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MFN 09-023 Supplement 3

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U.S. Nuclear Regulatory Commission
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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 375 Related to ESBWR Design Certification Application – Engineered Safety Systems – RAI Number 6.2-140 S05**

The purpose of this letter is to submit the GE Hitachi Nuclear Energy (GEH) response to the U.S. Nuclear Regulatory Commission (NRC) Request for Additional Information (RAI) sent by the Reference 1 NRC letter. GEH response to RAI Number 6.2-140 S05 is addressed in Enclosure 1.

Enclosure 2 contains markups to DCD Tier 1 and Tier 2 Section 6.2 as noted in the Enclosure 1 response.

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

Sincerely,

Peter M. Yandow FOR

Richard E. Kingston
Vice President, ESBWR Licensing

D068
NRO

Reference:

1. MFN 09-624, Letter from U.S. Nuclear Regulatory Commission to Jerald G. Head, *Request for Additional Information Letter No. 375 Related to ESBWR Design Certification Application,* October 1, 2009

Enclosures:

1. MFN 09-023 Supplement 3 - Response to Portion of NRC Request for Additional Information Letter No. 375 Related to ESBWR Design Certification Application – Engineered Safety Features – RAI Number 6.2-140 S05
2. MFN 09-023 Supplement 3 - Response to Portion of NRC Request for Additional Information Letter No. 375 Related to ESBWR Design Certification Application – Engineered Safety Features – RAI Number 6.2-140 S05 – Markups to ESBWR DCD Tier 1 and Tier 2 Section 6.2

cc:	AE Cubbage	USNRC (with enclosures)
	JG Head	GEH (with enclosures)
	DH Hinds	GEH (with enclosures)
	SC Moen	GEH (w/o enclosures)
	eDRFsection	0000-0108-5168

Enclosure 1

MFN 09-023 Supplement 3

Response to Portion of NRC Request for

Additional Information Letter No. 375

Related to ESBWR Design Certification Application

Engineered Safety Systems

RAI Number 6.2-140 S05

NRC RAI 6.2-140 S05

Provide updated RAI response, clarify implementation of PCC pool refill, and confirm vent fan discharge submergence and fan performance

In response to RAI 6.2-140, Supplement 4, GEH provided detailed results for 30-day containment analysis, which credited PCCS, PCCS pool refill, PARS, and six drywell gas recirculation (DGR) fans beyond three days. However, GEH later changed the design basis requiring operating only four of six DGR fans and provided selected results in ESBWR DCD Revision 6.

A. The selected plots provided in ESBWR DCD Revision 6 are not sufficient for the staff to perform confirmatory analysis and complete the review. GEH should update RAI 6.2-140 response to include the four fan case, which represents the new design basis.

B. GEH's response to RAI 6.2-140, Supplement 4, shows varying of the PCC pool refill rates to maximize the PCCS heat transfer. GEH should clarify how it will implement the controlled PCC pool refill rates during the operation of ESBWR.

C. ESBWR DCD Revision 6 states that "The vent fan discharge line is > 0.22 m (9 in) and < 0.25 m (10 in) below the top of the drain pan lip." Confirm that the DGR fan discharge line would stay submerged during the 30 day analysis.

D. ESBWR DCD Revision 6 Table 6.2-49 lists the minimum DGR fan performance requirements. Confirm that the DGR fan performance used in the containment analysis is bounded by the values listed in Table 6.2-49.

E. ESBWR DCD Revision 6 Figure 6.2-14e1 shows curve of analytical pressure limit.

a. Explain the regulatory significance of this curve.

b. Explain how this curve would be used in ESBWR design.

c. Explain the relevance of this curve to ITAAC, if any.

F. Update ESBWR DCD appropriately to include responses to parts B through D.

GEH Response

A: The plots provided in GEH's response to RAI 6.2-140S04 have been updated based on the analysis presented in ESBWR DCD Revision 6. These plots, 6.2-140 S05-C1-6 and 6.2-140 S05-D1-26, are presented below using the same naming convention for figure titles used in Supplement 4 of this RAI.

B: In the TRACG analysis, the PCC pool level was not kept at the highest possible level. Therefore, the containment pressure could be higher at times because of higher pool saturation temperature and lower PCC heat transfer. This trend is shown in the response to RAI 6.2-140S04.

In the response to Supplement 4 of this RAI, GEH presented a plot showing the PCC pool level with respect to time (Figure 6.2-140 S04-B1). The analysis currently presented in ESBWR DCD Revision 6 contains a PCC pool refill control scheme that maintains the level in the pool closer to the top of the PCC tubes (DCD Rev. 6 Figure 6.2-14e10). Using the information from the TRACG calculation presented in Supplement 4 of RAI 6.2-140, a DW pressure adder of 25 kPa (3.6 psi) is applied to the DW Pressure curves reported in ESBWR DCD Rev. 6 to adjust the results considering the highest possible PCC pool level. The effect of this adder is shown in Figure 6.2-140S05-2 below.

C: An error was discovered in the ITAAC Table 2.15.4-2, Item 14, which describes the location of the PCCS vent fan discharge as an elevation below the drain pan lip. The intent of this ITAAC is to define this elevation within a tolerance such that the ITAAC can be met in a way that ensures the submergence does not exceed what it is in the analysis. Therefore, the acceptance criteria in this item, as well as the text in Tier 2, Section 6.2.2.2.2 will be changed to consistently read:

> *"The elevation of the discharge on the PCCS vent fan line is 24 cm (9.4 in) below the top of the drain pan lip with a tolerance of 1.4 cm (0.6 in)."*

The TRACG analysis presented in ESBWR DCD Rev. 6 for the post-72 hour scenario does not maintain a 10 inch submergence of the vent fan discharge lines. However, a sensitivity study on the effect of the submergence was performed. The difference in PCC vent fan discharge elevation and GDCS pool level is seen to decrease over time as shown in Figure 6.2-140 S05-C5 below. However, the GDCS pool level illustrated in Figure 6.2-140 S05-C5 also confirms that the vent fan discharge does not become uncovered. The fan outlet is set in TRACG to a constant elevation of 20.91 m (referenced to Vessel Zero.) From the figure, the GDCS pool level in Ring 7, corresponding to the 4 vent fan pool, appears to reach a final level of 20.92 m. However, due to the fact that the discharge line is very close to being uncovered, an analytical DW pressure adder was developed as a safety margin.

Similar to the technique described in paragraph B above, an adder of 15 kPa (2.2 psi) is applied to the TRACG DW pressure response values as reported in ESBWR DCD Rev. 6. The basis for the additional pressure comes from a study conducted to gauge the effect of submergence of the discharge outlet on DW pressure. Shown in Figure 6.2-140S05-1 below, the DW pressure is seen to increase with increased submergence. The vertical section around 14 inches of submergence occurs early in vent fan operation and can be ignored. An adjustment factor is determined, considering submergence and decay heat as primary contributors to DW pressure. The DW pressure at the end of the increased submergence test case was 281 kPa; that results in a difference from the base case at the same time of ~12kPa. The submergence effect is then calculated as being 12 kPa divided by the difference in submergence of 10.5 inches, or 1.14 kPa/inch submergence. The stated submergence should be held at 10 inches, so multiplying the submergence effect value by 10 inches yields an adder to 11.4 kPa that is rounded up to 15 kPa. The effect of this adder plus the adder described in paragraph B is shown in Figure 6.2-140S05-2 below. This figure will also be added to the DCD as indicated in the attached markups as Figure 6.2-14e13. To reduce redundancy, Figures 6.2-14e1 and 6.2-14e2 will be modified by removing the Analytical Pressure Limit Curve.

D: To provide additional assurance that the fan performance is bounding, a sixth data point (at 1,570 CFM) will be added to DCD Tier 2, Table 6.2-49. The sixth data point provides enough data to cover the range of fan performance and bounds the TRACG data points shown in Figure 6.2-140S05-D6 below. Please see attached markups.

E(a): The Analytical Pressure Limit curve shown in ESBWR DCD Rev. 6 Figure 6.2-14e13 represents a system performance acceptance criterion. This curve is included to accommodate variations in IC/PCC pool levels, PCC vent fan discharge submergence variation, PCC vent fan performance characteristics and variations, PCC heat exchanger efficiency, and TRACG modeling, for example those discussed in B and C above. This curve indicates system performance consistent with the GDC 38 criteria to rapidly reduce pressure and maintain a reduced pressure.

E(b): The curve defines an acceptance criteria for the analysis; it indicates that the pressure is rapidly reduced and does not approach the design pressure after PCC vent fan have been activated. Furthermore, any subsequent analysis performed during the detailed design phase must fall below this criterion.

E(c): There is no ITAAC that applies to this curve as a test, analysis, or acceptance criteria.

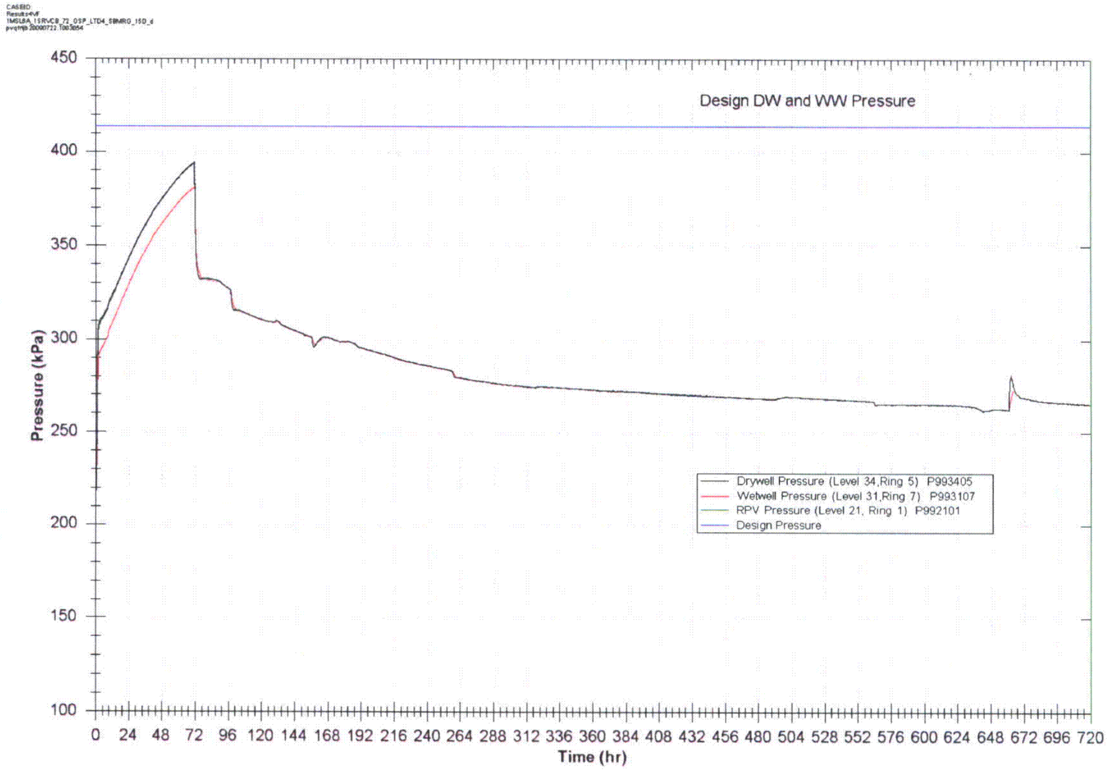


Figure 6.2-140 S05-C1 Main Steam Line Break, 1 DPV Failure (Bounding Case) - Containment Pressures (30 days).

