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MFN 06-215 Supplement 1

Docket No. 52-010

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U.S. Nuclear Regulatory Commission
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Washington, D.C. 20555-0001

Subject: **Response to Portion of NRC Request for Additional Information Letter No. 33 - Containment Systems - RAI Number 6.2-53 S01**

Enclosure 1 contains GEH's response to the subject NRC RAI originally transmitted via the Reference 1 letter and supplemented by an NRC request for clarification.

If you have any questions or require additional information, please contact me.

Sincerely,

Kathy Sedney for

James C. Kinsey
Project Manager, ESBWR Licensing

D068

NRO

Reference:

1. MFN 06-167, Letter from U.S. Nuclear Regulatory Commission to David Hinds, *Request for Additional Information Letter No. 33 Related to ESBWR Design Certification Application*, June 1, 2006

Enclosure:

1. MFN 06-215 Supplement 1 - Response to Portion of NRC Request for Additional Information Letter No. 33 - Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-53 S01

cc:	AE Cubbage	USNRC (with enclosures)
	BE Brown	GEH/Wilmington (with enclosures)
	GB Stramback	GEH/San Jose (with enclosures)
	eDRF	0000-0065-0522

Enclosure 1

MFN 06-215 Supplement 1

Response to Portion of NRC Request for

Additional Information Letter No. 33

Related to ESBWR Design Certification Application

Containment Systems

RAI Number 6.2-53 S01

NRC RAI 6.2-53 S01:

The GENE response to RAI 6.2-53 is for the feedwater line break accident, which was the limiting DBA then. Please update the response as follows:

(1) include the current limiting DBA of main steam line break accident,

(2) reflect the modeling changes stated in GENE letter MFN 06-364 in response to RAI 6.2-59, and

(3) include graphs for non-condensible gas pressure in wetwell versus time.

Update DCD Tier 2 to provide this information.

GEH Response:

In DCD Tier 2, Revision 3, the TRACG nodalization for the containment evaluation was modified to address the earlier comments from the NRC reviewers. The flow path between the Gravity Driven Cooling System (GDCS) air space and the drywell (DW) annulus was changed from 1-pipe connection to 2-pipe connection. This modification was to promote flow circulation and to purge the residual non-condensable (NC) gases in the GDCS pool air space.

This supplement provides an updated discussion of the containment responses with this nodalization modification. The main steam line break (MSLB) case with bounding conditions (DCD Tier 2, Revision 3, Subsection 6.2.1.1.3.5) was selected for this purpose. The following paragraphs discuss the containment response to the MSLB using this model, including the NC gases holdup, mixing and stratification. Two additional parametric cases were performed to assess the impact of 1-pipe versus 2-pipe connection, and the impact of the discharge location for the steam break flow. The discussions of these studies are also included in this supplement.

(1) Description of Main Steam Line Break Cases

Table 6.2-53S01-1 summarizes the four cases that are discussed and compared in this supplement.

Table 6.2-53S01-1: Summary of Main Steam Line Break Cases

Case #	Case ID	MSL Steam Break Location	GDCS Airspace and DW Connection	Comment
A	MSL3_1DPVCB_NL2Pa-72	Level 34	2-PIPE	DCD Tier 2, Revision 3, Subsection 6.2.1.1.3.5
B	MSL2_1DPVCB_L23NL-72	Level 23	1-PIPE	DCD Tier 2, Revision 2, Subsection 6.2.1.1.3.5
C	MSL3_1DPVCB_L23NL2Pa-72	Level 23	2-PIPE	Parametric case
D	MSL3_1DPVCB_NL-72	Level 34	1-PIPE	Parametric case

Referring to the TRACG nodalization (Figures 6.2-53S01-1 and 6.2-53S01-2), the broken main steam line is located at Level 34 and discharges steam to the DW at this elevation. In

the DCD Tier 2, Revision 2 evaluation, the MSL steam break flow was assumed to discharge at Level 23 (in the DW region below the reactor pressure vessel (RPV) bottom) and to force the NC gases in the DW to transfer into the wetwell (WW). Parametric cases are performed to assess the impact of the discharge location for the steam break flow.

