrations due to any of the considered loads as peak stresses because a fatigue evaluation was not required.

Westinghouse Calculation APP-MV50-S2C-012 includes the reinforcement design methodology and details for containment penetrations requested in this RAI. This calculation was available for review by the NRC staff during the audit in May '08 at the Westinghouse offices in Pittsburgh.

**Design Control Document (DCD) Revision:**

None

**PRA Revision:**

None

**Technical Report (TR) Revision:**

See Revision 1 of the Technical Report.

Revise the first paragraph of Section 2.3 as follows:

Static analyses were performed on a finite element model having greater detail around the penetrations than that described in section 2.1 and used for the time history dynamic analyses in section 2.2. The mesh in the panels around the personnel locks and equipment hatches was refined using elements with a size less than 0.25 $\sqrt{(Rt)}$. Three sub-models were generated, one for the upper personnel lock, one for the upper equipment hatch, and one combined sub-model for the lower personnel lock and equipment hatch. The coarsely meshed panels around the openings in the dynamic model were replaced by the refined mesh panels. The refined model used in static analyses to evaluate the large penetrations is shown in Figure 2-6(a). The refined submodel for the upper equipment hatch is shown in Figures 2-6(b) and 2-6(c).

Add Figure 2-6(c) as follows:

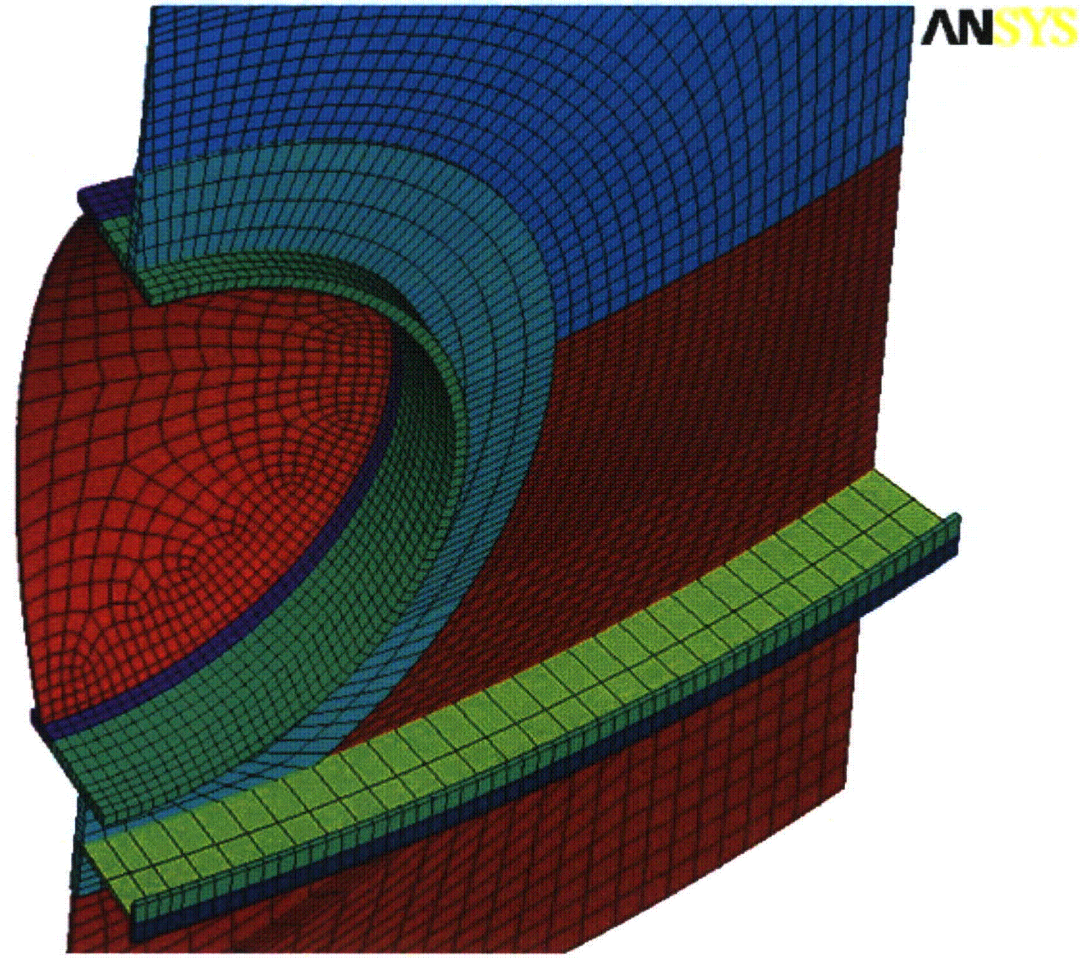



Figure 2-6(c) – Equipment Hatch (El. 141'-6") Panel – Vertical Section

# AP1000 TECHNICAL REPORT REVIEW

## Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR09-005
Revision: 2

***Question:***

There is insufficient description in TR-9 of the load cases analyzed. For each penetration, the staff requests the applicant to address the following in TR-9:

- How many actual load cases were analyzed?
- How are these combined to check all the required load combinations?
- Is the containment post-accident flooding load combination applicable? It is not identified in the load combination table included in the report.

