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Your ref: Docket No. 52-006
Our ref: DCP/NRC2493

May 22, 2009

Subject: AP1000 Response to Request for Additional Information (SRP 6)

Westinghouse is submitting a response to the NRC request for additional information (RAI) on SRP Section 6. 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-SRP6.2.1.1-SPCV-07

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, Manager
Licensing and Customer Interface
Regulatory Affairs and Standardization

/Enclosure

1. Response to Request for Additional Information on SRP Section 6

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NRO

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ENCLOSURE 1

Response to Request for Additional Information on SRP Section 6

AP1000 TECHNICAL REPORT REVIEW

Response to Request For Additional Information (RAI)

RAI Response Number: RAI-SRP6.2.1.1-SPCV-07
Revision: 0

Question:

RAI SRP6.2.1.1-SPCV-01 through -04 requested additional information on the change to the maximum external pressure analyses. Westinghouse referenced calculation notes APP-MV50-Z0C-020, Rev. 0 in their response. The following issues remain regarding this analysis and the RAI responses:

a) In response to RAI SRP 6.2.1.1-SPCV-01, Westinghouse stated that while the accident analysis biased the heat transfer coefficients low, the external pressure analysis used nominal heat transfer coefficients. Provide details on how the nominal heat transfer coefficients used in the external pressure analysis differ from those described in the accident analysis documented in WCAP-15846.

b) Westinghouse assumed that the heat loss at operating reactor power was equal to the maximum capacity of the fan coolers, or 26167 Btu/s. Justify why this approach results in a bounding value for heat loss. Clarify why Appendix B and D of the referenced calc-notes list heat rates of 2536.33 Btu/s rather than the stated 26167 Btu/s for both the heater and cooler. Provide the value actually used in the WGOTHIC model.

c) There is a 10x difference in time scale between DCD Figure 6.2.1.1-11 and the associated data points from Appendix E of the referenced calc notes. Please resolve the discrepancy. If the scale in the DCD Figure is correct, justify why analysis ended after 6 minutes.

d) In response to RAI-SRP6.2.1.1-SPCV-01 and -03, Westinghouse provided values calculated by WGOTHIC for the heat transfer coefficients of the containment shell, baffle, and shield building. Explain how these were derived (specific time point and WGOTHIC conductor) and why they differ from the heat transfer coefficients reported in the referenced calc notes (where at 3600 sec, h-outside containment shell =5.2 B/hr-ft^2-°F and h-inside containment shell =1.6 B/hr-ft^2-°F).

e) Although the referenced calc-notes state that the containment shell temperature was initially set to -18°F for the second part of the analysis (actuation of fan coolers after steady state operation at low temperature), the WGOTHIC model included in the Appendix has the shell conductors set to 69°F. Please provide a plot of the containment shell temperature versus time for this transient.

f) In response to RAI SRP 6.2.1.1-SPCV-04, Westinghouse states that the changes to the shield building air inlets make the air velocity in the annulus less dependent on external wind speed. In the original design, the assumed 48 mph wind speed was modeled with a 25 mph annulus velocity. For the new shield building design, describe how annulus velocity was modeled and how this correlates to a 48 mph wind speed.

Westinghouse Response:

a) The analyses described in WCAP-15846 are performed to calculate the passive containment pressure response to loss-of-coolant accidents and main steam line breaks. In these accident sequences, there is a large mass and energy release to the containment, the PCS water is actuated, and evaporative cooling is credited on the outside of the PCS shell. Lower bounded heat and mass transfer coefficients are used to calculate a conservatively high peak pressure for the containment design analyses. Upper bounded heat and mass transfer coefficients are used to calculate a conservatively low containment back pressure for the ECCS evaluation model.

The external pressure analysis for the passive plant is analogous to an inadvertent containment cooling actuation analysis in a conventional nuclear plant containment building. The passive containment does not have an internal containment spray system that can be spuriously actuated. Therefore, the limiting sequence for the external pressure analysis is the inadvertent actuation of the containment cooling system fan cooler at the coldest environmental conditions.