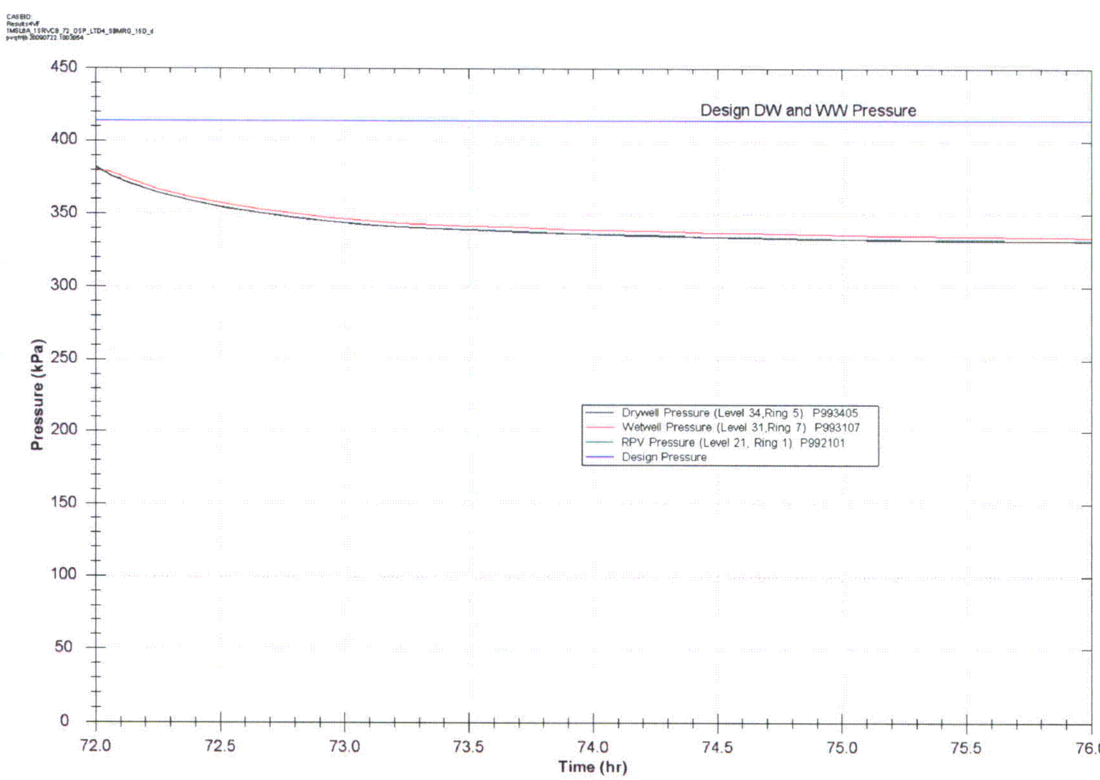


Figure 6.2-140 S05-C1a Main Steam Line Break, 1 DPV Failure (Bounding Case)- Containment Pressures (72-76 hr).

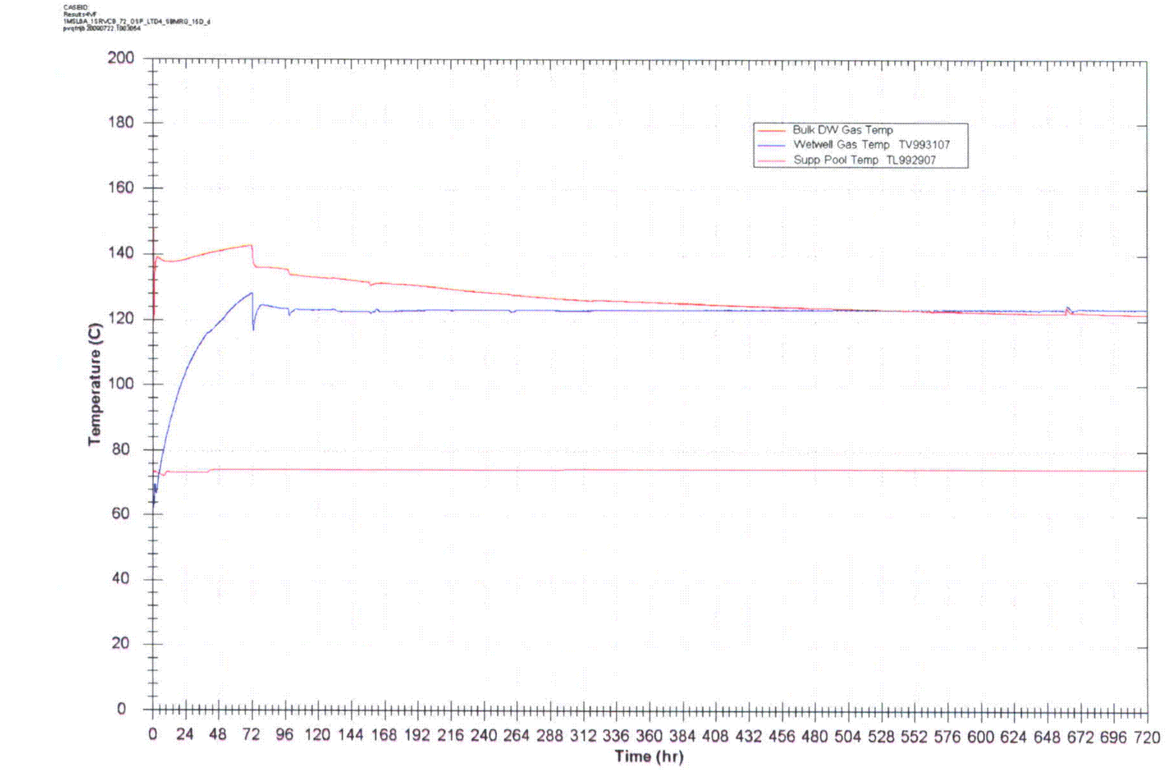


Figure 6.2-140 S05-C2 Main Steam Line Break, 1 DPV Failure (Bounding Case) - Containment Temperatures (30 days).

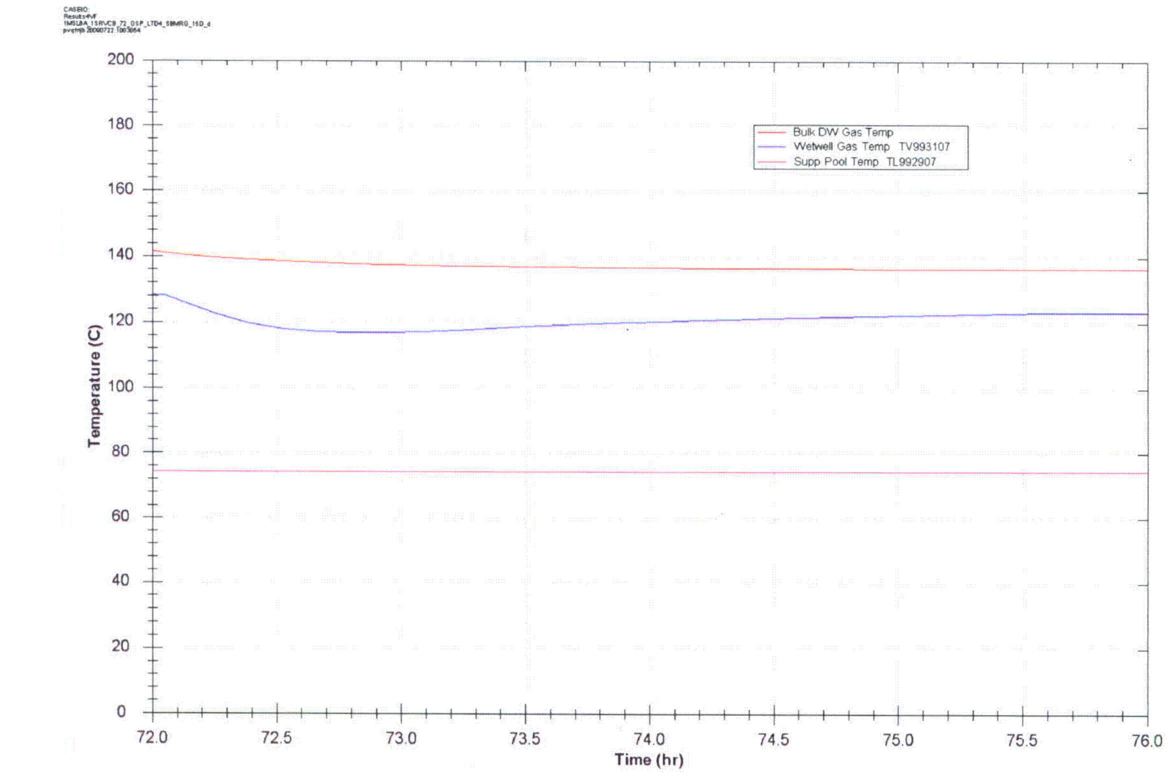


Figure 6.2-140 S05-C2a Main Steam Line Break, 1DPV Failure (Bounding Case) - Containment Temperatures (72-76 hr).

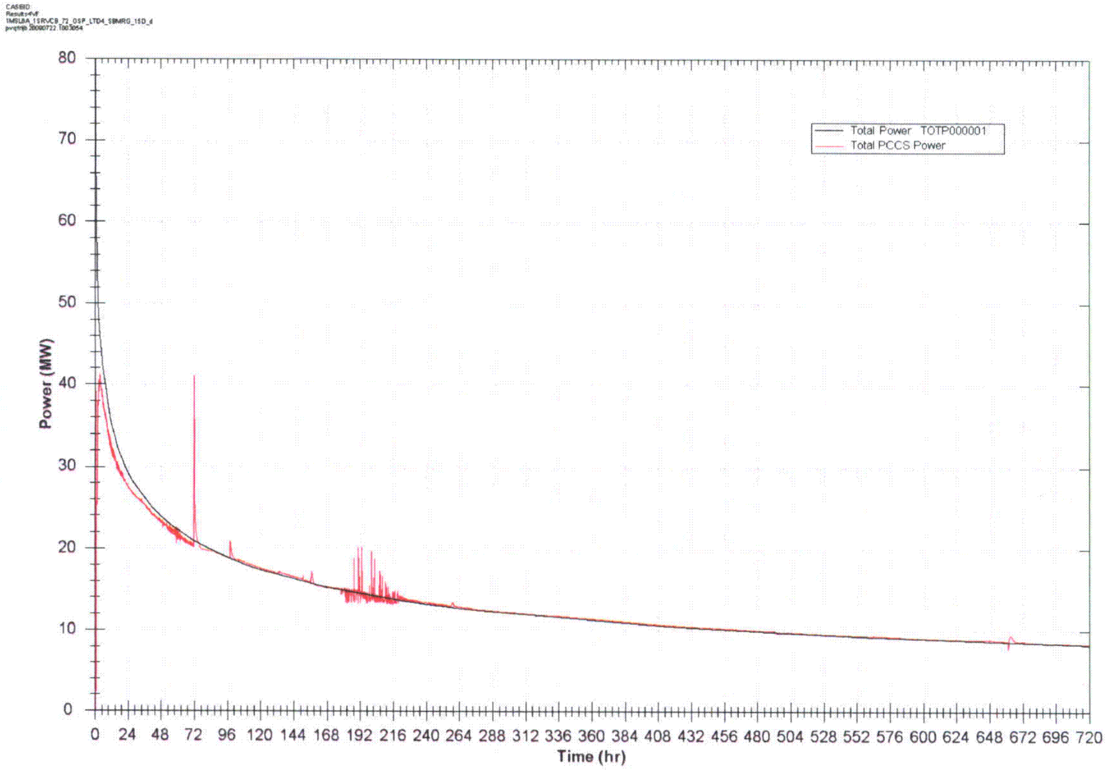


Figure 6.2-140 S05-C3 Main Steam Line Break, 1 DPV Failure (Bounding Case) - PCCS Heat Removal versus Decay Heat (30 days).

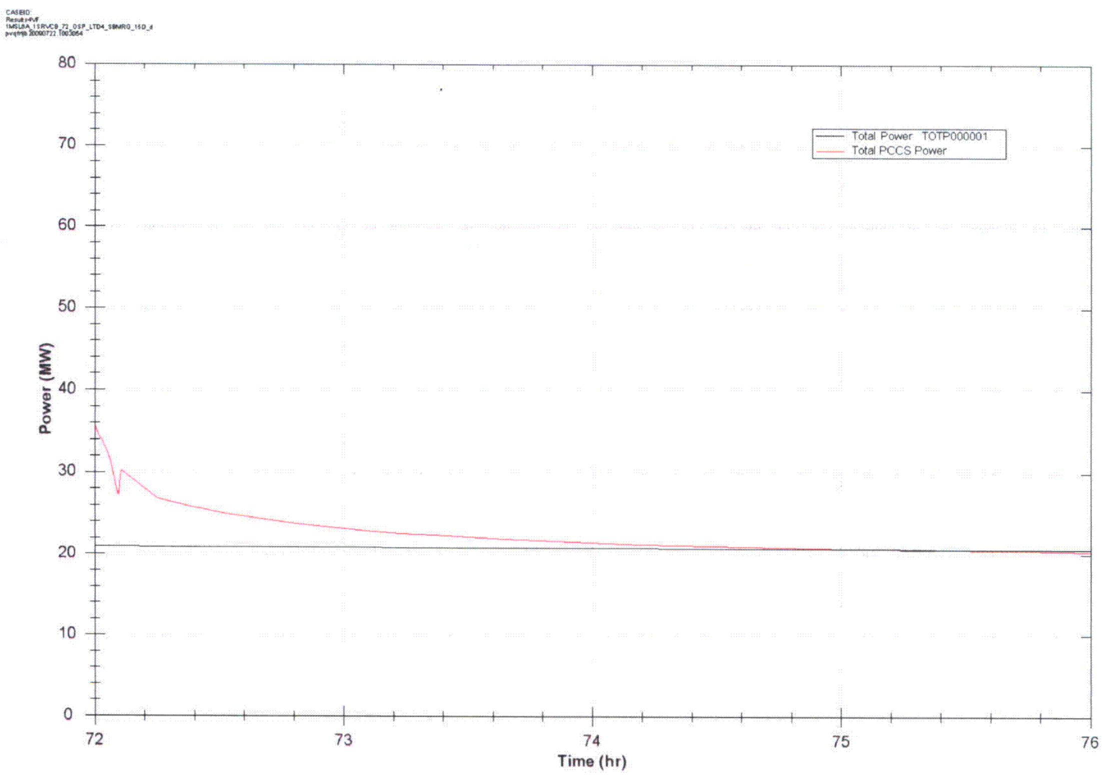


Figure 6.2-140 S05-C3a Main Steam Line Break, 1 DPV Failure (Bounding Case) - PCCS Heat Removal versus Decay Heat (72-76 hr).