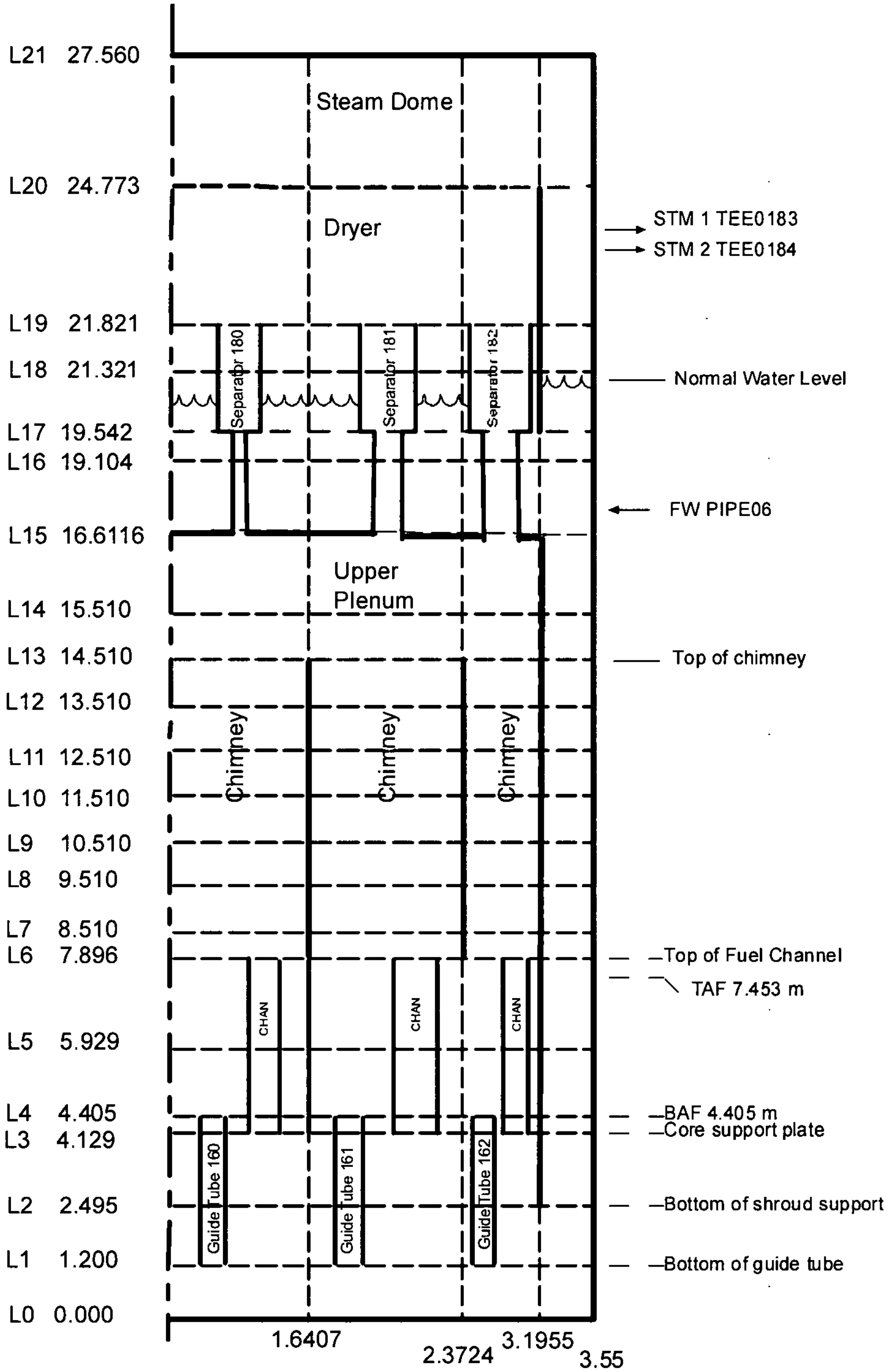

Figure 6.2-53S01-1: DCD TRACG Nodalization of the ESBWR RPV

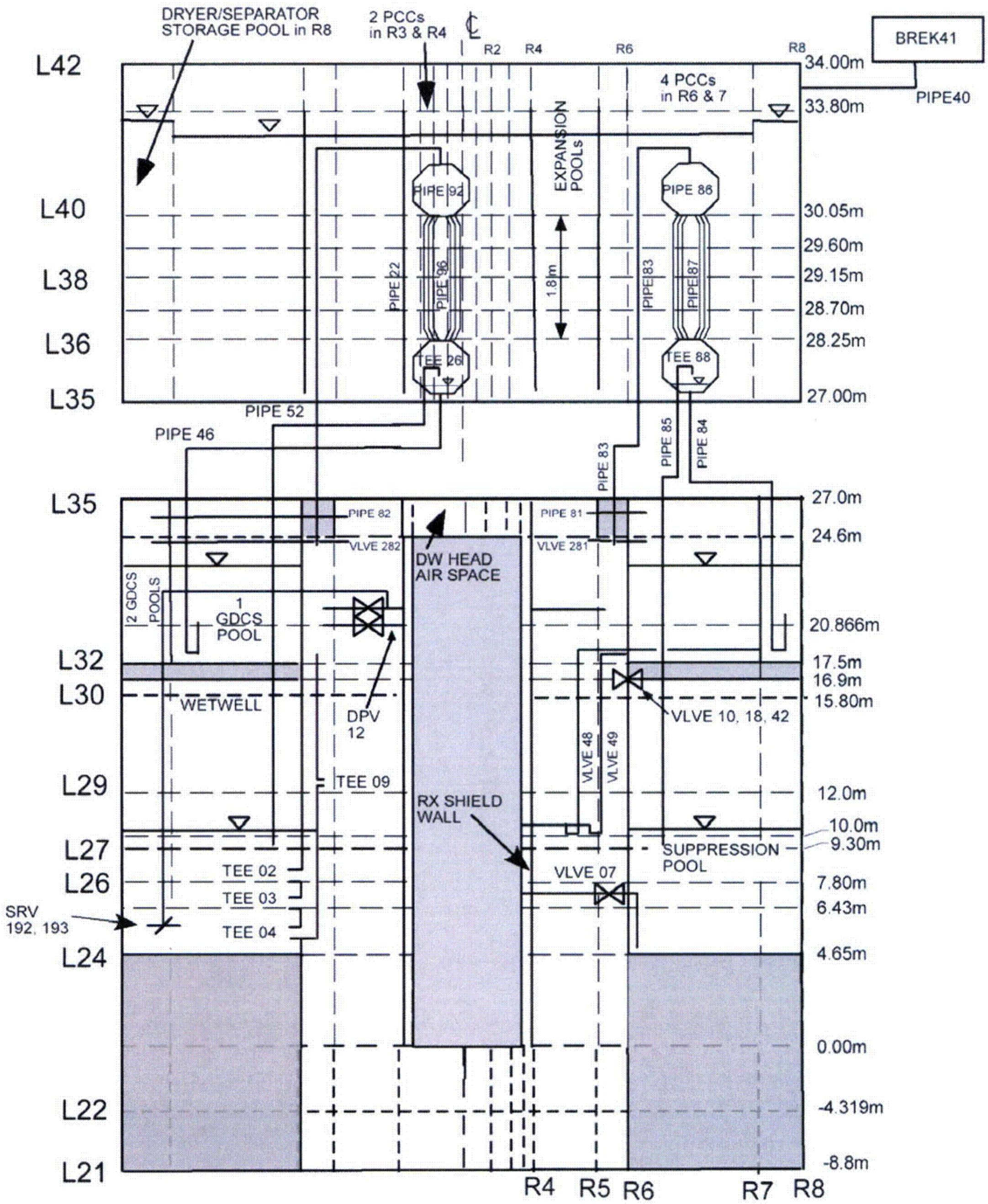

Figure 6.2-53S01-2: DCD TRACG Nodalization of the ESBWR Containment

(2) Main Steam Line Break – Limiting Case (Case A: MSL3_1DPVCB_NL2Pa-72)

The containment responses to a postulated MSLB are discussed in the following paragraphs and figures. This case assumes a single failure of 1 depressurization valve (DPV) and bounding conditions (DCD Tier 2, Revision 3, Table 6.2-6), and assumes 100% double-ended break.

Figure 6.2-53S01-3 shows the RPV, DW and WW pressures, and Figure 6.2-53S01-3a shows the same responses in short-term time scale.

Following the postulated loss-of-coolant accident (LOCA), the DW pressure increases rapidly leading to the clearing of the Passive Containment Cooling System (PCCS) and main vents. At around 77 seconds, the DW pressure reaches a peak value of 249 kPa (36.1 psia). This peak pressure is below the design pressure of 413.7 kPa (60 psia) with large margin. During this blowdown period, a significant amount of NC gases is purged into the WW and pressurizes the WW. The RPV continues to depressurize due to the break flow and the Automatic Depressurization System (ADS) flows. At around 0.2 hours, the RPV pressure drops below the pressure point at which the GDCS water is allowed to inject into the downcomer by gravity head. The subcooled GDCS water continues flowing into the vessel and reduces the steaming from the RPV and the DW pressure. At around 0.64 hours, the DW pressure drops below the WW pressure, causing the openings of vacuum breakers and allowing some NC gases to flow back into the DW. Consequently, the system pressures drop to a value of about 200 kPa.

Subsequently, the decay heat overcomes the subcooling of the GDCS water and steaming resumes (at ~ 0.67 hours, Figure 6.2-53S01-3a). The resumption of RPV steaming causes the DW pressure to increase again starting from 0.67 hours.

Figure 6.2-53S01-4 shows the downcomer collapsed level, and Figure 6.2-53S01-5 shows the GDCS pool water levels. After the initiation of the GDCS flow, the GDCS pool water level drops and consequently the downcomer collapsed level rises. For the rest of the transient, the downcomer collapsed level maintains an equilibrium position at around the elevation of the DPVs (Stub Tube elevation at 21.91 m). The corresponding GDCS pool equilibrium level is about 21.4 m.

Figure 6.2-53S01-6 compares the total heat removal by the PCCS with the decay heat. From 6 to 30 hours, about 90 to 95% of the decay heat is removed by the PCCS and discharged to the Isolation Condenser (IC)/Passive Containment Cooling (PCC) pools, which are outside of the containment. The residual decay heat (about 5 to 10% not removed by the PCCS) corresponds to the reduction in RPV steaming rate. The reduction is due to the small portion of the decay heat that is used to heat up the incoming cooler GDCS water.
Figure 6.2-53S01-7 compares the GDCS pool water temperature with the downcomer water temperatures. In this design, the hot PCCS condensate (~105°C) drains to the GDCS pools and mixes with the remaining water (for the MSLB case, ~ 1000 m^3) in the pools. The GDCS water injected into the RPV during the MSLB transient is at a temperature considerably lower than that for the PCCS condensate. For the reference design used in the report NEDC-33083P-A, "TRACG Application for ESBWR", the hot PCCS condensate drains directly into the RPV. After 60 hours, the mixture temperature approaches an equilibrium temperature of 95°C (Figure 6.2-53S01-7).

Figure 6.2-53S01-8 shows the IC/PCC pool water level. The IC/PCC pool water level drops due to boiloff by the decay heat. At 35 hours, the pool level drops below the elevation of 29.6 m, (or top ¼ portion of the PCCS condenser tube length uncovered). The connection valves open to allow the water from the Dryer/Separator storage pools to flow into the IC/PCC pools. This increase in PCCS condenser tube coverage causes a small increase in PCCS condensation power (Figure 6.2-53S01-6).

Figures 6.2-53S01-9 through 6.2-53S01-13 show the NC gases pressures in the DW annulus, lower DW, air gap between the RPV and the reactor shield wall, the DW head airspace, and the GDCS pool airspace. Most of the initial NC gases in the DW annulus are purged into the WW within 3 hours. It takes about 24 hours to purge most of the NC gases in the DW head airspace (Figure 6.2-53S01-12). It takes about 20 hours to purge most of the NC gases in the GDCS pool airspaces (Figure 6.2-53S01-13).

Figures 6.2-53S01-14 and 6.2-53S01-15 show the suppression pool water temperatures at different elevations in Ring 7 (next to the horizontal vents) and Ring 8 (away from the horizontal vents). Shortly after the blowdown period, the suppression pool stratification model prevents any mixing in the bottom three levels (Levels 25, 26 and 27) in the suppression pool (The stratification model sets the flow areas to zero in the radial direction at these 3 levels when there is no discharge from the vent or safety relief valve (SRV) discharge line to the lower level). Figure 6.2-53S01-15 shows that the water temperatures in these levels (in Ring 8) remain constant for the 72 hour transient after the initial heatup from the blowdown. After the blowdown, the pool surface temperatures (Level 29 in Rings 7 and 8) increase an additional 5°K as the result of the energy/steam in the PCCS vent flow and the increase in the WW air temperatures (Figures 6.2-53S01-16 and 6.2-53S01-17).

Figures 6.2-53S01-16 and 6.2-53S01-17 show the WW gas temperatures at different elevations in Ring 7 (next to the vacuum breakers and leakage) and Ring 8 (away from the vacuum breakers). Air temperatures at Levels 29 and 30 follow closely with pool surface water temperatures. The increase for the gas temperature at the top WW corner next to the leakage path (Level 31, Ring 7) is larger than for other temperatures due to the inflow of hotter gas from the DW via the leakage path and the gas stratification model. The WW gas stratification model applies a large value of loss coefficient (100000) at the axial faces (Rings 7 and 8, between Levels 30 and 31) and restricts the mixing between the cells at Levels 30 and 31.

Figures 6.2-53S01-17a shows the WW total and NC gas pressures in Ring 7.

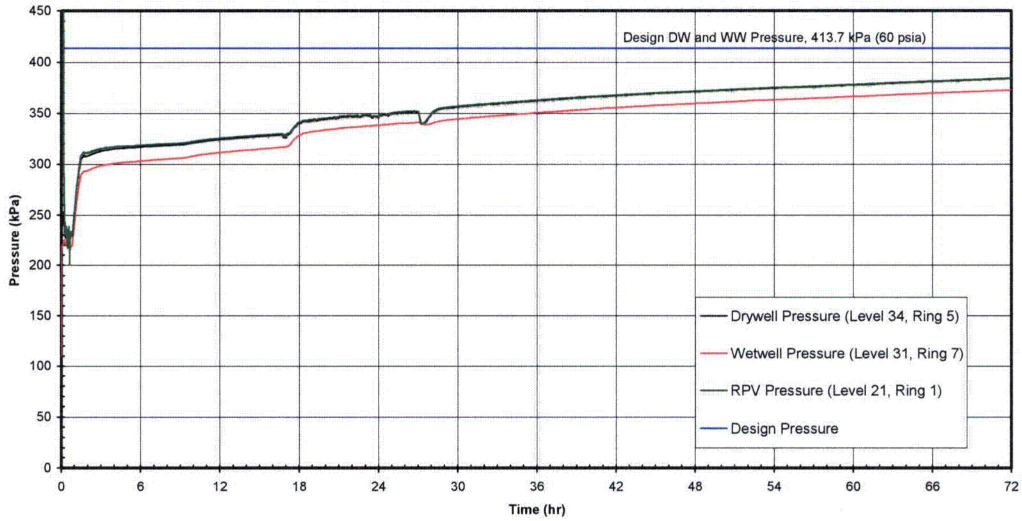

Figure 6.2-53S01-3: Containment Pressure Response
(Case A: MSL3_1DPVCB_NL2Pa-72)