Natural convection heat transfer with condensation is the principal method of energy exchange to the inside surface of the containment shell. For the peak pressure containment analyses described in WCAP-15846, it is conservative to calculate lower bounded heat and mass transfer to the external shell. The McAdams turbulent free convection correlation, with a lower bounding multiplier value of 0.73, is used to calculate the condensation heat and mass transfer rate to the inside surface of the containment shell in the peak pressure analysis. For the external pressure analysis, it is conservative to calculate a lower internal pressure. The containment atmosphere is assumed to have an initial relative humidity of 100%; the pressure will decrease as water vapor in the air is condensed on the shell and fan cooler coils.

The WGOTHIC DIRECT heat transfer coefficient option, with the condensation option set to MAX, is used to calculate the heat and mass transfer rates to the inside and outside surfaces of the containment shell in both the steady-state and transient phases of the external pressure analysis. The DIRECT option uses the McAdams turbulent free convection correlation. The MAX condensation option uses the maximum value between the Uchida and Gido-Koestel condensation correlations.

b) The response to RAI-SRP6.2.1.1-SPCV-01 was reviewed along with the input values discussed in calculation APP-MV50-Z0C-020, Rev. 0. The value of 26,167 Btu/sec for the heat load at operating reactor power quoted in the RAI responses is in error. The actual value for the containment heat loads entered in WGOTHIC and used in calculation APP-MV50-Z0C-020 was 2536.33 BTU/s. As discussed below, this value is appropriate and conservative.

The containment heating and cooling calculation APP-VCS-M3C-001 Rev. B was reviewed to estimate the value of the containment heat load and compare it with the value used in APP-MV50-Z0C-020. APP-VCS-M3C-001 Rev. B provides an estimate of the containment heat loads on a room-by-room basis to size the containment cooling system. The containment cooling system is sized to provide 15% margin to the total containment heat loads and takes credit for passive heat removal through the shell on a summer day, assuming the peak ambient temperature of 115°F.

Therefore, the containment heat load can be estimated as:

Total heat-removal capacity of the fan coolers	8.82 MBtu/hr
Heat removed through shell	+0.67 MBtu/hr
15% margin added to fan-cooler capacity	-1.42 MBtu/hr
Heat load to the containment	8.07MBtu/hr
	= 2242 Btu/sec

The maximum initial containment temperature provides the limiting condition for the peak external pressure. Therefore, the heat load used in the steady-state WGOTHIC analysis in APP-MV50-Z0C-020 to calculate the initial containment conditions is conservative.

For the transient analysis, calculation APP-MV50-Z0C-020 assumed a maximum fan-cooler capacity of 2536.33 Btu/sec. The maximum fan-cooler heat-removal capacity from APP-VCS-M3C-001 is 2450.6 Btu/sec (8.82 MBtu/hr). The larger fan-cooler heat-removal value is limiting for the peak external pressure; therefore the value of 2,536.33 Btu/sec used in calculation APP-MV50-Z0C-020 is conservative. The fan-cooler heat removal is assumed to be a linear function of the containment temperature, with the maximum heat-removal rate at 120°F and 0 Btu/sec heat removal rate at 32°F. The actual minimum temperature of the chilled water is 40°F (from APP-VWS-M3-001, Rev. B), so the fan-cooler heat-removal rate used for the calculation in APP-MV50-Z0C-020 is conservative.

For the transient calculation, a lower containment heat loading is conservative for the external peak pressure. The heat load to the containment for the transient calculation is the containment heat load of 2242 Btu/sec plus the heat load from the fan-cooler motors, which is 1.02 MBtu/hr or 283 Btu/sec. The total containment heat load based on APP-VCS-M3C-001 is 2525 Btu/sec, which is within 1% of the value (2536 Btu/sec) assumed in calculation APP-MV50-Z0C-020.