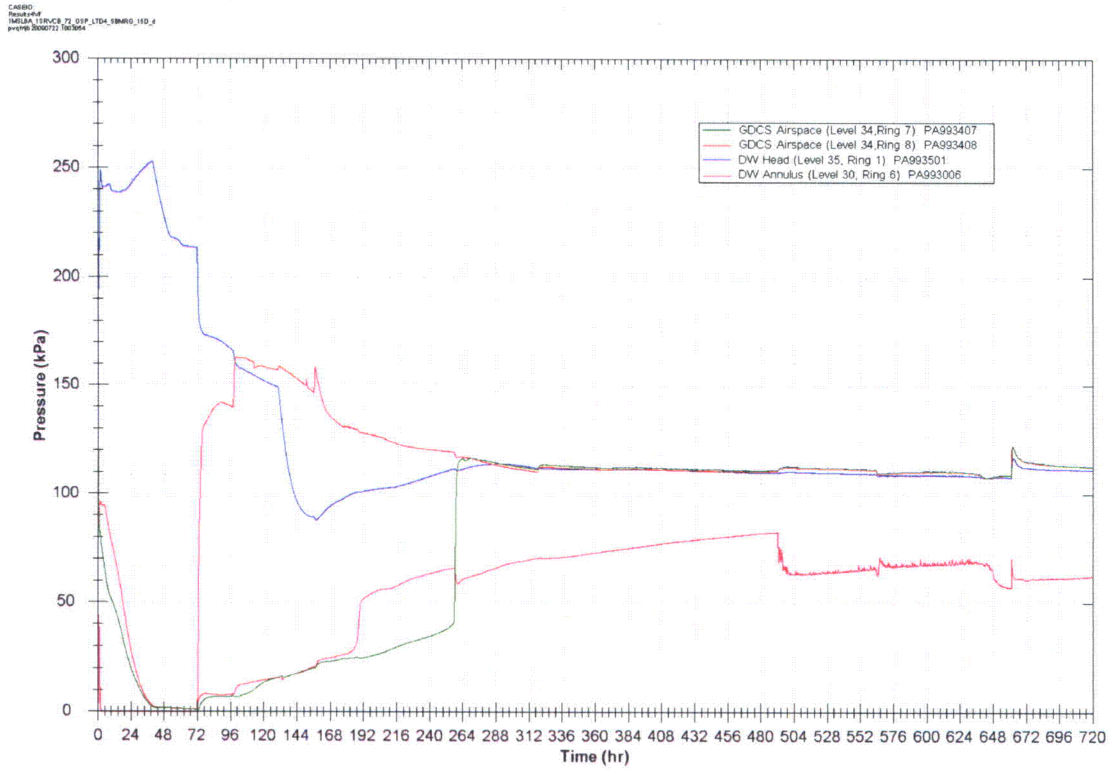


Figure 6.2-140 S05-C4 Main Steam Line Break, 1 DPV Failure (Bounding Case) - Drywell and GDCS Noncondensable Gas Pressures (30 days).

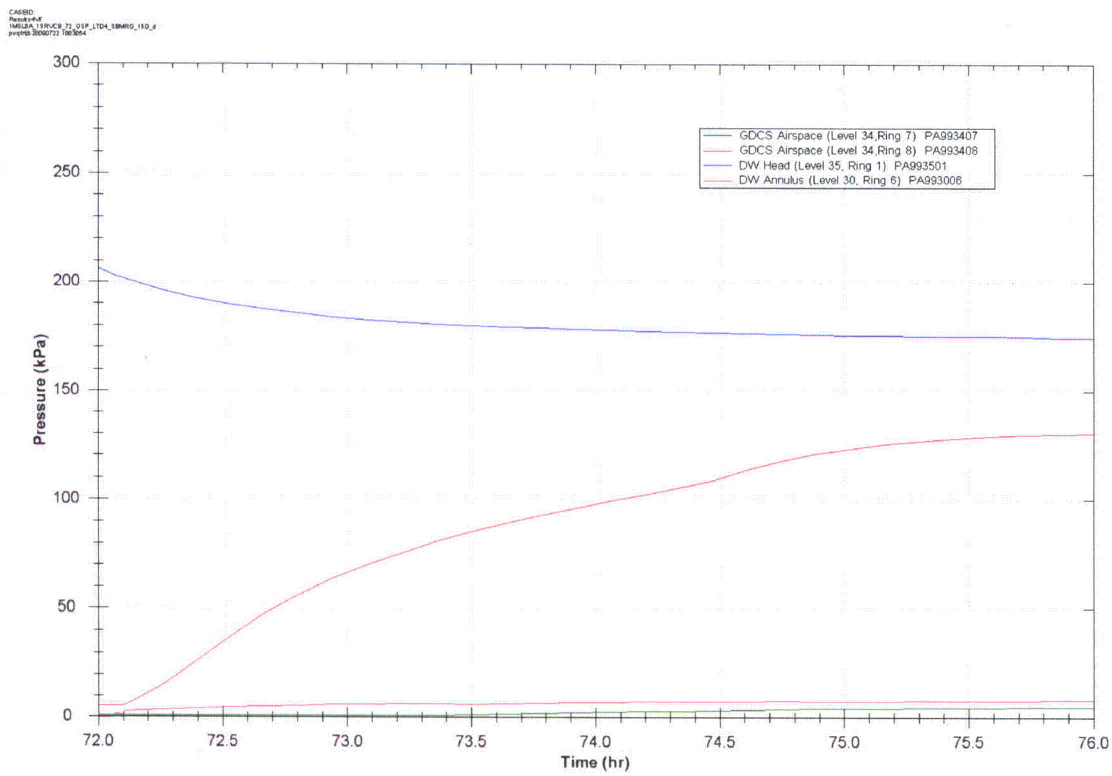


Figure 6.2-140 S05-C4a Main Steam Line Break, 1 DPV Failure (Bounding Case) - Drywell and GDCS Noncondensable Gas Pressures (72-76 hr).

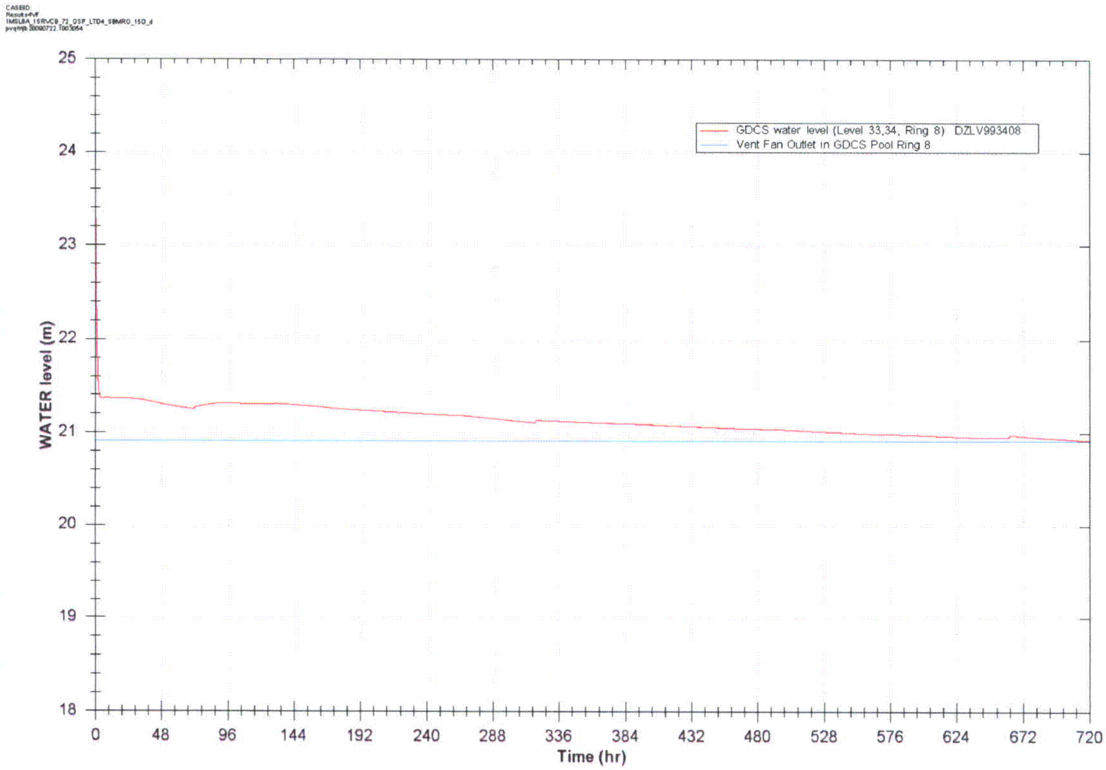


Figure 6.2-140 S05-C5 Main Steam Line Break, 1 DPV Failure (Bounding Case) - GDCS Pool Water Level (30 days).

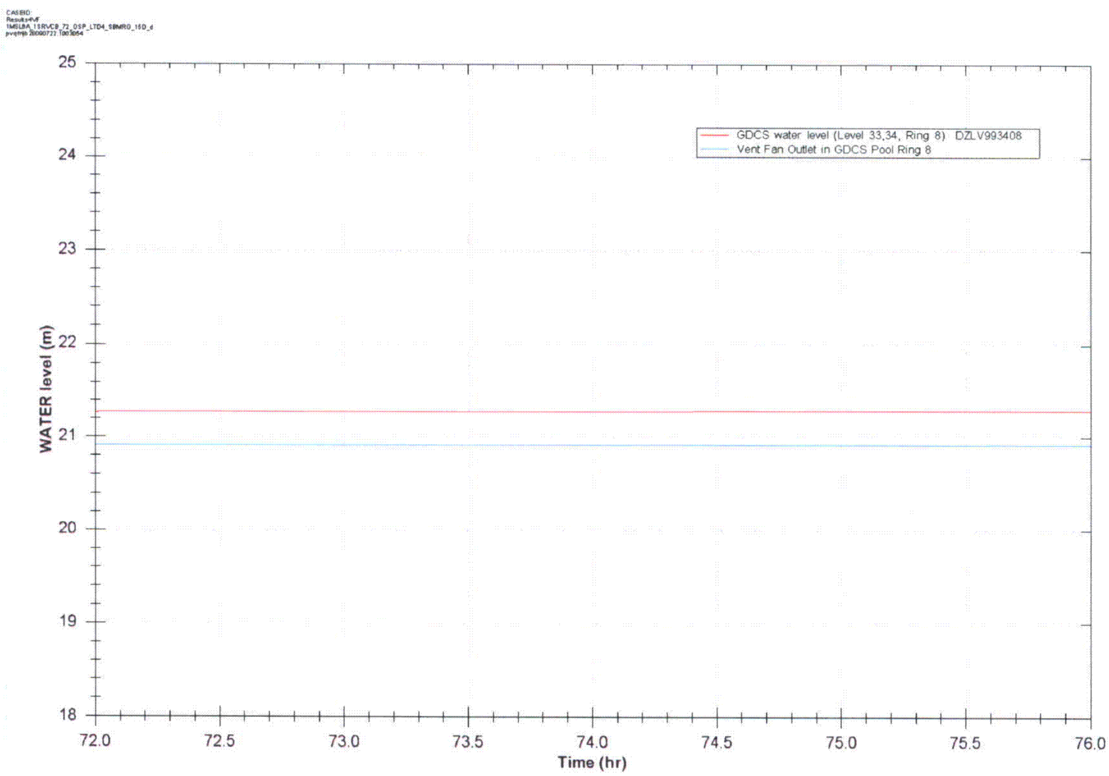


Figure 6.2-140 S05-C5a Main Steam Line Break, 1 DPV Failure (Bounding Case) - GDCS Pool Water Level (72-76 hr).