**Westinghouse Response:**

- **Load Cases / Load Combinations:**

During review of the earlier response to this RAI, the NRC had requested that the load combinations in the Containment Design Report (APP-MV50-S3R-003), the technical report on containment penetrations (APP-GW-GLR-005), and the DCD be revised to be consistent.

Section 2.3 of the report was revised to describe the individual load cases and their combination. Response Revision 1 to RAI-TR09-008 includes DCD and technical report changes to address this issue.

The CB&I report APP-MV50-S3R-003, and calculations APP-MV50-S2C-012 and APP-MV50-S2C-012 were reviewed in detail by the NRC staff during the last audit.

Note: See response to RAI #3 for the NRC findings and resolution by Westinghouse.

- **Post Accident Flooding Load:**

The post accident flooding load combination is not applicable in the design of the containment vessel. Containment flooding events are described in DCD subsection 3.4.1.2.2.1. Curbs are provided around openings through the maintenance floor at elevation 107′-2″ to control flooding into the lower compartments. The maximum curb elevation of 110′-2″ establishes the maximum flooding on the containment vessel boundary. There are seals at elevation 107′-2″ between the containment vessel and maintenance floor as shown in sheet 2 of DCD Figure 3.8.2-8. In the event of seal leakage hydrostatic pressure could be imposed on the vessel behind the concrete. Pressure loads below elevation 100' are resisted by the mass concrete of the nuclear island basemat. Pressure loads above elevation 100' would be carried by the steel vessel. Hence there could be a maximum hydrostatic head of 10' corresponding to a hydrostatic pressure of about 5 psi.

The containment vessel is designed for a design pressure of 59 psi. This pressure exceeds the maximum calculated pressure in design basis accidents.

Maximum flooding occurs late during the accident transient. The combination of hydrostatic pressure at elevation 100' and containment pressure is less than the design pressure of 59 psi. Hence, the post-LOCA flooding event is enveloped by the other design cases.

**Design Control Document (DCD) Revision:**

See RAI-TR09-008, Revision 1

**PRA Revision:**

None

**Technical Report (TR) Revision:**

See RAI-TR09-008, Revision 1

# AP1000 TECHNICAL REPORT REVIEW

**Response to Request For Additional Information (RAI)**

RAI Response Number: RAI-TR09-006
Revision: 2

***Question:***

There is insufficient description in TR-9 of the stress results. For each penetration, the staff requests the applicant to include the following in TR-9:

- Tabulated summary of stress results for all of the analyzed load conditions.
- Tabulated summary of combined stresses for the identified load combinations.
- Tabulated summary of the comparisons to ASME Code allowable stress limits for all applicable Service Levels.

**Westinghouse Response:**

Section 2.4.2.1 has been added to the report to provide the requested information.

Based on discussions with NRC reviewers after submittal of this response a note will be added to Table 2-5 and Table 2-6 of TR-09 on differences in calculation results. This note is described below.

During an NRC review subsequent to submittal of this RAI response the reviewers requested detailed stress results for other penetrations. ~~This staff request is a significant expansion of the scope of the technical report. The design of the containment penetrations was included in the certified design and is not subject to review as part of the design certification amendment. APP-GW-GLR-009 (TR-09) was written to address a COL information item requirement to complete the design of the reinforcement for large penetration. TR-09 includes the information required of the COL information item. Additional information will not be provided on the design of the penetrations.~~ It was agreed to add a new section 2.7 in TR09 Revision 2 to address the methodology for other penetrations for which the design has not been completed. (See attachment to RAI-TR09-001 Rev.2 response.)

**Design Control Document (DCD) Revision:**

None

**PRA Revision:**

None

**Technical Report (TR) Revision:**

~~See Revision 1 of the Technical Report.~~ As described above.

Add the following note to Table 2-5

Note: Hand calculations are used to check Primary General Membrane stresses ($P_m$).

Add the following note to Table 2-6

Note: ANSYS output is used to make Local Stress Intensity Code check.

# AP1000 TECHNICAL REPORT REVIEW

## Response to Request For Additional Information (RAI)

RAI Response Number: RAI-TR09-008
Revision: 2

***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.

**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 conditionsloss of all AC in cold weather" event (cases A1 and D2 in Table 2-4).