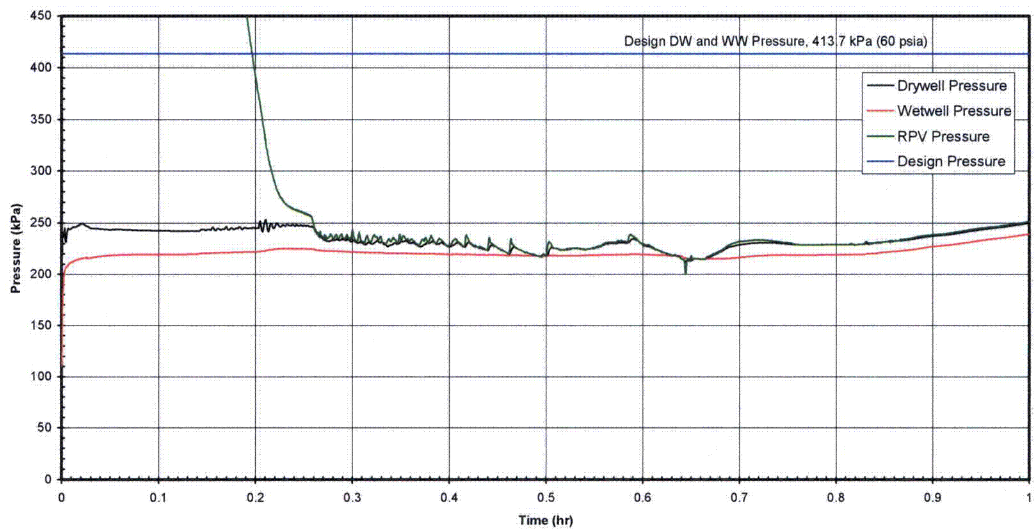

Figure 6.2-53S01-3a: Containment Pressure Response (Short-term time scale)
(Case A: MSL3_1DPVCB_NL2Pa-72)

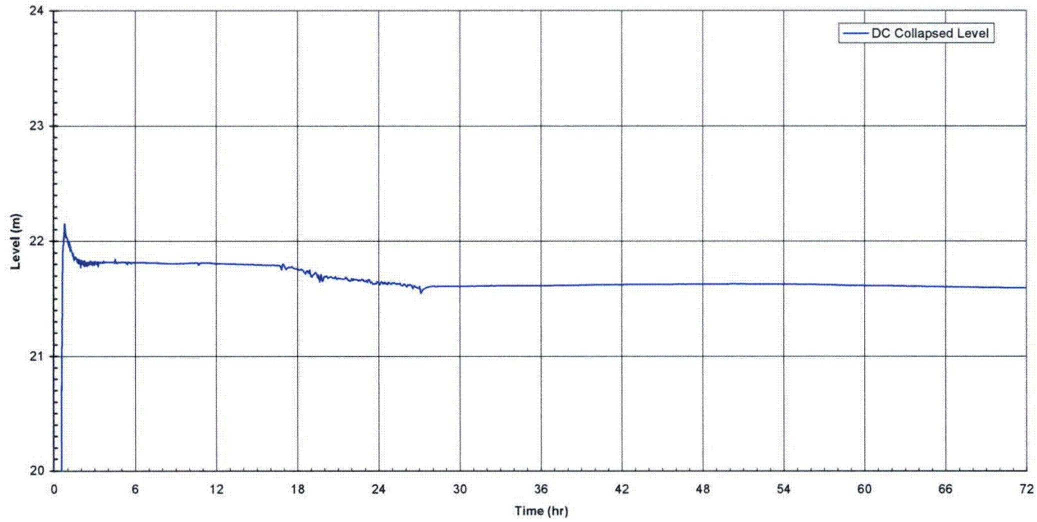

Figure 6.2-53S01-4: Downcomer Collapsed Level (Case A: MSL3_1DPVCB_NL2Pa-72)

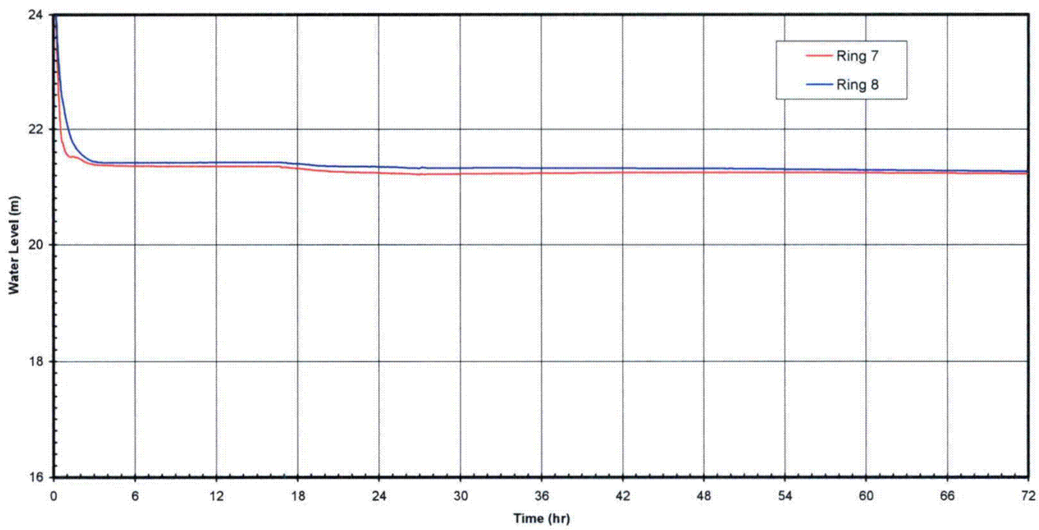

Figure 6.2-53S01-5: GDCS Pool Levels (Case A: MSL3_1DPVCB_NL2Pa-72)

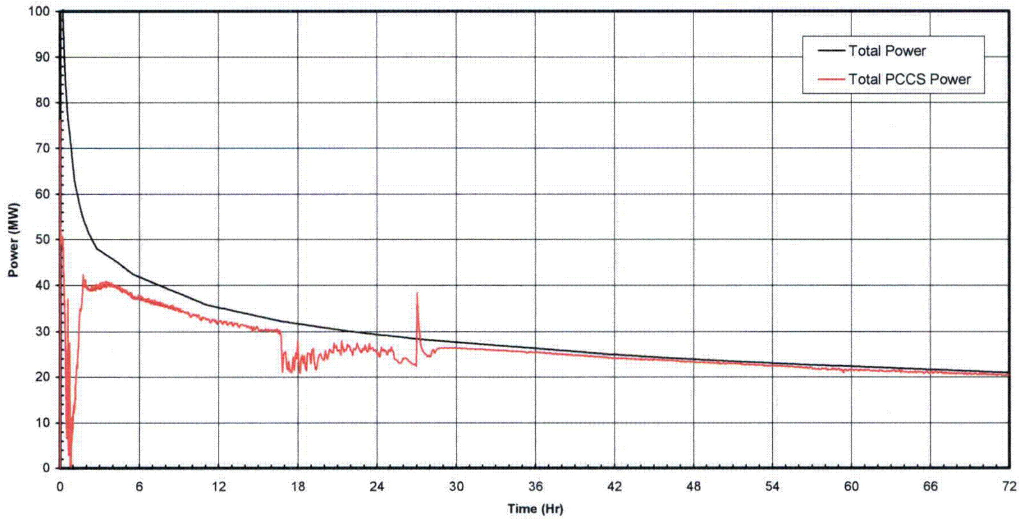

Figure 6.2-53S01-6: PCCS Heat Removal versus Decay Heat (Case A: MSL3_1DPVCB_NL2Pa-72)

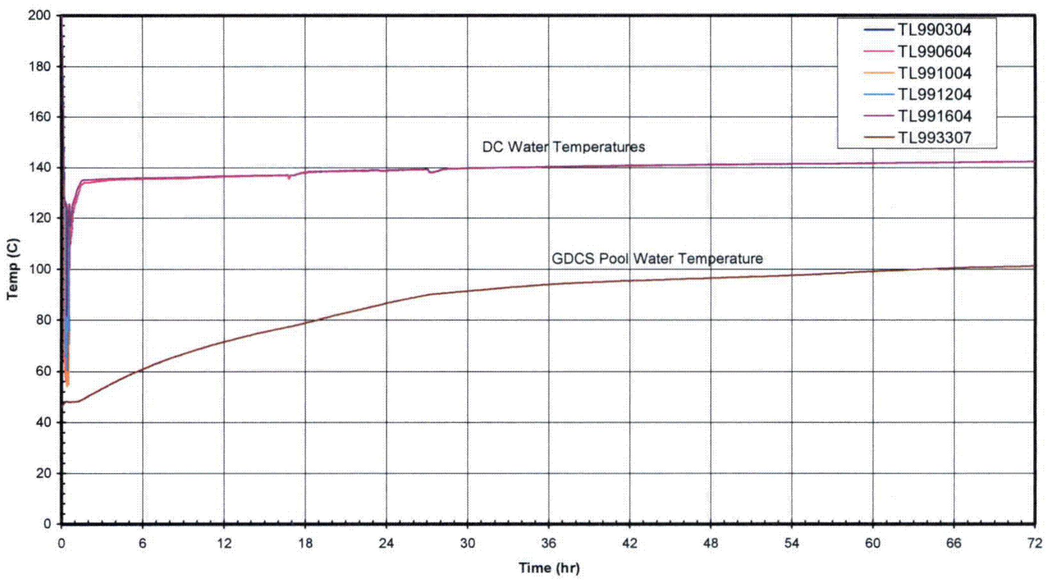

Figure 6.2-53S01-7: GDCS Pool Water Temperature (Case A: MSL3_1DPVCB_NL2Pa-72)