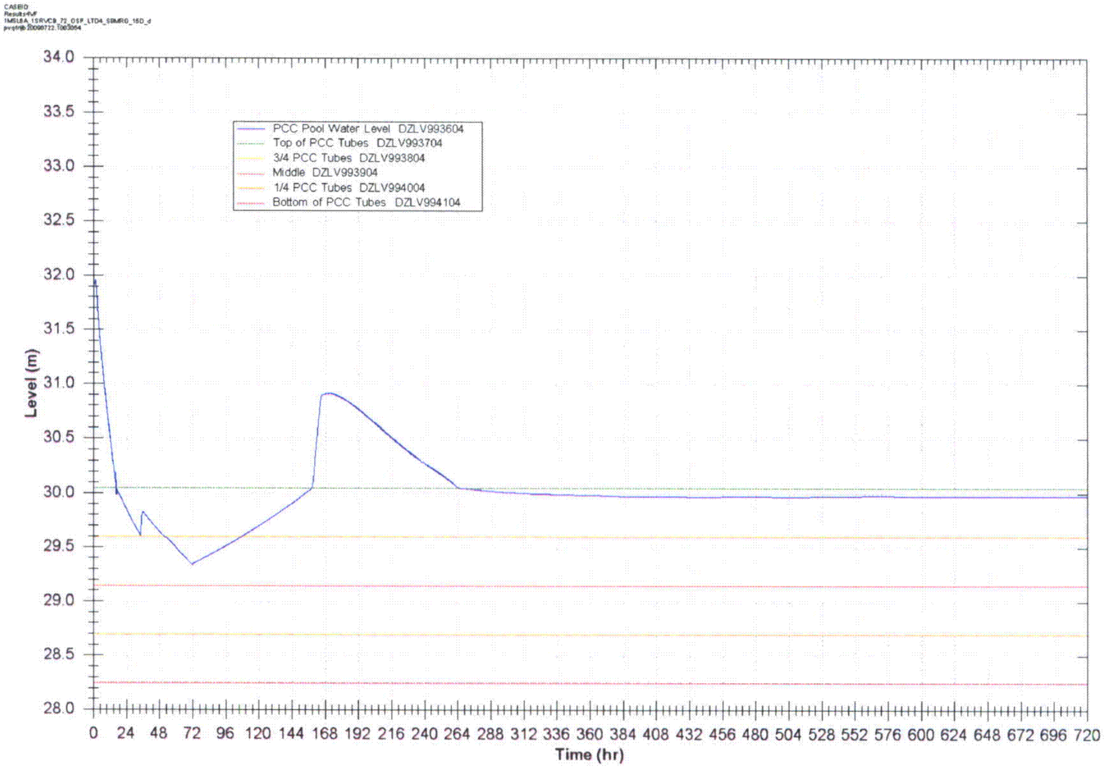


Figure 6.2-140 S05-C6 Main Steam Line Break, 1 DPV Failure (Bounding Case) - PCCS Water Level (30 days).

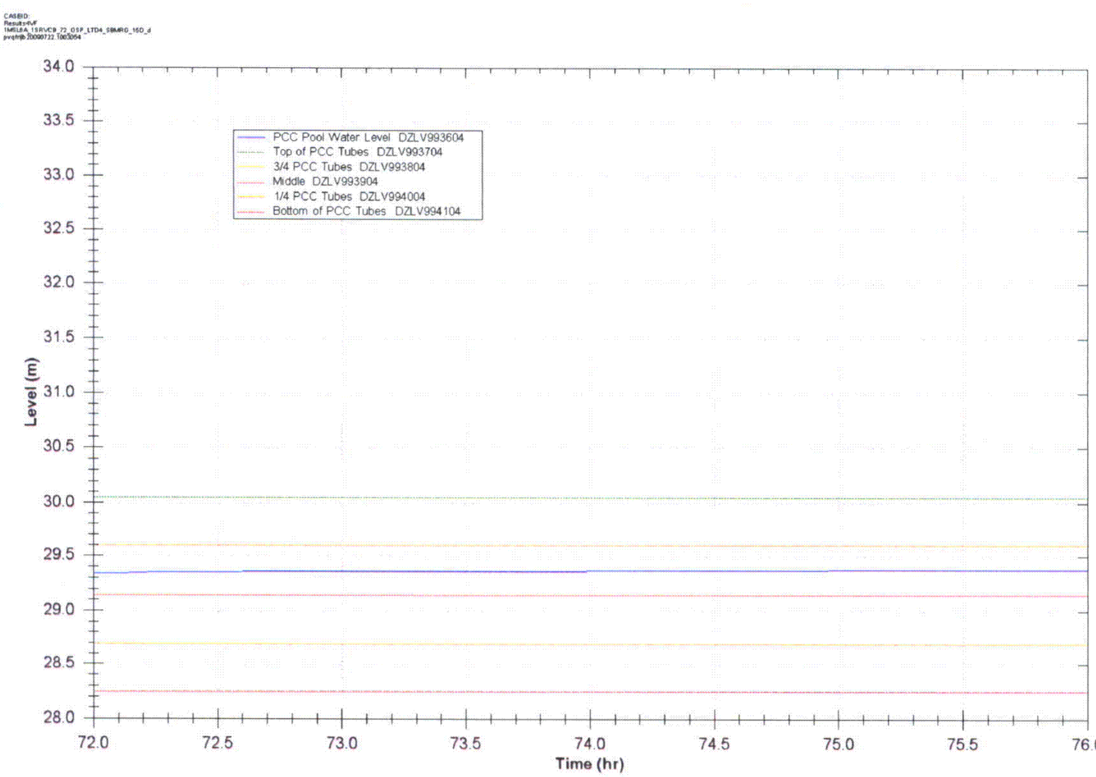


Figure 6.2-140 S05-C6a Main Steam line Break, 1DPV Failure (Bounding Case) - PCCS Water Level (72-76 hr).

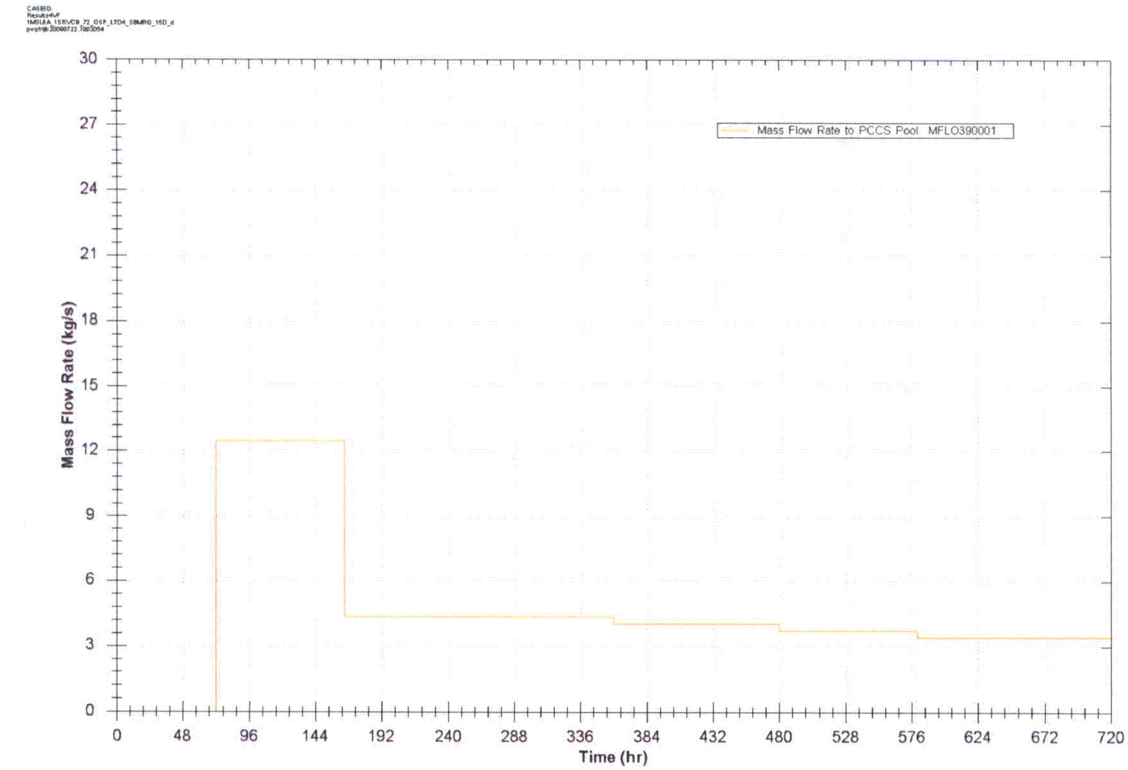


Figure 6.2-140 S05-D1 Main Steam Line Break, 1DPV Failure (Bounding Case), Mass Flow Rate to PCCS Pool (30 Days).

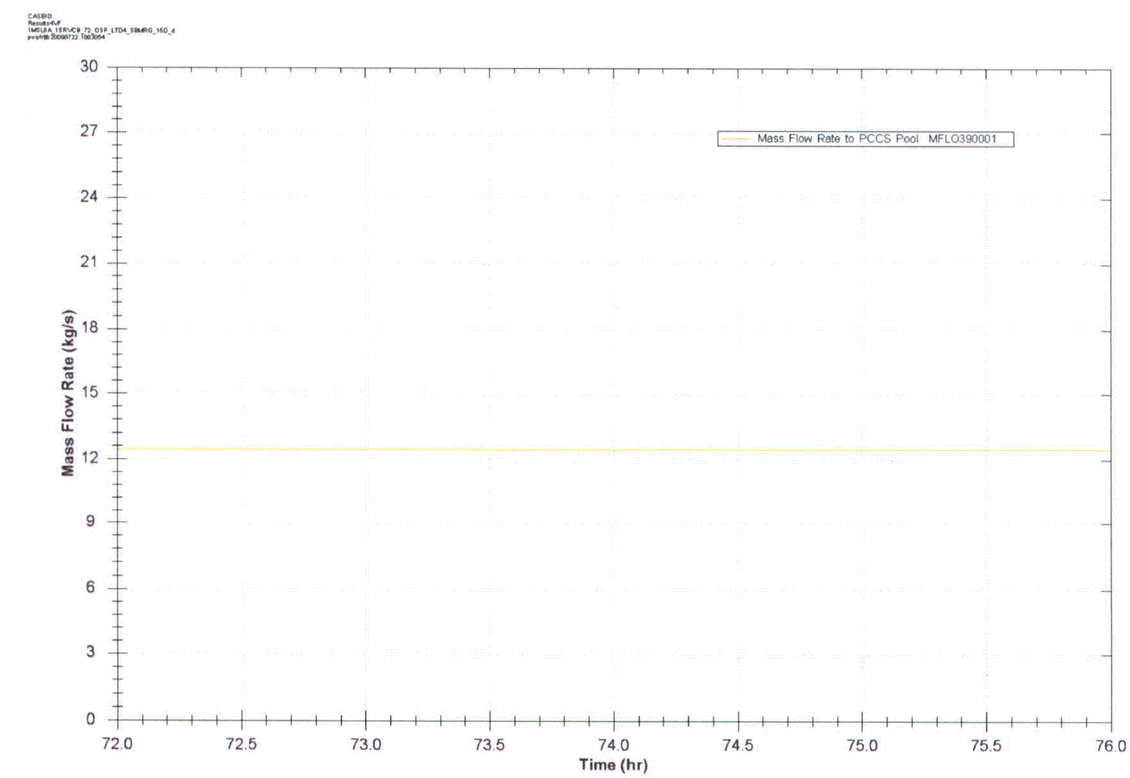


Figure 6.2-140 S05-D1a Main Steam Line Break, 1DPV Failure (Bounding Case), Mass Flow Rate to PCCS Pool (72 hr-76 hr).