Therefore, the heat loads and fan-cooler heat capacity presented in APP-MV50-Z0C-020, Rev. 0 are appropriate and conservative for the peak external pressure calculation.

c) The DCD figure 6.2.1.1-11 time scale is in error and should be corrected. See DCD revisions section below.

d) The heat-transfer coefficients provided in the RAI responses were taken from different thermal conductors than the heat-transfer coefficients plotted in the calcnote. The heat transfer coefficients calculated by WGOTHIC for one "stack" of shell thermal conductors (PCS shell from the dome to the operating deck) from the steady-state run are presented in Table D-1. The heat transfer coefficients calculated by WGOTHIC for one stack during the transient are provided in Figures D-1 and D-2.

Table D-1
Heat Transfer Coefficients from the Steady State Run

	Inside HTC	Outside HTC
Location	Btu/hr-ft^2-°F	Btu/hr-ft^2-°F
Top of Dome	1.8	1.1
-	3.5	4.5
-	2.8	7.4
-	2.9	7.8
-	3.4	7.8
-	1.9	7.7
-	1.6	7.7
Bottom of Shell	1.6	5.1

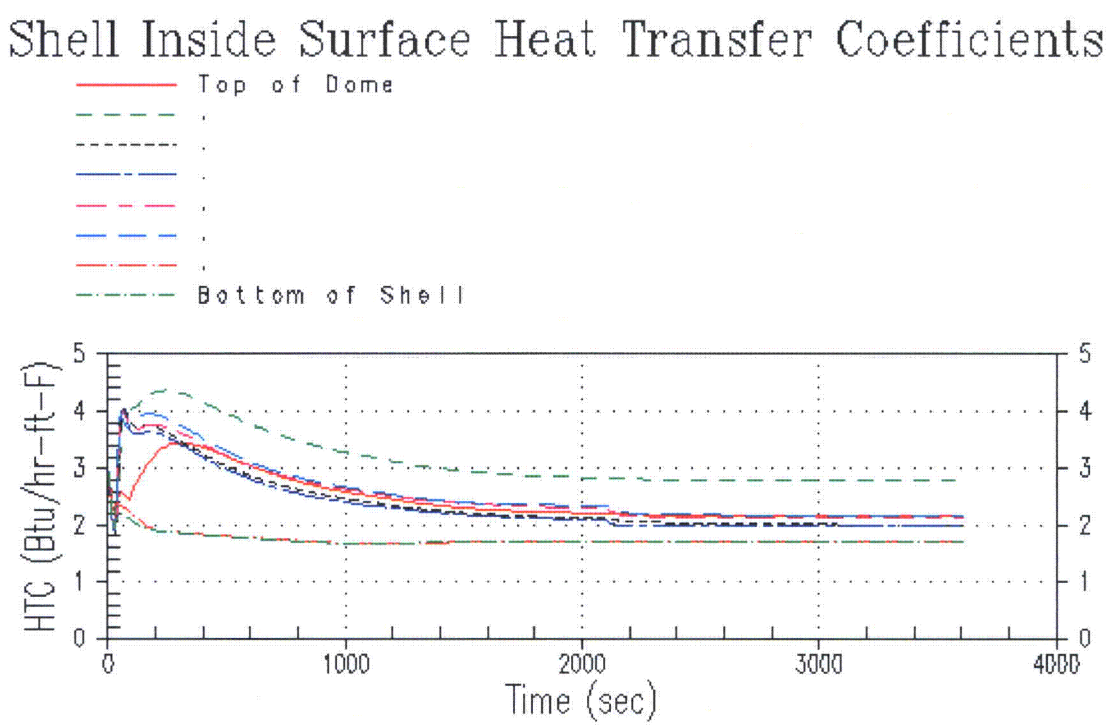


Figure D-1

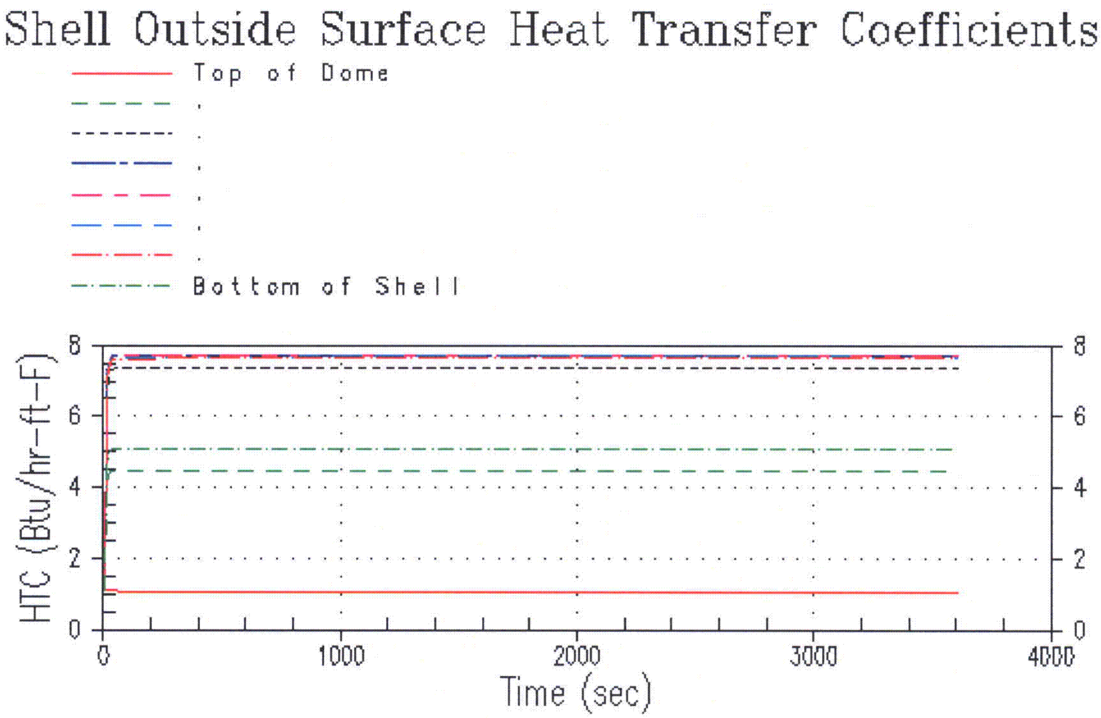


Figure D-2

e) The containment shell initial temperatures were appropriately set to -18°F in the transient WGOTHIC run of APP-MV50-Z0C-020. The initial temperature was determined from a conservative estimate of the average temperature of the shell in the steady-state run. The temperature response of one PCS "stack" during the transient is provided in Figure E-1.