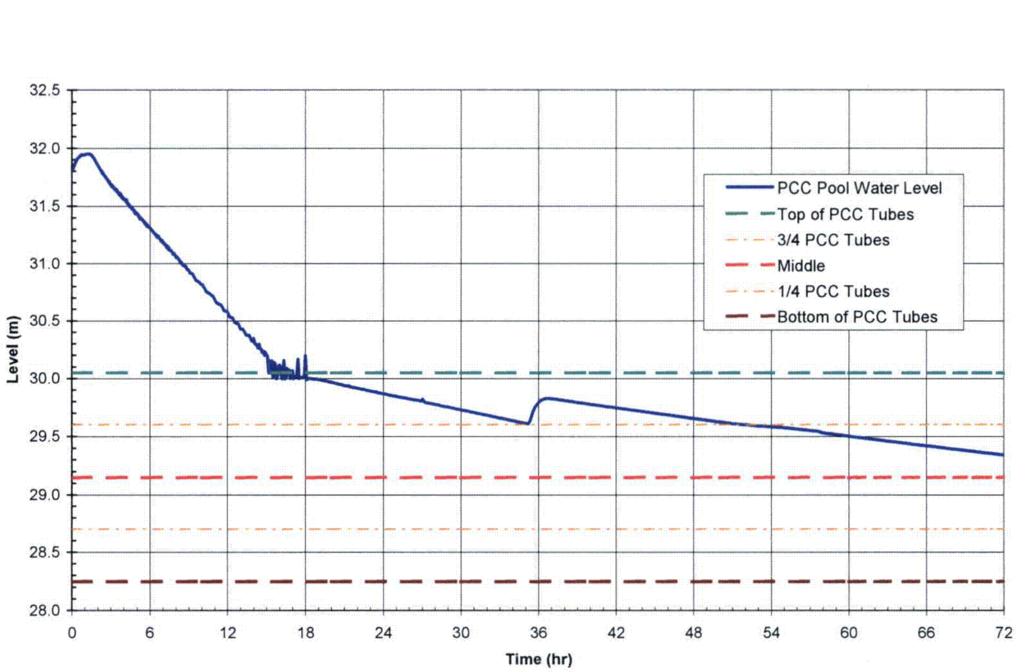

Figure 6.2-53S01-8: IC/PCC Pool Water Level (Case A: MSL3_1DPVCB_NL2Pa-72)

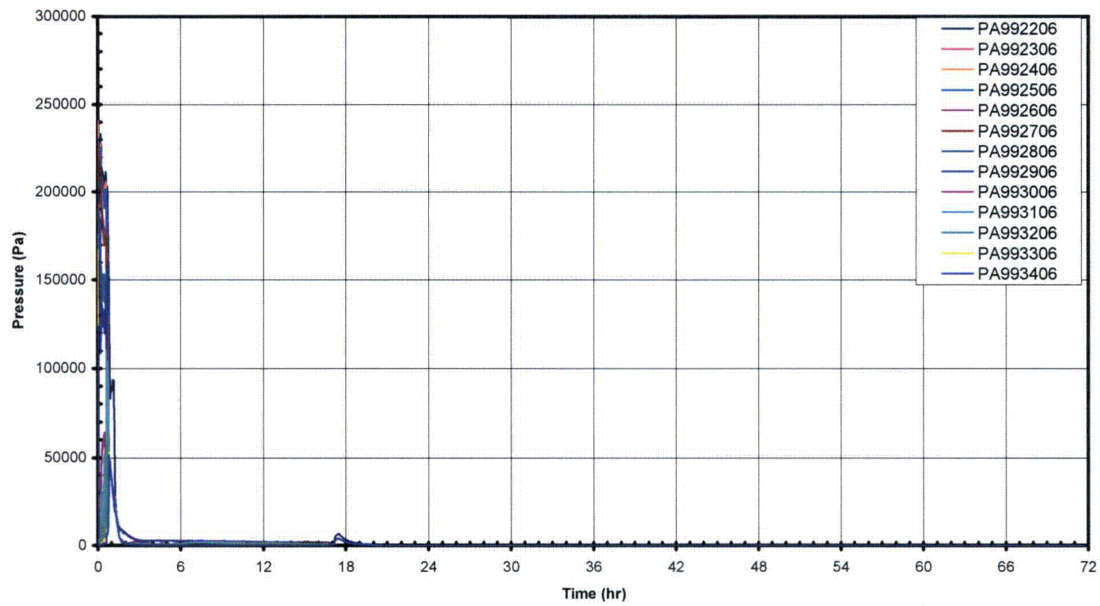

Figure 6.2-53S01-9: DW Annulus NC Gas Pressures (Level 23=2nd Level from Bottom, 34=Top) (Case A: MSL3_1DPVCB_NL2Pa-72)

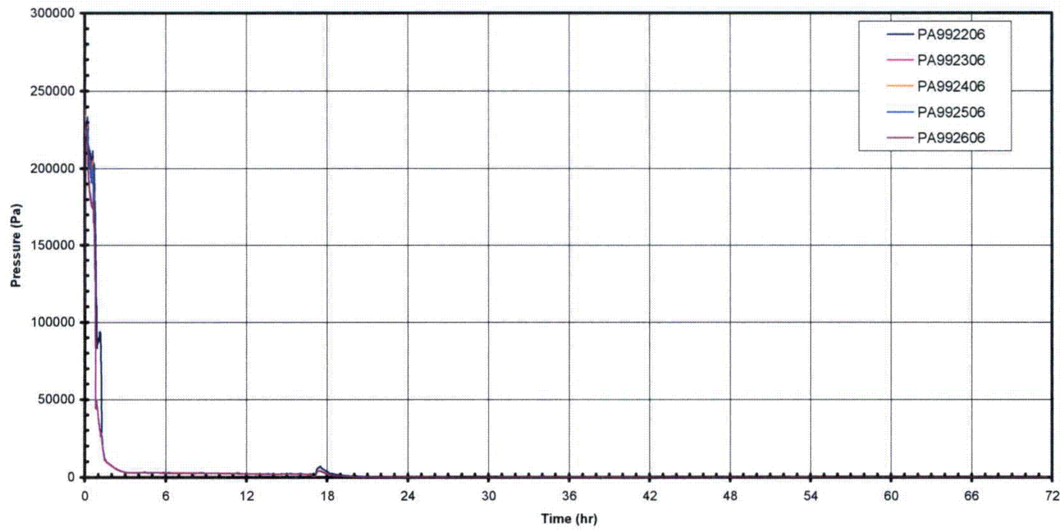

Figure 6.2-53S01-10: Lower DW NC Gas Pressures (23=2nd level from DW Bottom) (Case A: MSL3_1DPVCB_NL2Pa-72)

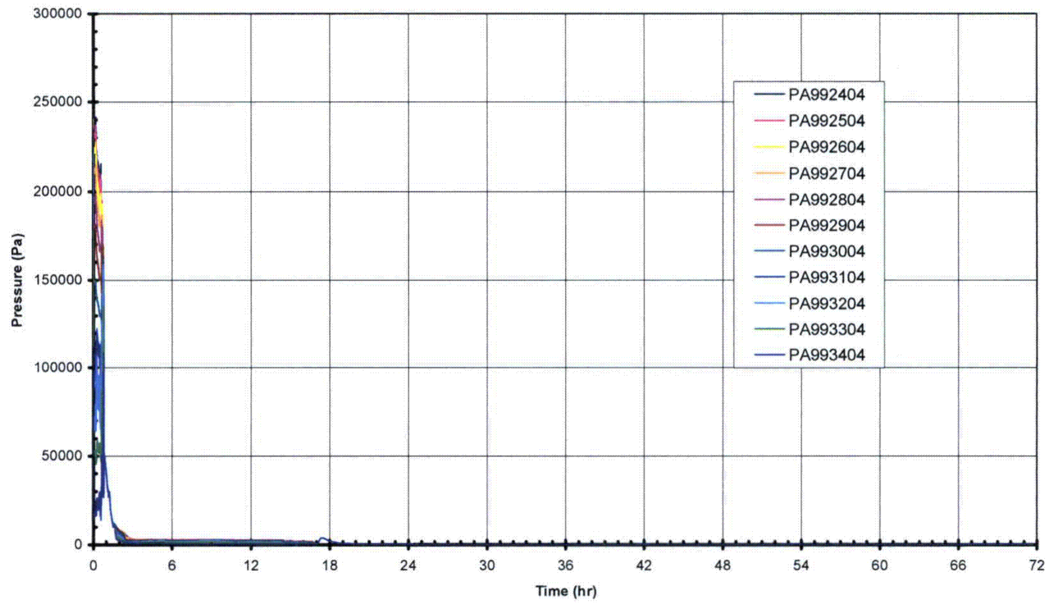

Figure 6.2-53S01-11: DW-Reactor Shield Wall NC Gas Pressures (Level 24=Bottom, 34=Top) (Case A: MSL3_1DPVCB_NL2Pa-72)