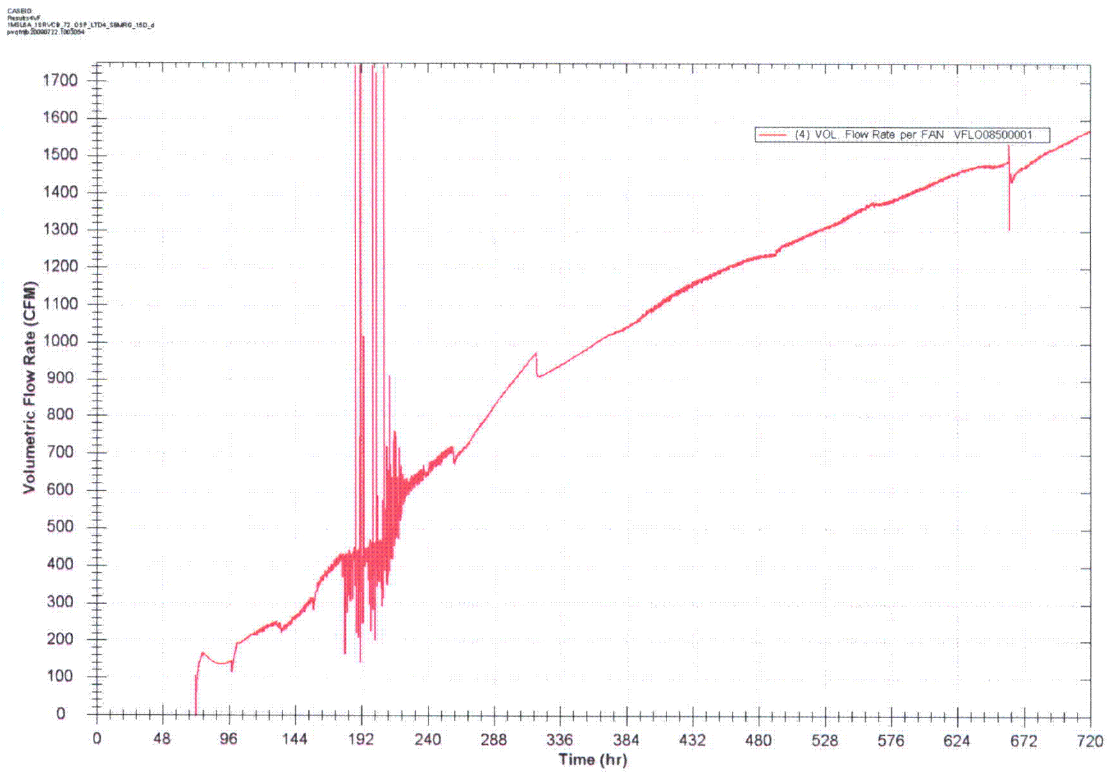


Figure 6.2-140 S05-D2 Main Steam Line Break, 1DPV Failure (Bounding Case), PCCS Recirculation Volumetric flow Rate (30 Days).

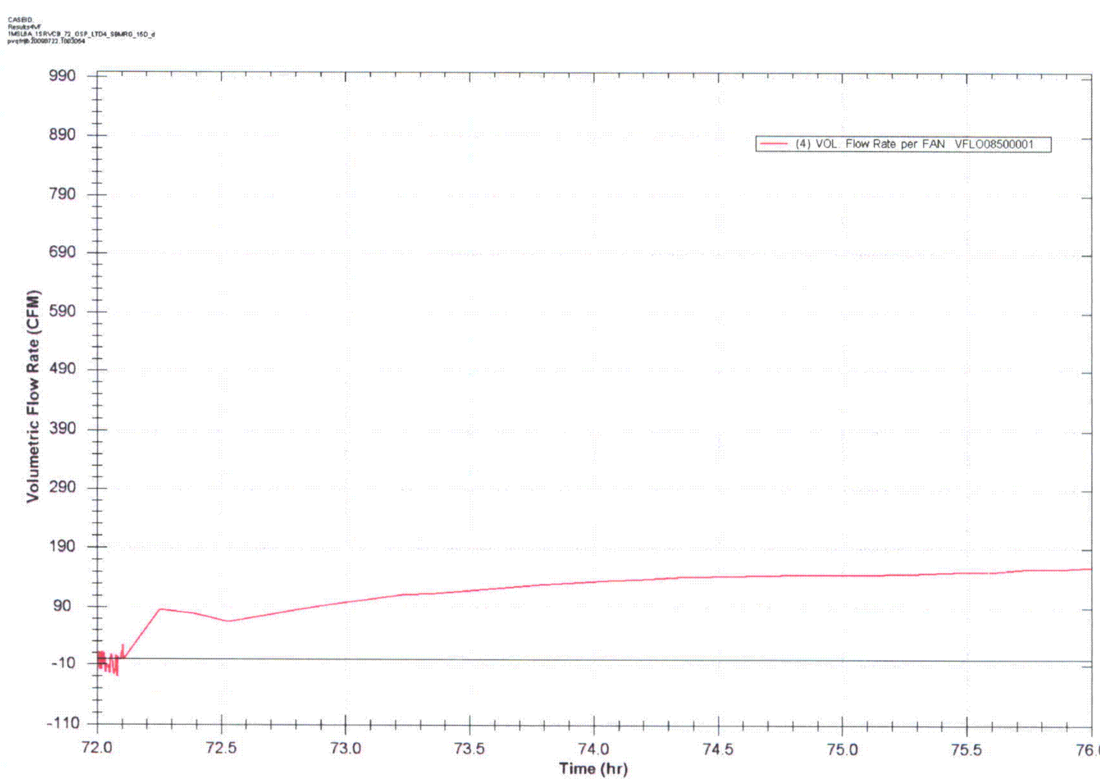


Figure 6.2-140 S05-D2a Main Steam Line Break, 1DPV Failure (Bounding Case), PCCS Recirculation Volumetric flow Rate (72 hr-76 hr).

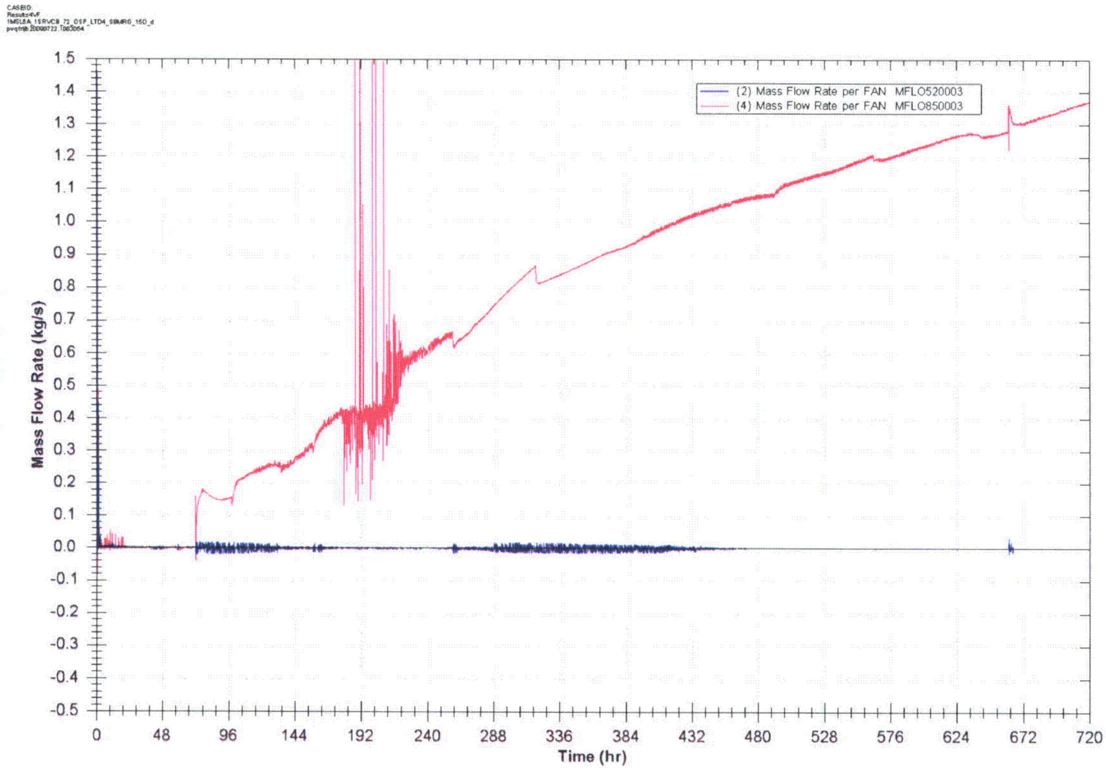


Figure 6.2-140 S05-D3 Main Steam Line Break, 1DPV Failure (Bounding Case), PCCS Recirculation Mass flow Rate (30 Days).

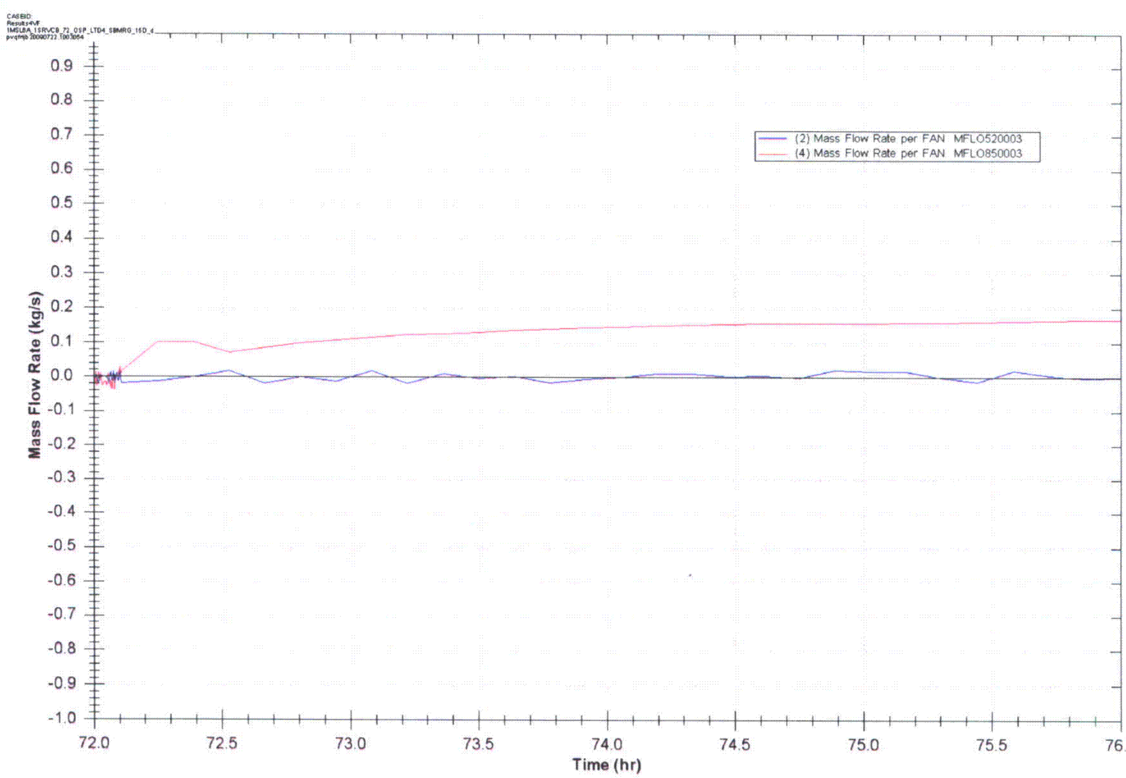


Figure 6.2-140 S05-D3a Main Steam Line Break, 1DPV Failure (Bounding Case), PCCS Recirculation Mass flow Rate (72-76 hr).

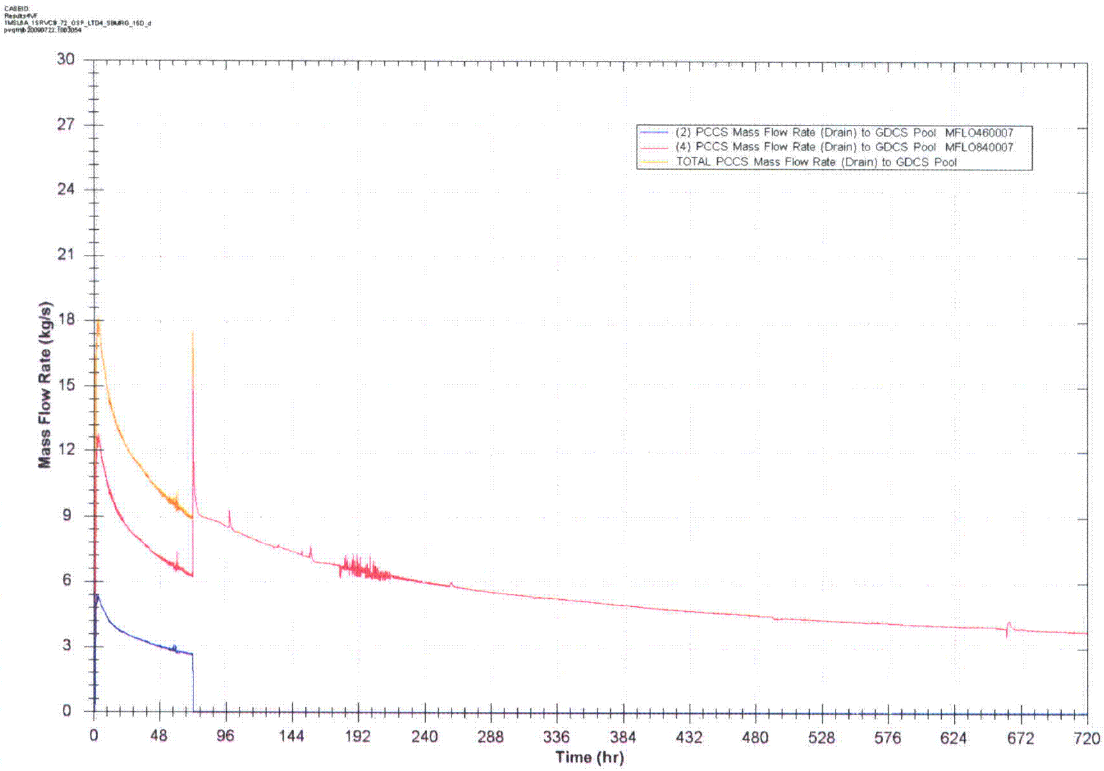


Figure 6.2-140 S05-D4 Main Steam Line Break, 1DPV Failure (Bounding Case), PCCS Condensate Mass Flow Rate to GDCS (30 Days).