**Design Control Document (DCD) Revision:**

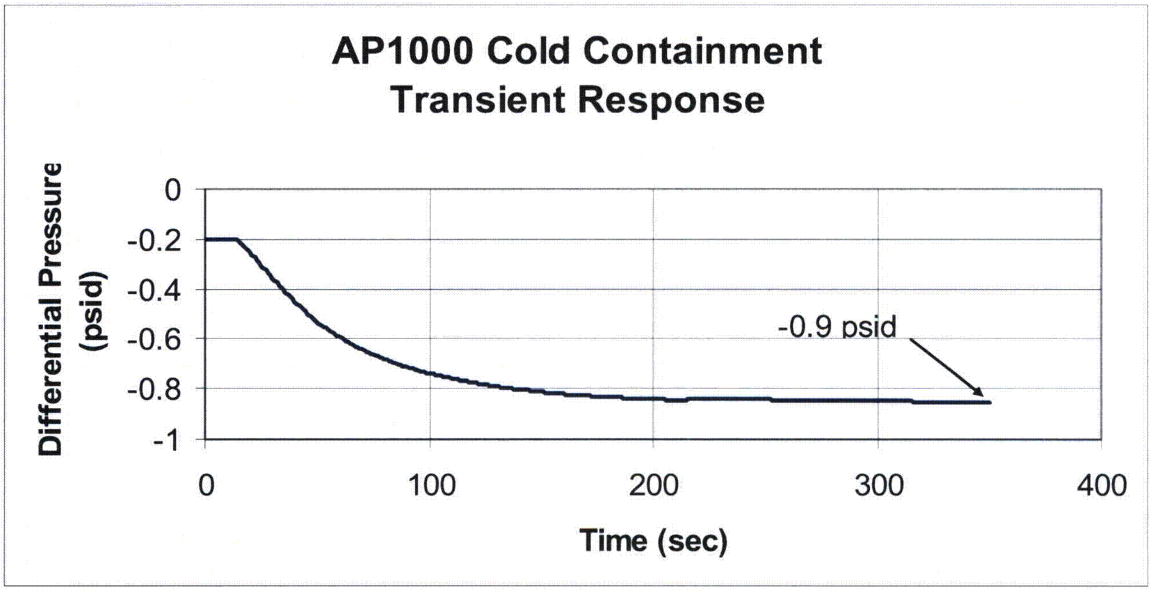
**6.2.1.1.4 External Pressure Analysis**

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 coolingloss 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 Tthe initial internal containment temperature is conservatively calculated assumed to be 69120°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 alighn 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.



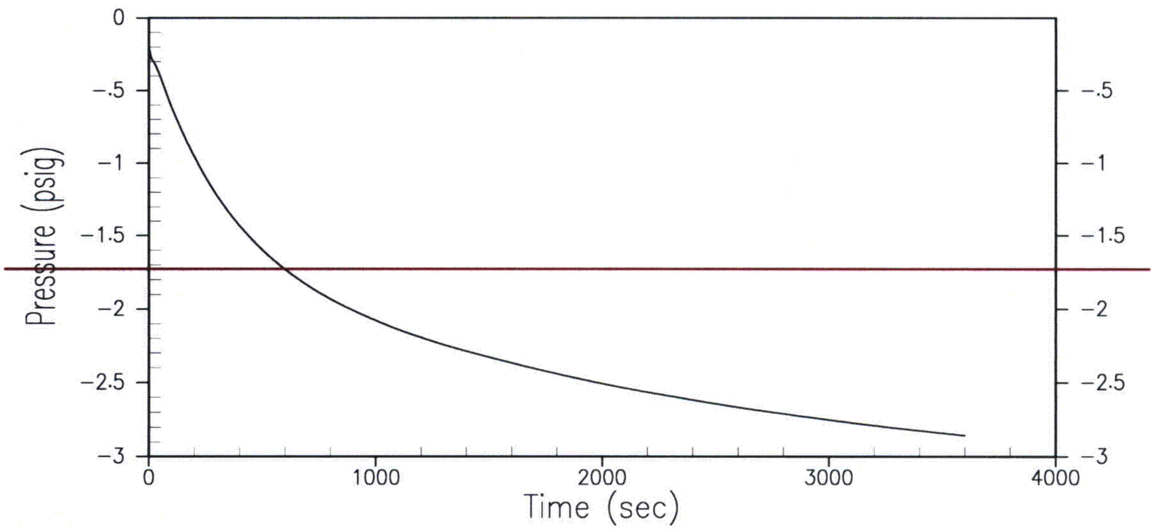




Figure 6.2.1.1-11 AP1000 External Pressure Analysis Containment Pressure vs. Time

**PRA Revision:**
None

**Technical Report (TR) Revision:**

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 0~~2~~.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.

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).