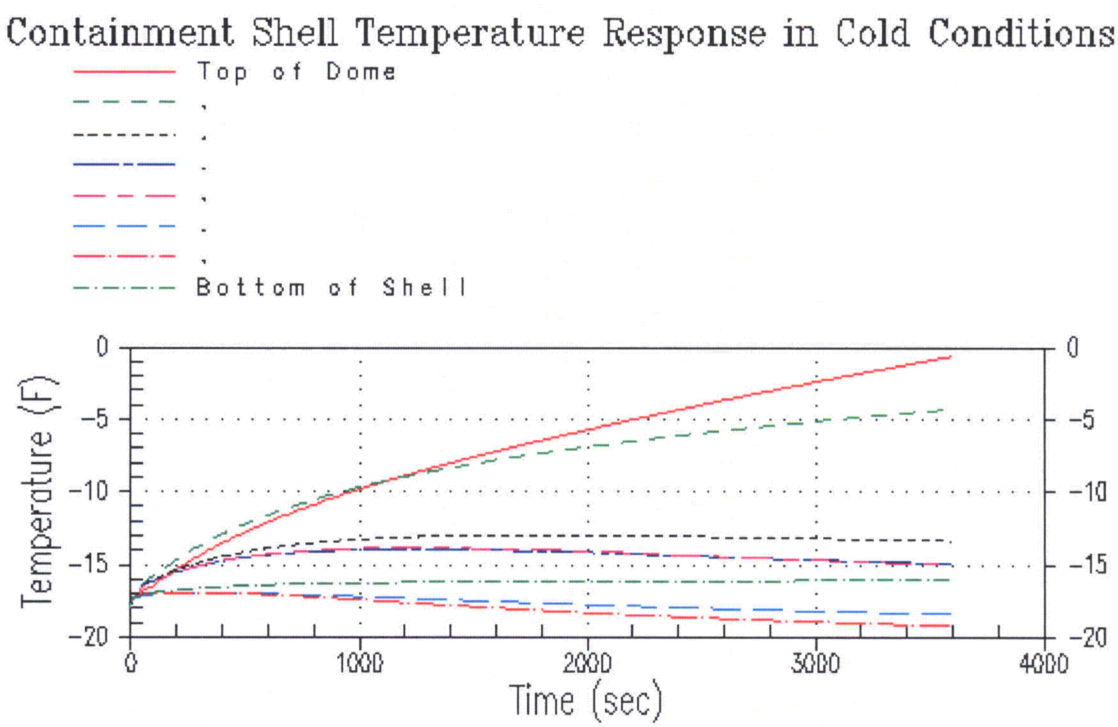


Figure E-1

f) The wind-induced annulus velocity does not have a significant impact on the calculation with respect to the annulus velocity induced by the gas-density difference in the PCS. In the APP-MV50-Z0C-020 analysis, WGOTHIC calculates the velocity through the annulus, which is 25 ft/s (17 mph), based on density differences. A sensitivity analysis was run increasing the heat-transfer coefficients in the PCS annulus by 1.62 in the transient pressure case. The Nussult number is a function of the velocity (Reynold's number) raised to the 0.8 power, so the resulting heat-transfer coefficient corresponds to an annulus velocity of 36.8 ft/s (25 mph). The WGOTHIC heat-transfer coefficients on the outer shell surface increase as shown in Figure F-1. The impact on the peak external pressure is 0.024 psi (Figure F-2), which is a 3% increase in the external pressure.