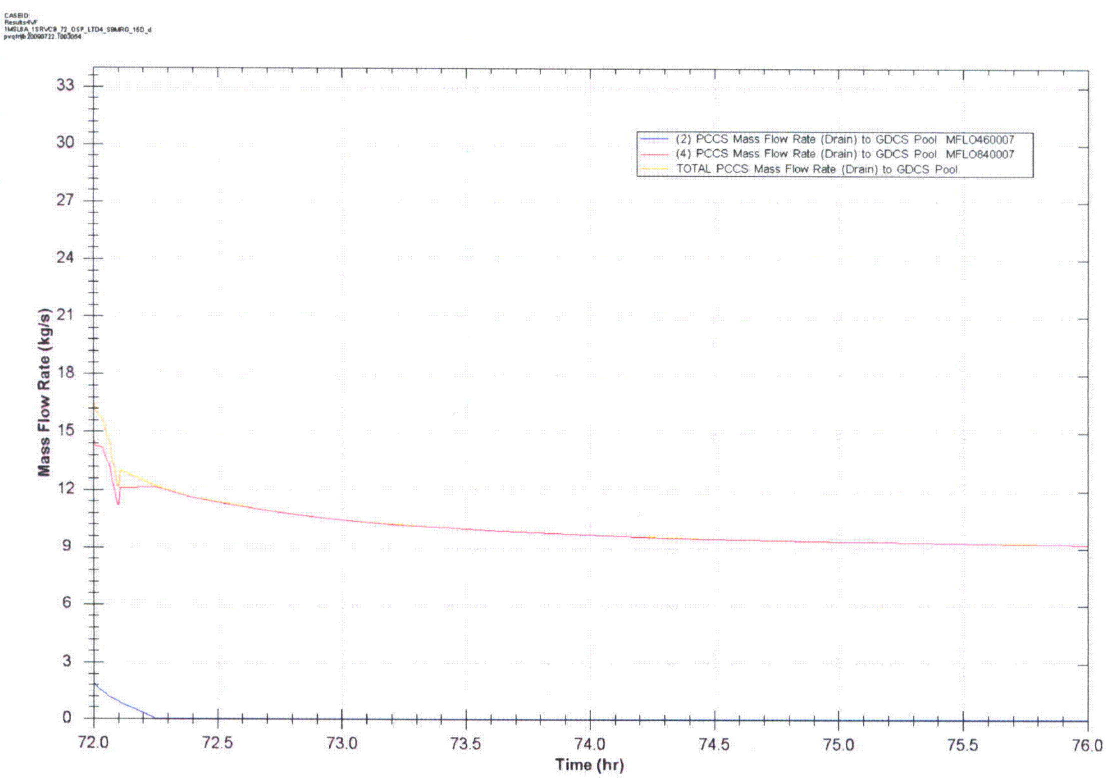


Figure 6.2-140 S05-D4a Main Steam Line Break, 1DPV Failure (Bounding Case), PCCS Condensate Mass Flow Rate to GDCS (72 hr-76 hr).

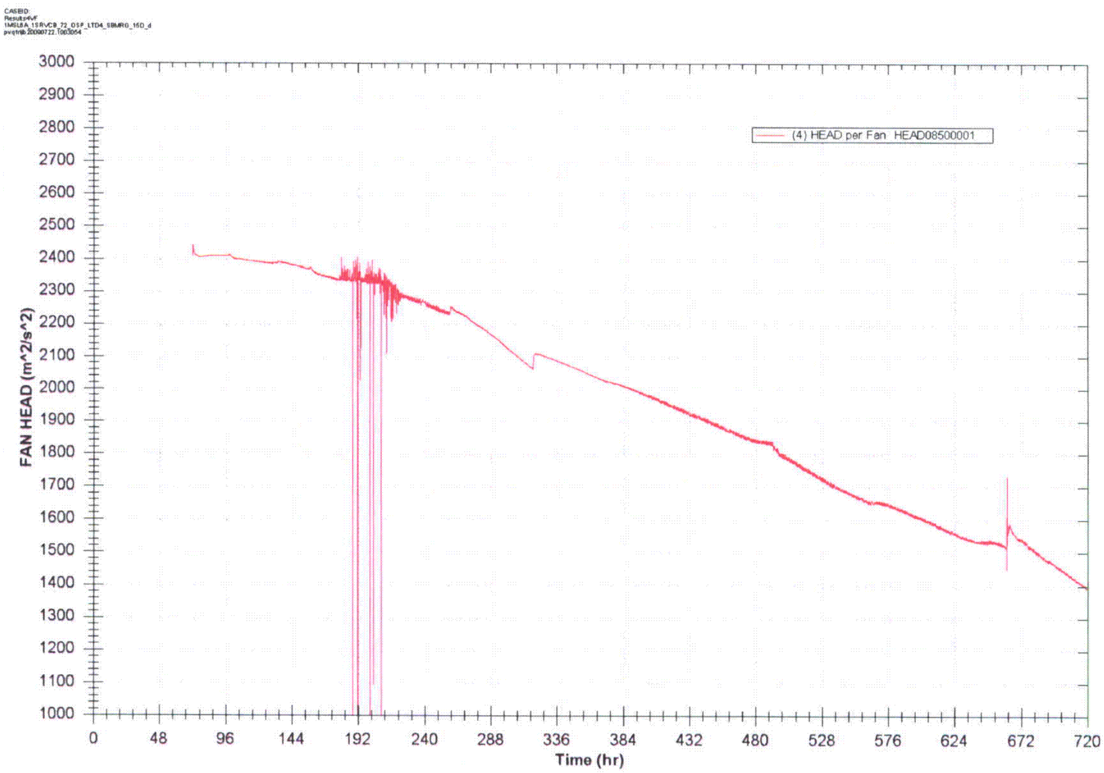


Figure 6.2-140 S05-D5 Main Steam Line Break, 1DPV Failure (Bounding Case), PCCS Vent Fan Head (30 Days).

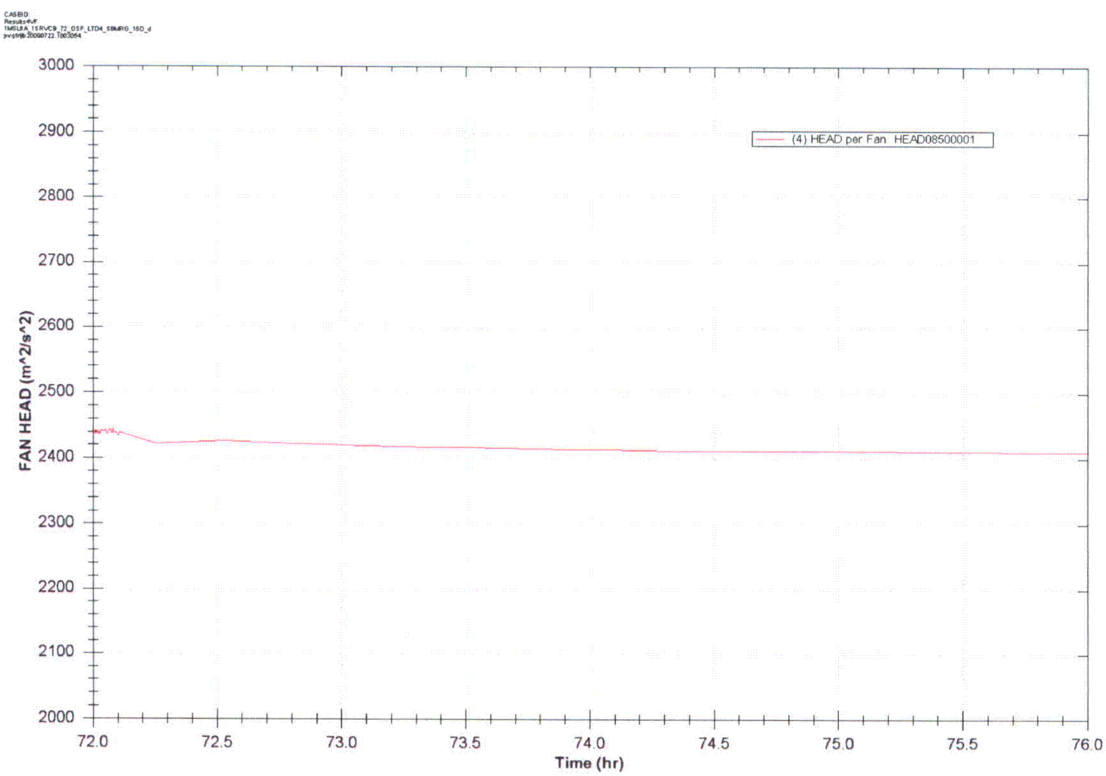


Figure 6.2-140 S05-D5a Main Steam Line Break, 1DPV Failure (Bounding Case), PCCS Vent Fan Head (72 hr-76 hr).

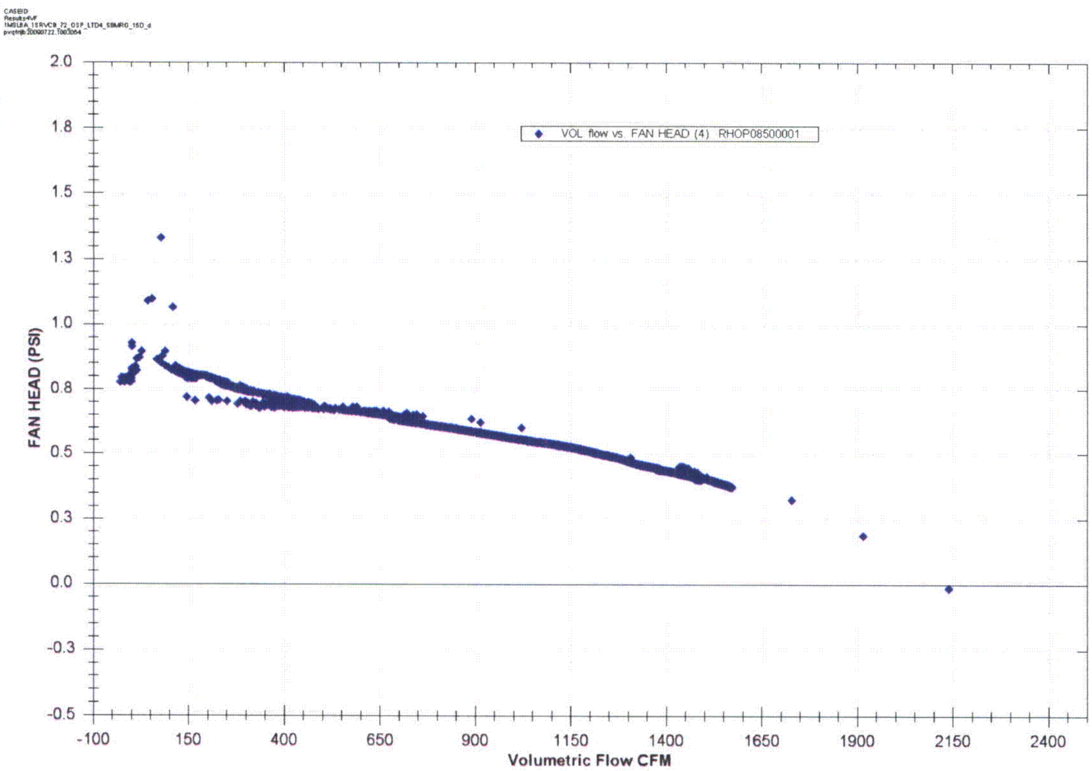


Figure 6.2-140 S05-D6 Main Steam Line Break, 1DPV Failure (Bounding Case), PCCS Vent Fan, Volumetric Flow vs. Head (30 Days).