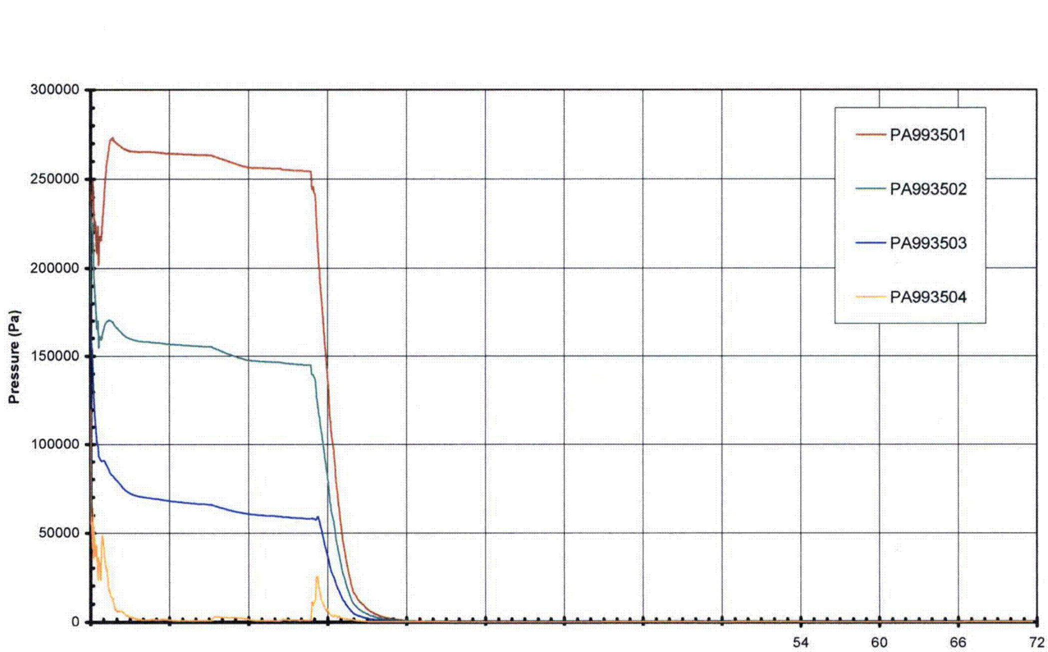

Figure 6.2-53S01-12: DW Head NC Gas Pressures (Level 35=Drywell Head) (Case A: MSL3_1DPVCB_NL2Pa-72)

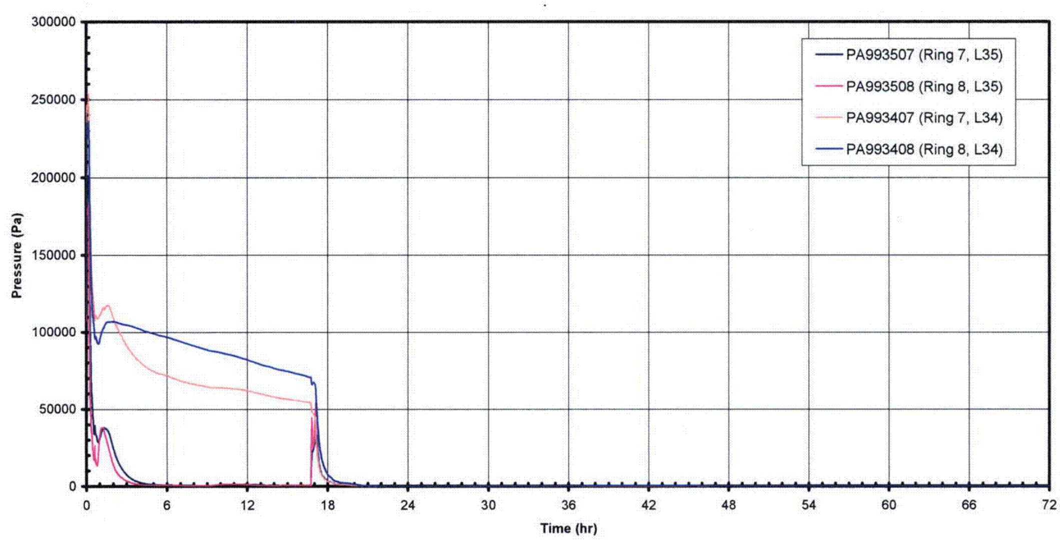

Figure 6.2-53S01-13: DW Head NC Gas Pressures (Level 35=Drywell Head) (Case A: MSL3_1DPVCB_NL2Pa-72)

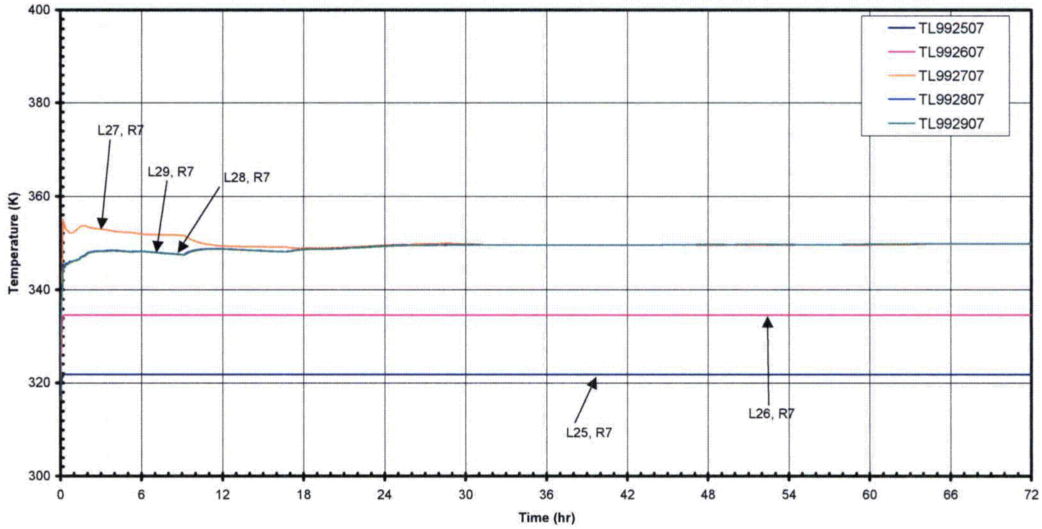

Figure 6.2-53S01-14: Suppression Pool Water Temperatures (at Ring 7) (Case A: MSL3_1DPVCB_NL2Pa-72)

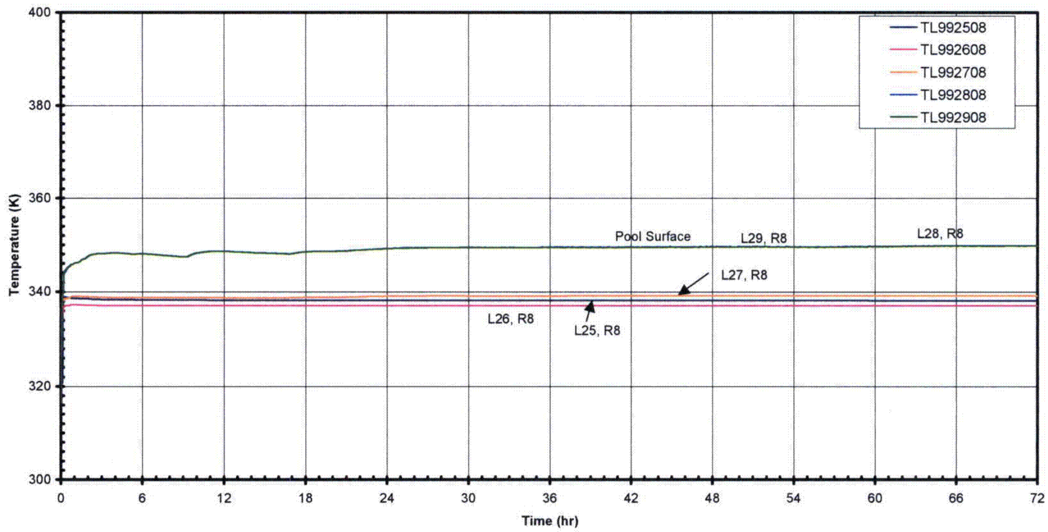

Figure 6.2-53S01-15: Suppression Pool Water Temperatures (at Ring 8) (Case A: MSL3_1DPVCB_NL2Pa-72)

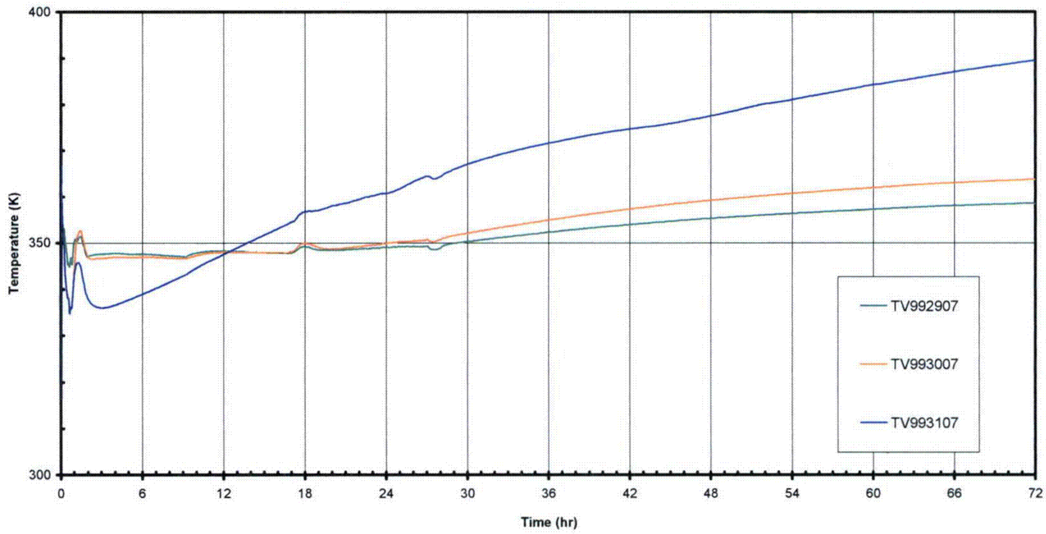

Figure 6.2-53S01-16: Wetwell Air Temperatures (at Ring 7)
(Case A: MSL3_1DPVCB_NL2Pa-72)