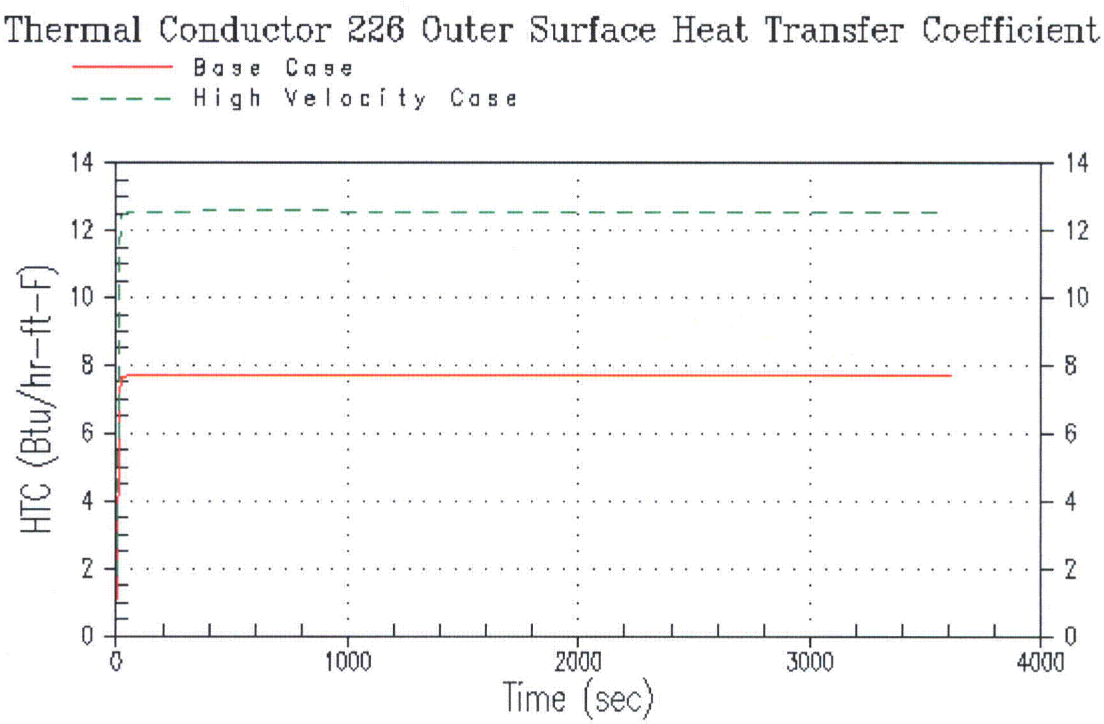
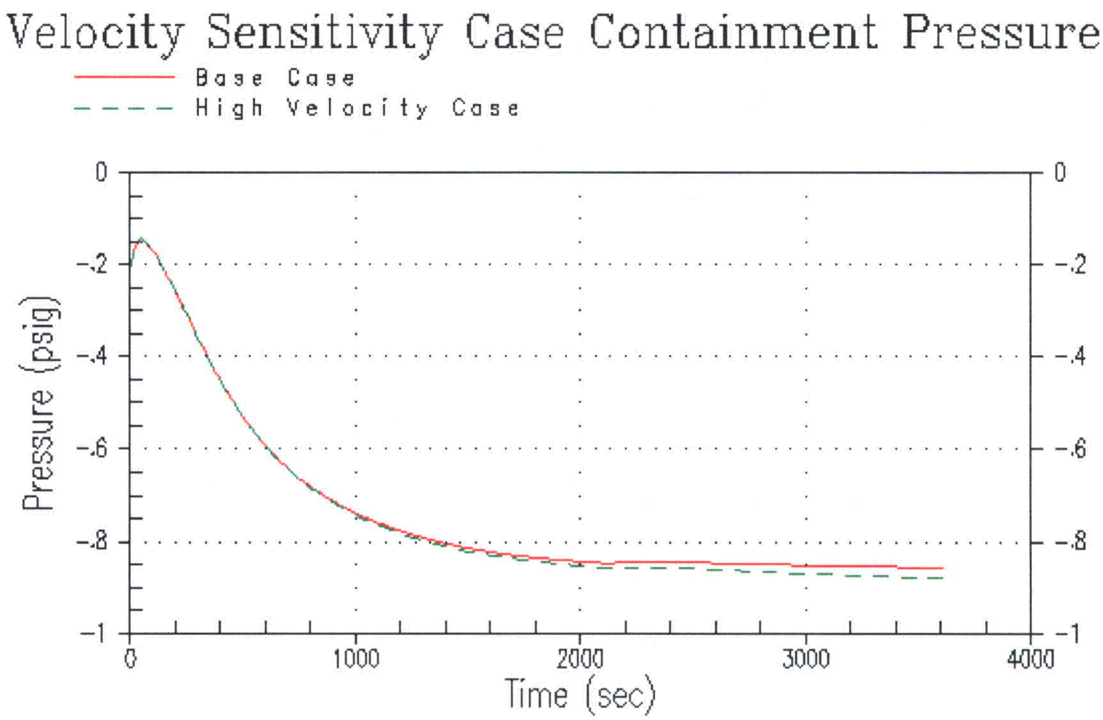