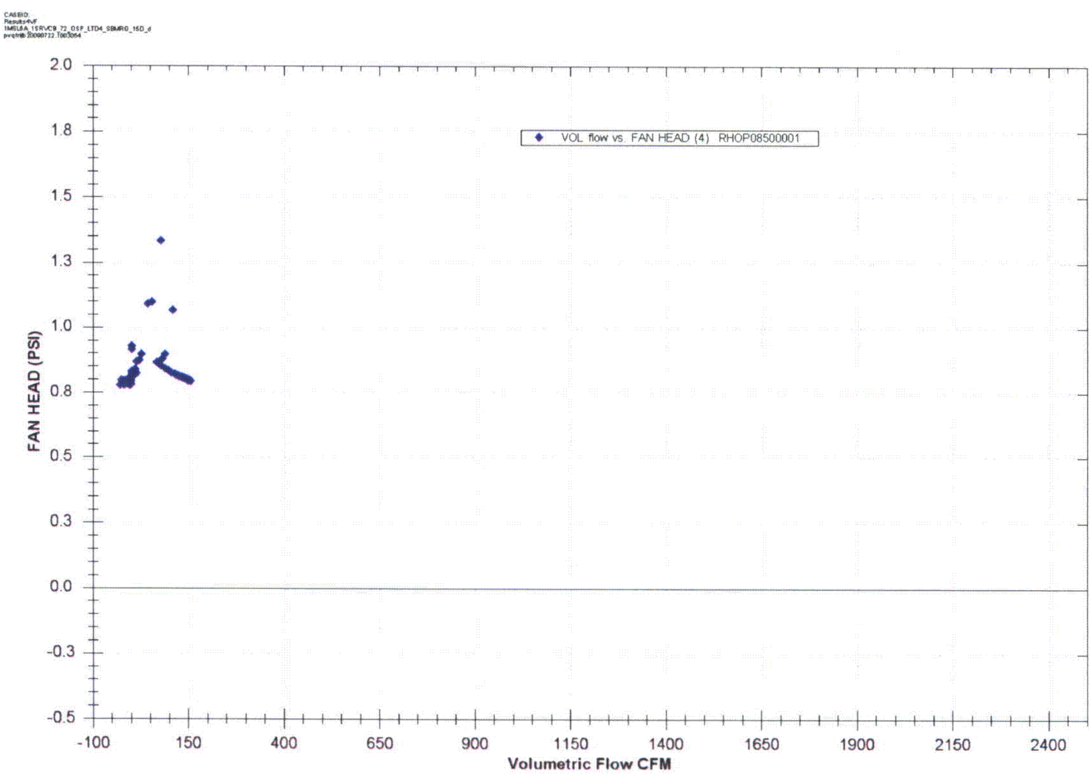


Figure 6.2-140 S05-D6a Main Steam Line Break, 1DPV Failure (Bounding Case), PCCS Vent Fan, Volumetric Flow vs. Head (72 hr-76 hr).

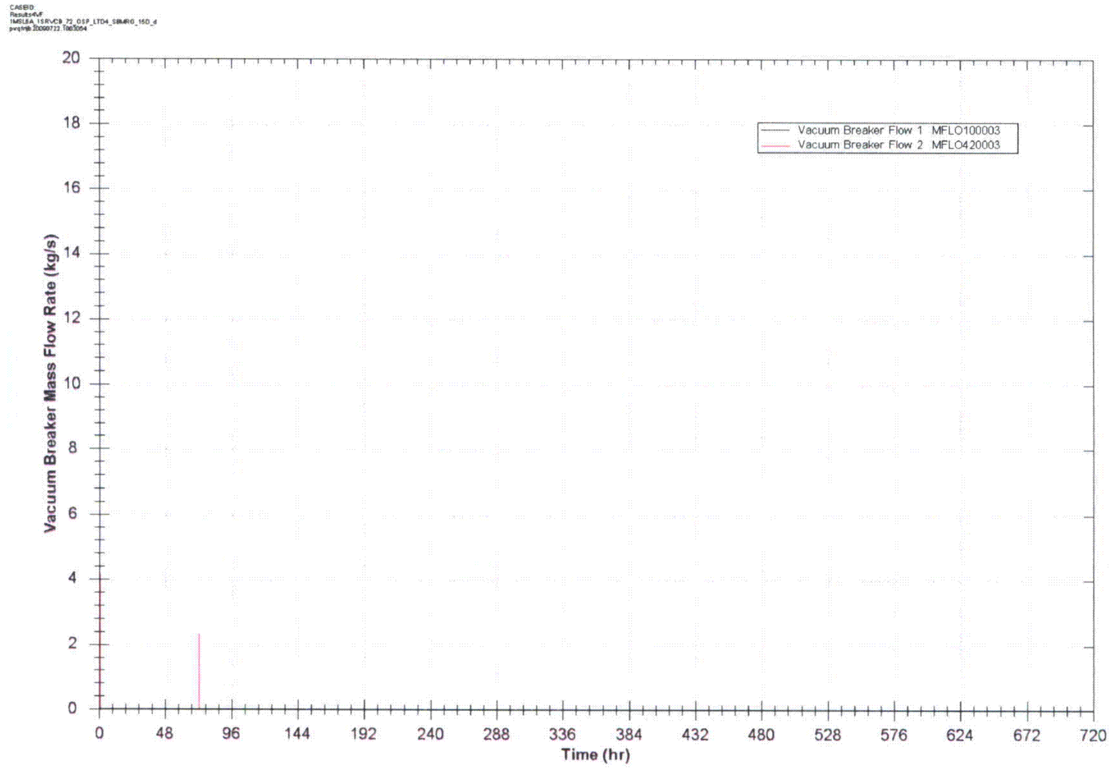


Figure 6.2-140 S05-D7 Main Steam Line Break, 1DPV Failure (Bounding Case) PCCS Vent Fan, DW-WW Vacuum Breaker (30 Days).

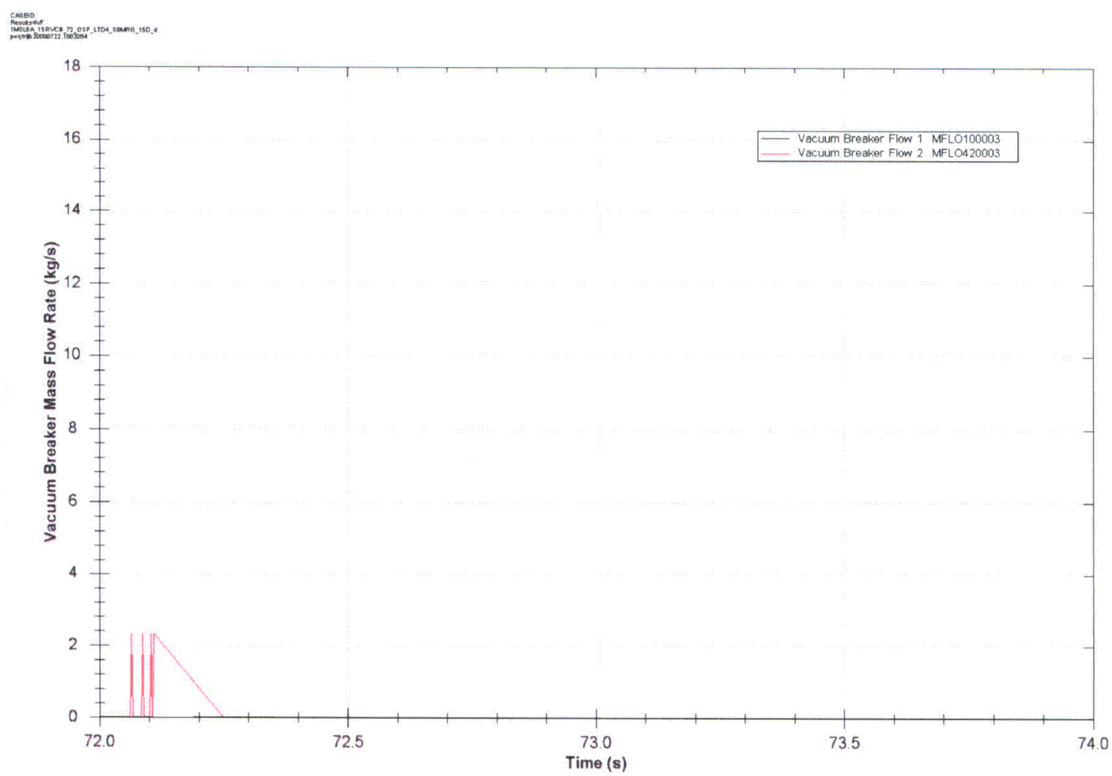


Figure 6.2-140 S05-D7a Main Steam Line Break, 1DPV Failure (Bounding Case) PCCS Vent Fan, DW-WW Vacuum Breaker (72 hr-74 hr).

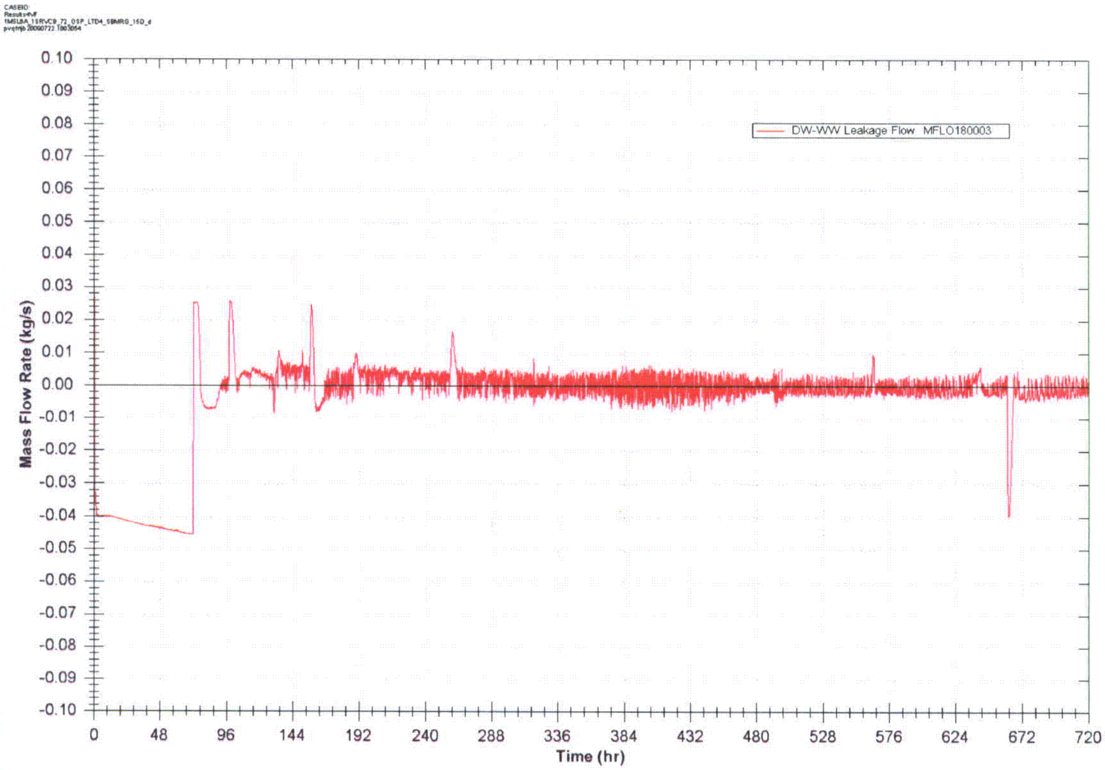


Figure 6.2-140 S05-D8 Main Steam Line Break, 1DPV Failure (Bounding Case) PCCS Vent Fan, DW-WW Leakage (30 Days).

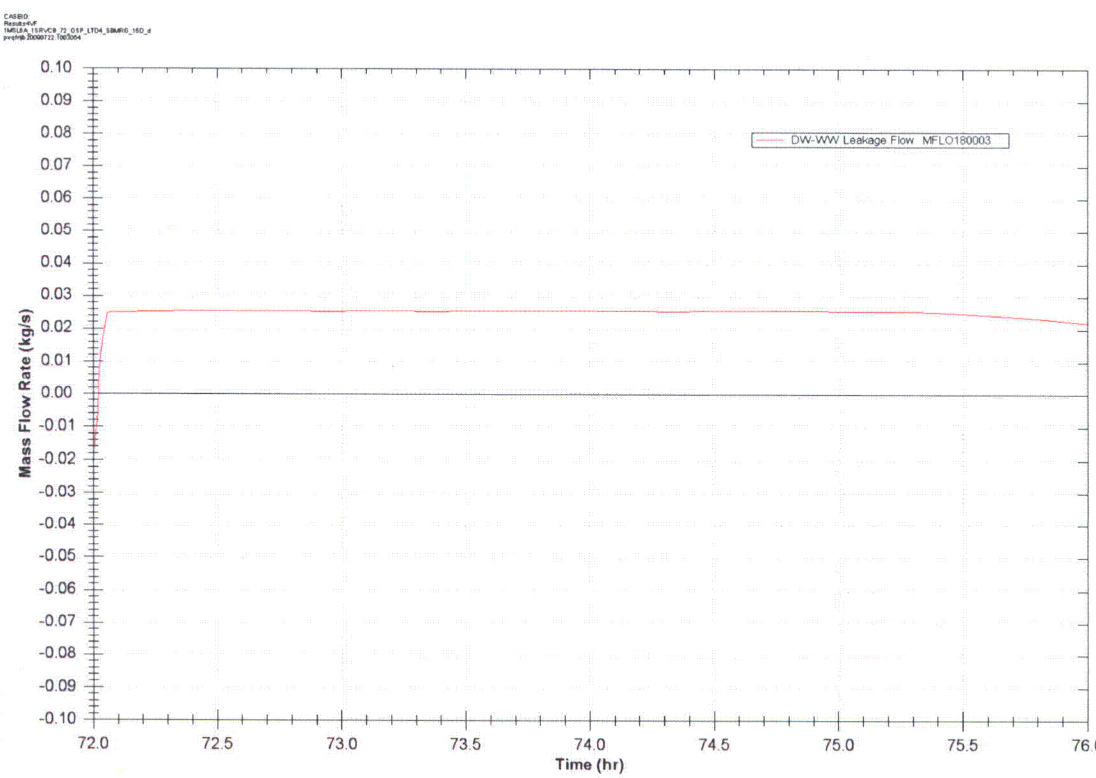


Figure 6.2-140 S05-D8a Main Steam Line Break, 1DPV Failure (Bounding Case) PCCS Vent Fan, DW-WW Leakage (72 hr-76 hr).