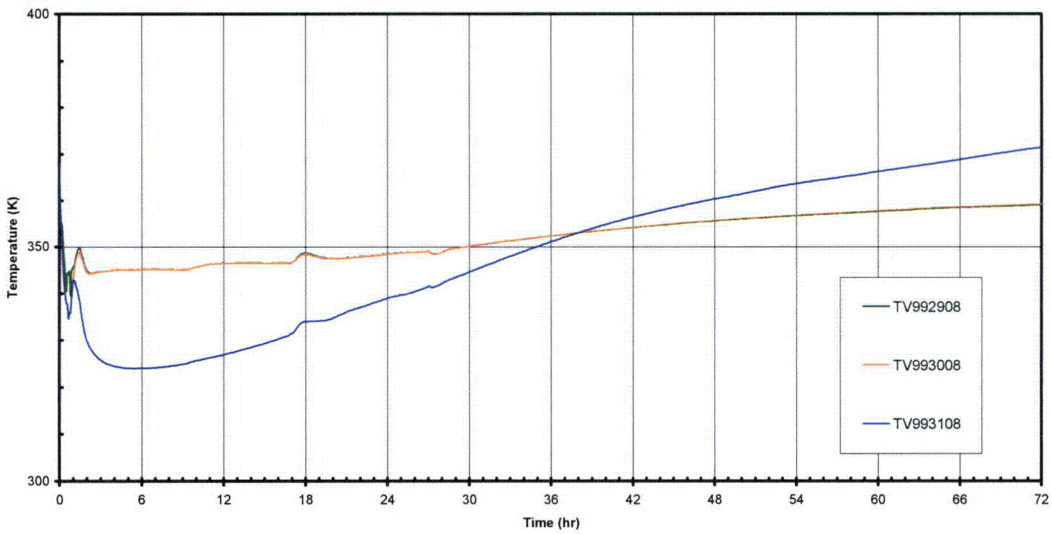

Figure 6.2-53S01-17: Wetwell Air Temperatures (at Ring 8)
(Case A: MSL3_1DPVCB_NL2Pa-72)

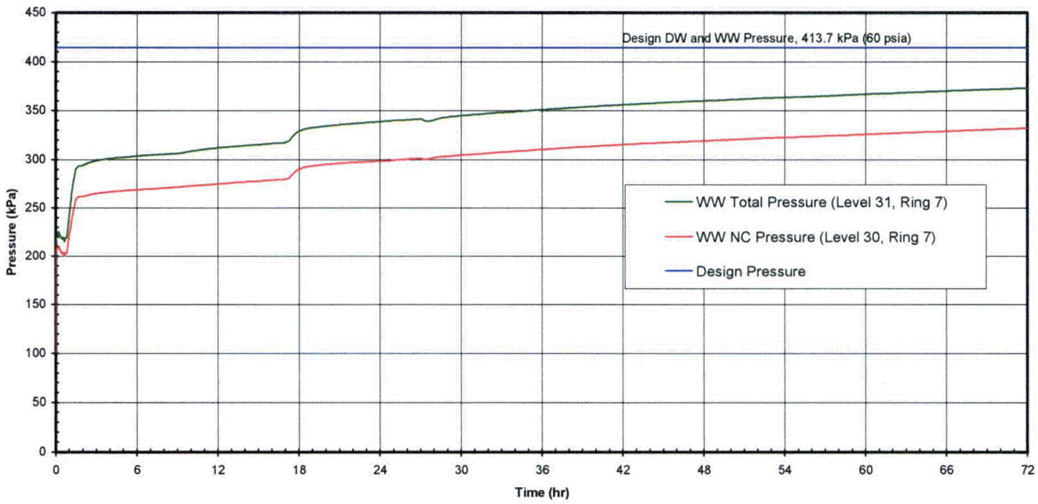

Figure 6.2-53S01-17a: Wetwell NC Pressure (in Ring 7)
(Case A: MSL3_1DPVCB_NL2Pa-72)

(3) <u>Effect of 1-pipe versus 2-pipe TRACG Nodalizations with Steam Break Flow Discharged at Level 23</u> (Case B versus Case C)

The MSLB limiting case (Case B: MSL2_1DPVCB_L23NL-72) presented in the DCD Tier 2, Revision 2, uses a TRACG nodalization with 1-pipe connection to simulate the flow path between the GDCS pool airspace and the DW, and artificially assumes to discharge at Level 23 (instead of Level 34) in the DW region below the RPV bottom. A parametric case was performed to assess the impact of 1-pipe versus 2-pipe connection in the TRACG nodalizations on the DW pressure. In this parametric case (Case C: MSL3_1DPVCB_L23NL2Pa-72), the steam break flow discharge location remains unchanged (at Level 23). However, 2 pipes are used to simulate the connection between the GDCS pool airspace and the DW (Figure 6.2-53S01-2), to purge the residual NC gases in this space.

Figures 6.2-53S01-18 to 6.2-53S01-20 compare the DW pressures and the GDCS pool airspace air pressures between these two cases. The case with 2-pipe model (MSL3_1DPVCB_L23NL2Pa-72) shows almost complete clearing of NC gases in the GDCS pool airspace after 20 hours. The case with 1-pipe model (MSL2_1DPVCB_L23NL-72) shows small amount of residual NC gases remaining in the GDCS pool airspace after 22 hours. As a result of effective clearing of NC gases with 2-pipe model, the DW pressure for the case with 2-pipe model is slightly higher than that for the case with 1-pipe model (Figure 6.2-53S01-18).

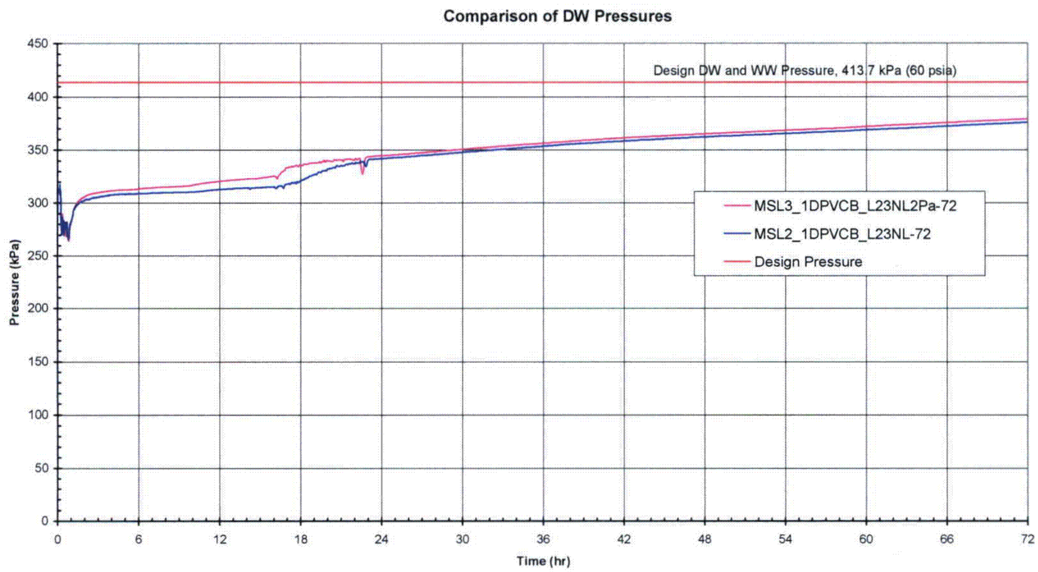

Figure 6.2-53S01-18: Comparison of DW Pressures (Case B vs. Case C: 2-Pipe versus 1-Pipe, Steam Source at Level 23)

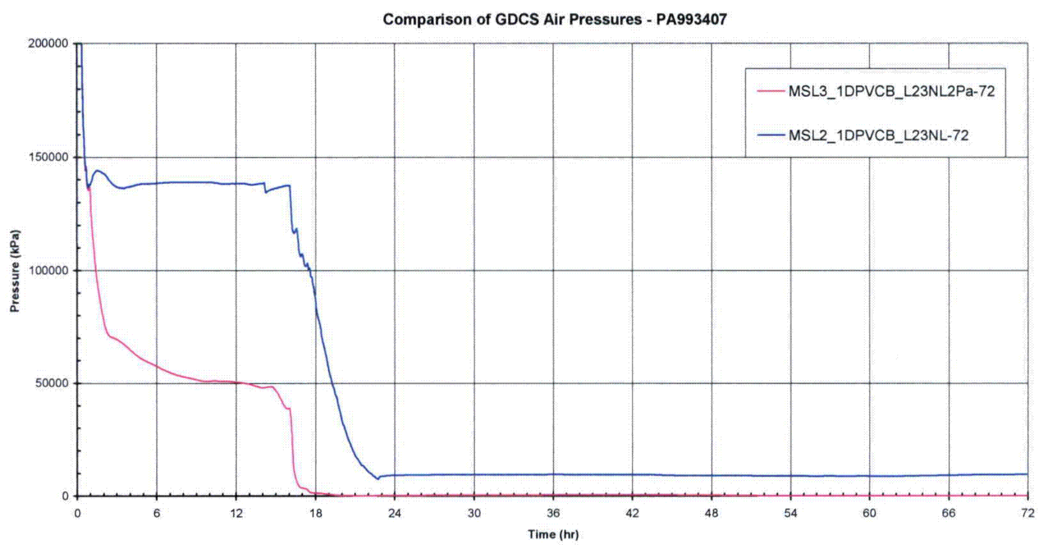

Figure 6.2-53S01-19: Comparison of GDCS Pool Airspace Air Pressures (Ring 7) (Case B vs. Case C: 2-Pipe versus 1-Pipe, Steam Source at Level 23)