Figure F-1

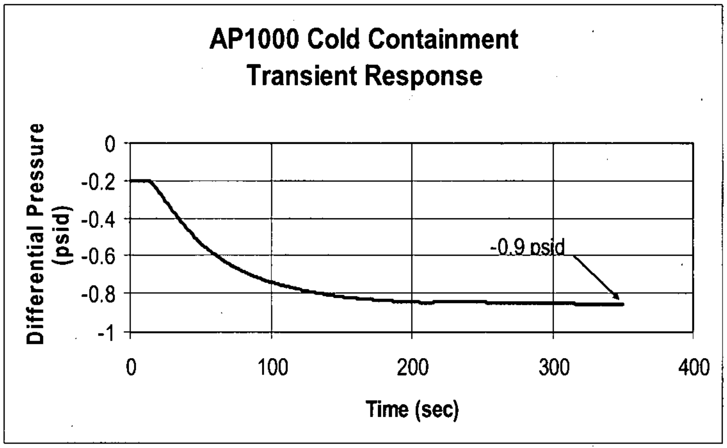


Velocity Sensitivity Case Containment Pressure
Base Case
High Velocity Case
Pressure (psig)
0
-.2
-.4
-.6
-.8
-1
0
1000
2000
3000
4000
Time (sec)

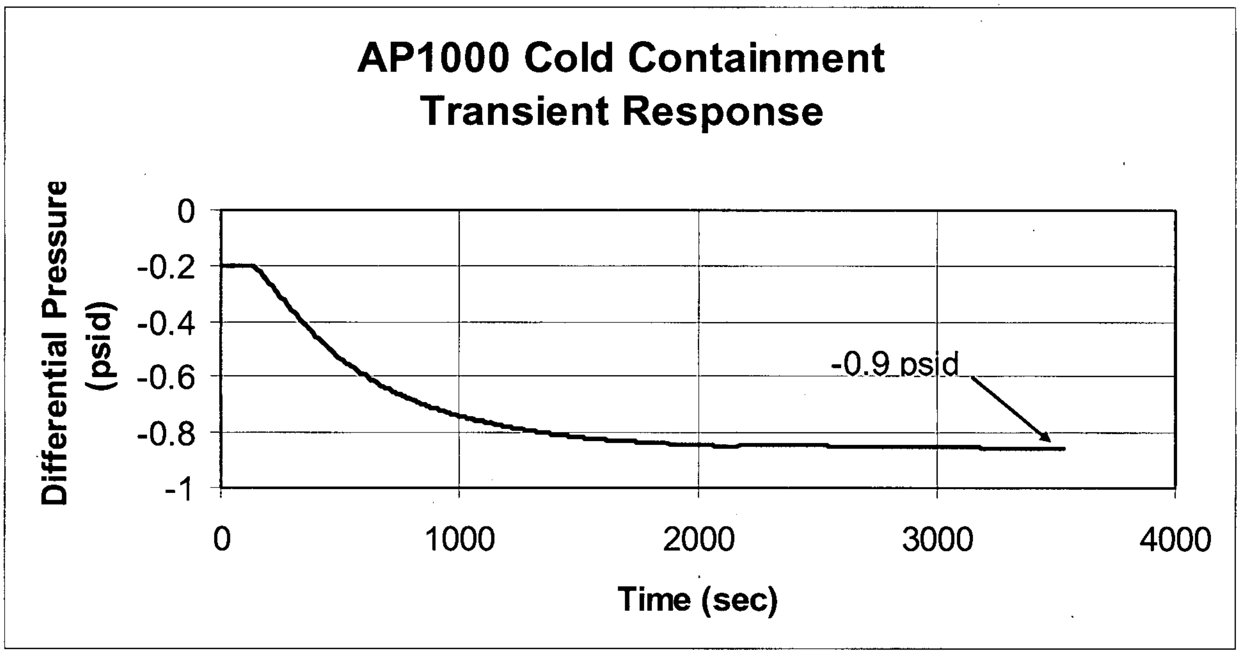
Figure F-2

Design Control Document (DCD) Revision:

Replace the current DCD Rev. 17 Figure 6.2.1.1-11 (shown here)



With this version:



PRA Revision: None

Technical Report (TR) Revision: None