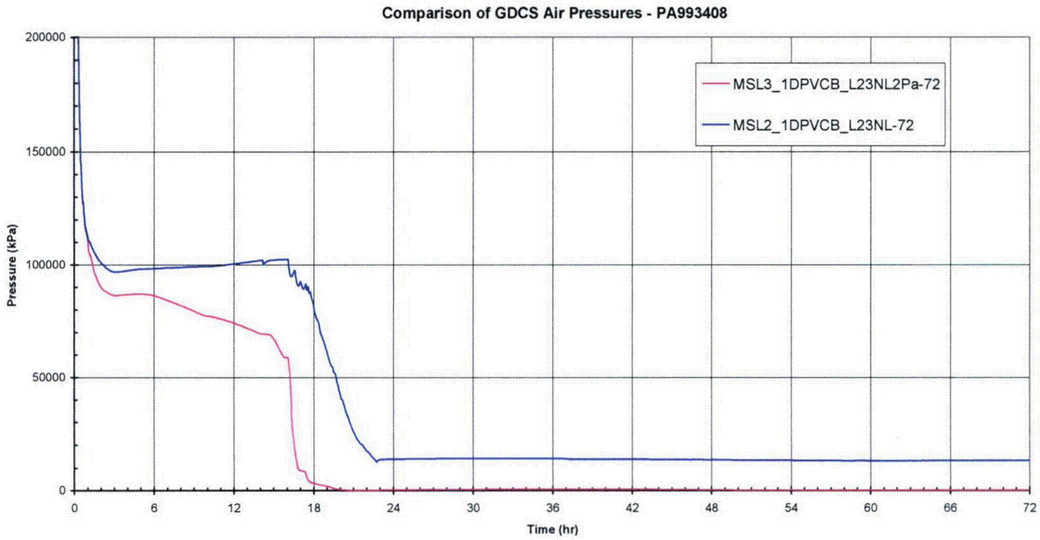

Figure 6.2-53S01-20: Comparison of GDCS Pool Airspace Air Pressures (Ring 8) (Case B vs. Case C: 2-Pipe versus 1-Pipe, Steam Source at Level 23)

(4) <u>Effect of 1-pipe versus 2-pipe TRACG Nodalizations with Steam Break Flow Discharged at Level 34</u> (Case A versus Case D)

Additional parametric case was performed to assess the impact of 1-pipe versus 2-pipe in the TRACG Nodalizations on the DW pressure. The limiting case (Case A: MSL3_1DPVCB_NL2Pa-72) discussed in Section 2 was modified from 2-pipe connection to 1-pipe connection (Case D: MSL3_1DPVCB_NL-72) in the GDCS pool airspace. The steam source of break location for both cases is located at Level 34, the elevation for the broken main steam line.

Figures 6.2-53S01-21 to 6.2-53S01-23 compare the DW pressures and the GDCS pool airspace air pressures between these two cases. The case with 2-pipe model at Level 34 (MSL3_1DPVCB_NL2Pa-72) shows almost complete clearing of NC gases in the GDCS pool airspace after 20 hours. The case with 1-pipe model (MSL3_1DPVCB_NL-72) shows a small amount of residual NC gases remaining in the GDCS pool airspace after 21 hours. As a result of effective clearing of NC gases with 2-pipe model, the DW pressure for the case with 2-pipe model is slightly higher than that for the case with 1-pipe model (Figure 6.2-53S01-21).

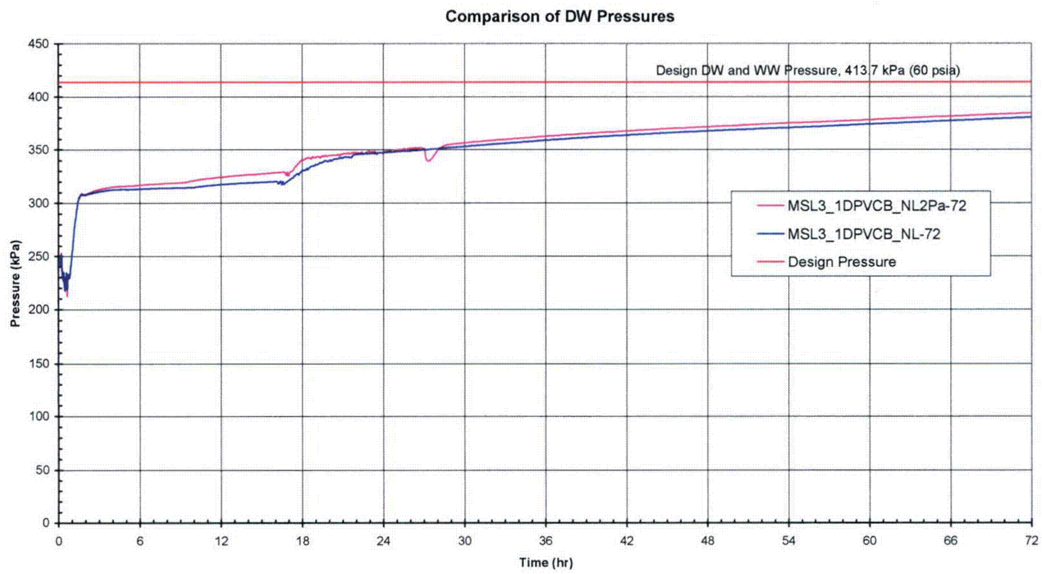

Figure 6.2-53S01-21: Comparison of DW Pressures (Case A vs. Case D: 2-Pipe versus 1-Pipe, Steam Source at Level 34)

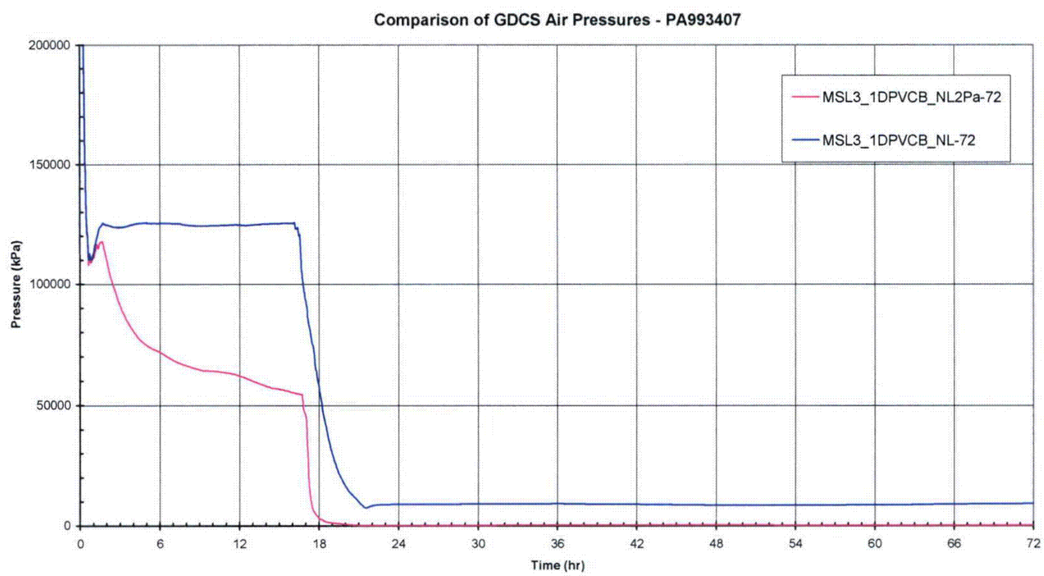

Figure 6.2-53S01-22: Comparison of GDCS Pool Airspace Air Pressures (Ring 7) (Case A vs. Case D: 2-Pipe versus 1-Pipe, Steam Source at Level 34)

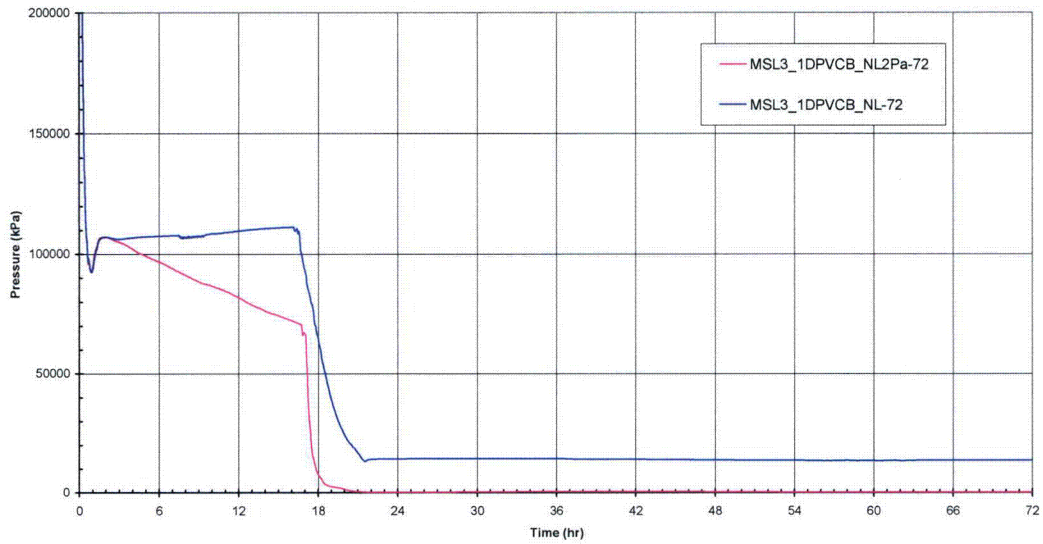

Figure 6.2-53S01-23: Comparison of GDCS Pool Airspace Air Pressures (Ring 8) (Case A vs. Case D: 2-Pipe versus 1-Pipe, Steam Source at Level 34)

(5) Effect of Steam Discharge Locations – Level 34 versus Level 23 (Case A versus Case C)

The limiting case (Case A: MSL3_1DPVCB_NL2Pa-72) discussed in Section 2 uses 2-pipe connection in the GDCS pool airspace and with steam break flow discharged at Level 34, the elevation for the broken main steam line. The parametric case (Case C: MSL3_1DPVCB_L23NL2Pa-72) discussed in Section 3 uses 2-pipe connection, but the steam source of break location is assumed at Level 23. These two cases are compared to assess the effect of steam source locations on the DW pressure.

Figures 6.2-53S01-24 to 6.2-53S01-26 compare the DW pressures and the GDCS pool airspace air pressures between these two cases. With 2-pipe model, both cases show almost complete clearing of NC gases in the GDCS pool airspace after 20 hours. However, the case with steam break flow discharged at Level 34 shows slightly higher DW pressure than that for the case with steam break flow discharged at Level 23 (Figure 6.2-53S01-24).

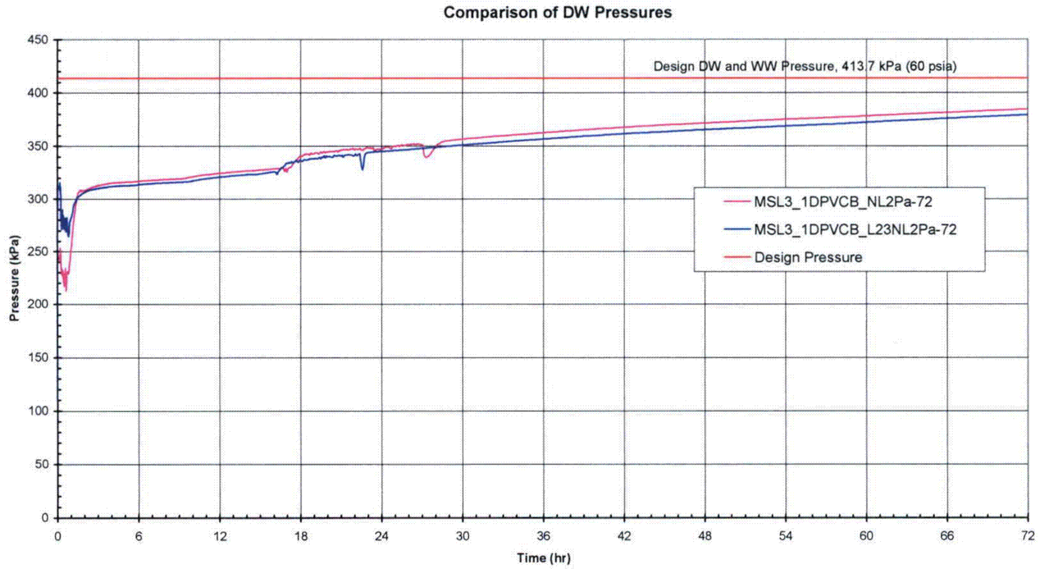

**Figure 6.2-53S01-24: Comparison of DW Pressures
(Case A vs. Case C: Level 34 versus Level 23, 2-Pipe Connection)**

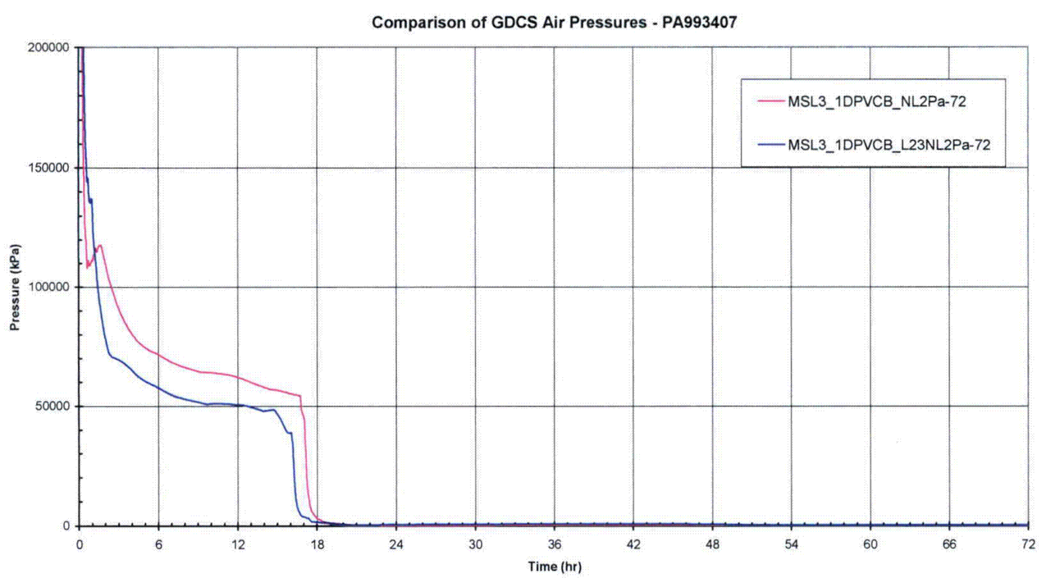

**Figure 6.2-53S01-25: Comparison of GDCS Pool Airspace Air Pressures (Ring 7)
(Case A vs. Case C: Level 34 versus Level 23, 2-Pipe Connection)**

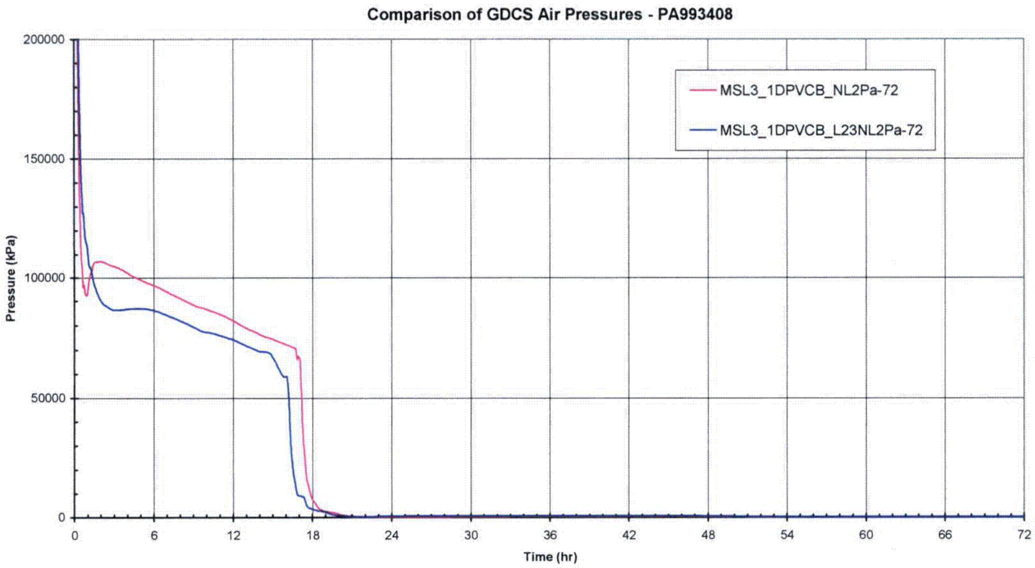

Figure 6.2-53S01-26: Comparison of GDCS Pool Airspace Air Pressures (Ring 8) (Case A vs. Case C: Level 34 versus Level 23, 2-Pipe Connection)

(6) Summary

This supplement provides an updated discussion of the containment responses on the limiting MSLB case with bounding conditions (DCD Tier 2, Revision 3, Subsection 6.2.1.1.3.5). The discussion includes the NC gases holdup, mixing and stratification. This supplement also discusses the results from additional parametric cases, the impact of 1-pipe versus 2-pipe connection, and the impact of the discharge location for the steam break flow.

Table 6.2-53S01-2 summarizes the maximum DW pressures of these cases. The MSLB case (DCD Tier 2, Revision 3, Subsection 6.2.1.1.3.5) with 2-pipe connection and steam break flow discharged to Level 34 produces the highest DW pressures among these cases. The use of 2-pipe connection to simulate the flow path between the GDCS pool air space and the DW effectively purges out all NC gases remaining in this air space, leading to higher DW pressure compared to the case with 1-pipe connection. The case with steam break flow discharged at Level 34 shows slightly higher DW pressure than that discharged at Level 23.

Table 6.2-53S01-2: Summary of Maximum DW Pressures for Main Steam Line Break Cases

Case #	Case ID	MSL Steam Break Location	GDCS Airspace and DW Connection	Maximum DW Pressure (kPa)
A	MSL3_1DPVCB_NL2Pa-72	Level 34	2-PIPE	384.2
B	MSL2_1DPVCB_L23NL-72	Level 23	1-PIPE	375.4
C	MSL3_1DPVCB_L23NL2Pa-72	Level 23	2-PIPE	378.8
D	MSL3_1DPVCB_NL-72	Level 34	1-PIPE	380.0

Results of these comparisons conclude that the simulation with 2-pipe connection and steam break flow discharged at the same elevation as the main steam line generates highest DW pressure than other combinations of simulation. This simulation was used for the limiting MSLB case presented in DCD Tier 2, Revision 3, Subsection 6.2.1.1.3.5

DCD Impact:

DCD Tier 2, Subsection 6.2.1.1.3.5, will be revised to provide the additional information discussed in this supplement.