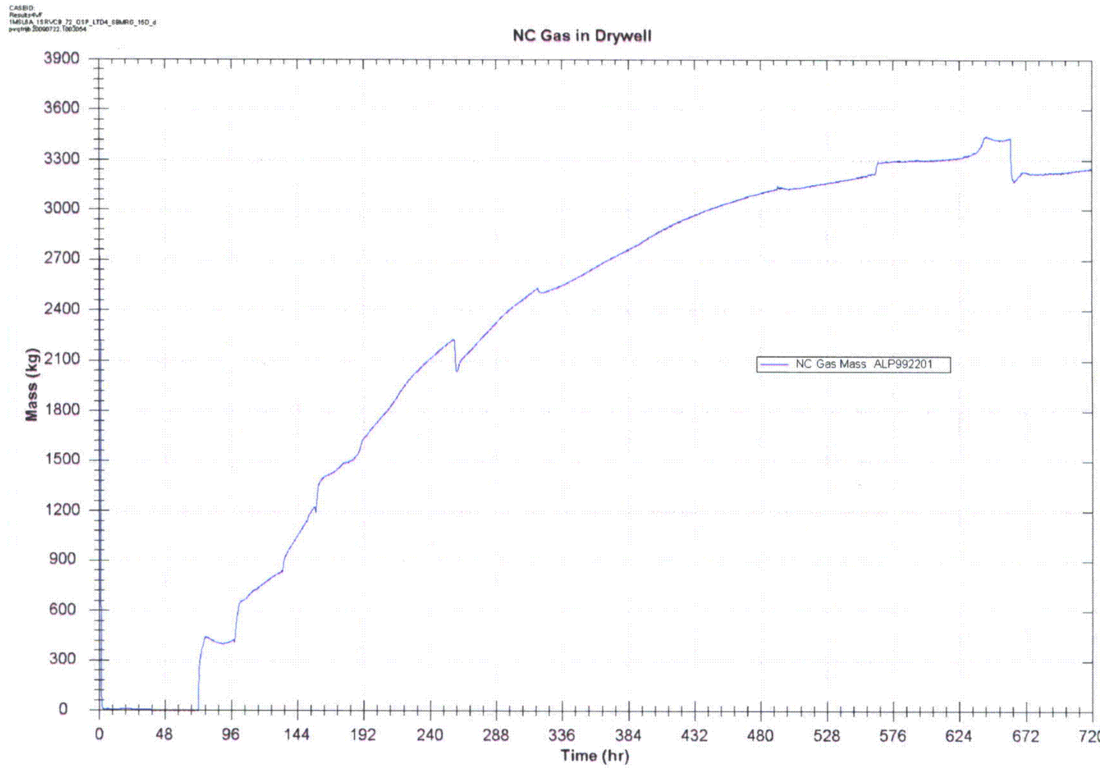


Figure 6.2-140 S05-D9 Main Steam Line Break, 1DPV Failure (Bounding Case), DW Total Noncondensable Gas Mass (30 Days).

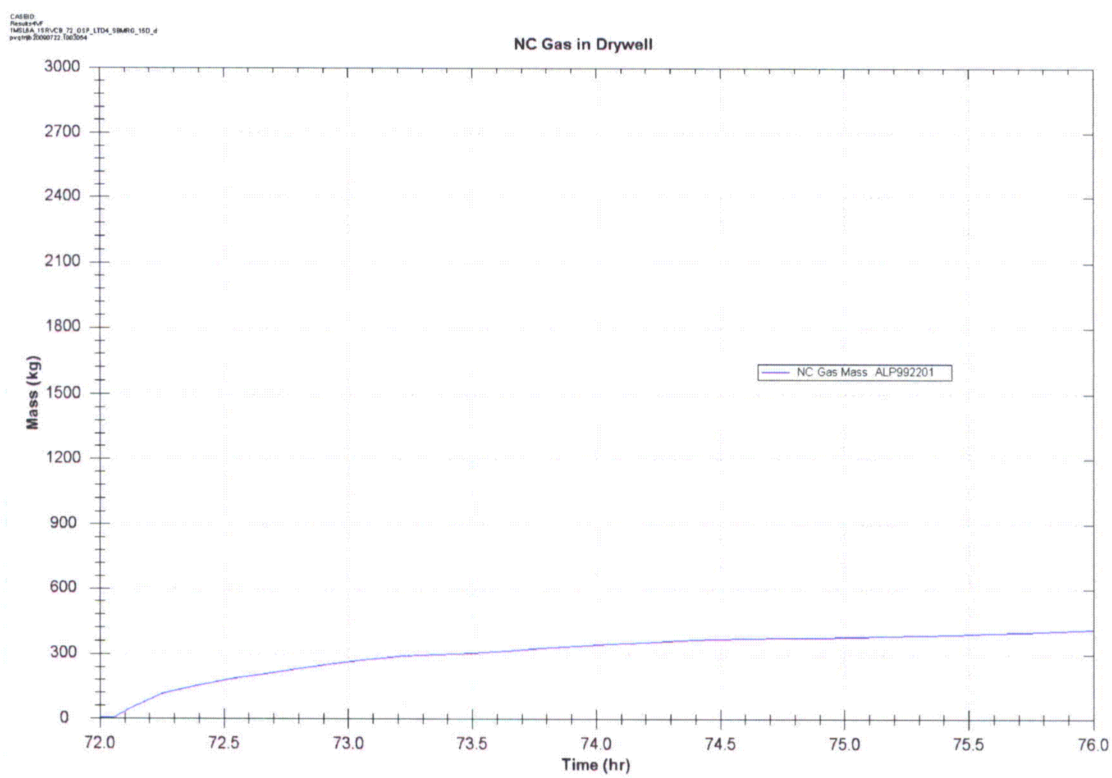


Figure 6.2-140 S05-D9a Main Steam Line Break, 1DPV Failure (Bounding Case), DW Total Noncondensable Gas Mass (72 hr-76 hr).

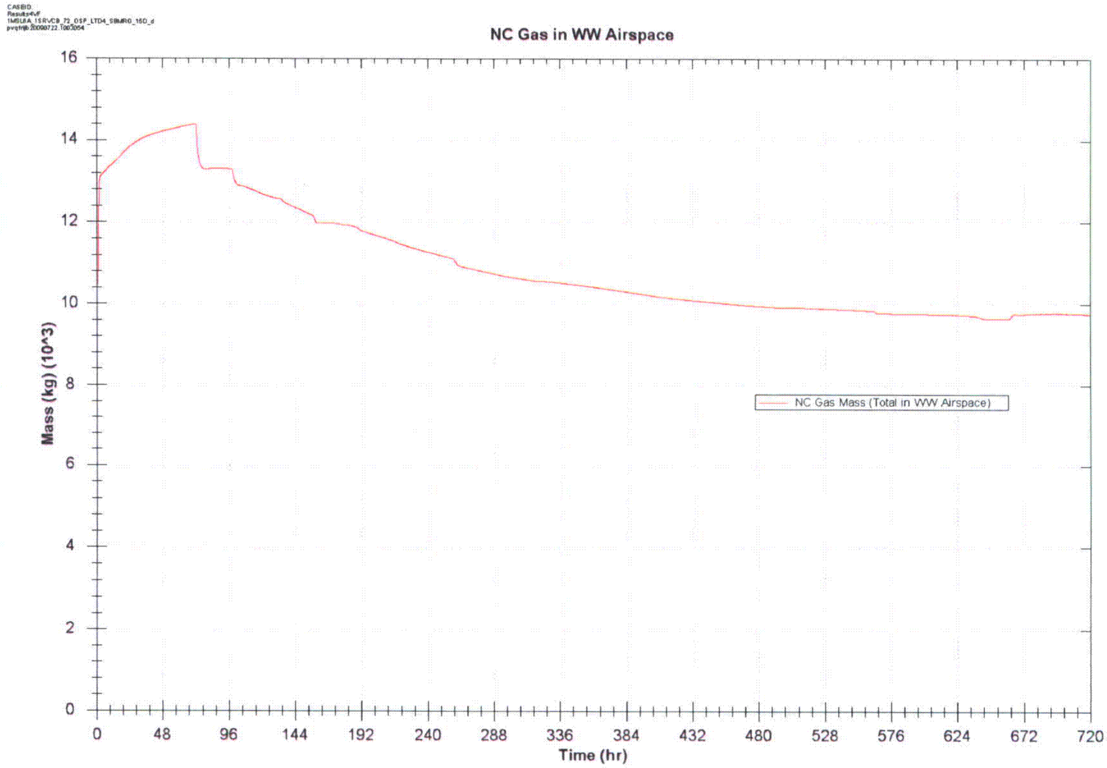


Figure 6.2-140 S05-D10 Main Steam Line Break, 1DPV Failure (Bounding Case), Total WW Noncondensable Gas Mass in Air Space (30 Days).

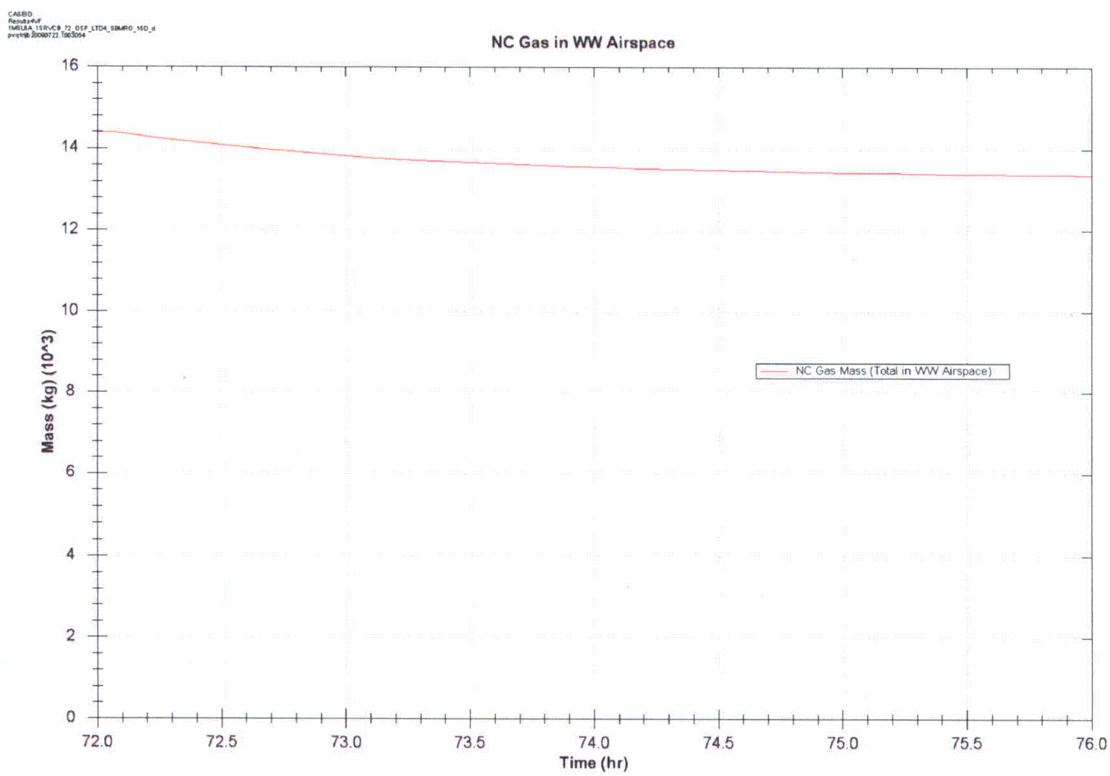


Figure 6.2-140 S05-D10a Main Steam Line Break, 1DPV Failure (Bounding Case), Total WW Noncondensable Gas Mass in Air Space (72 hr-76 hr)

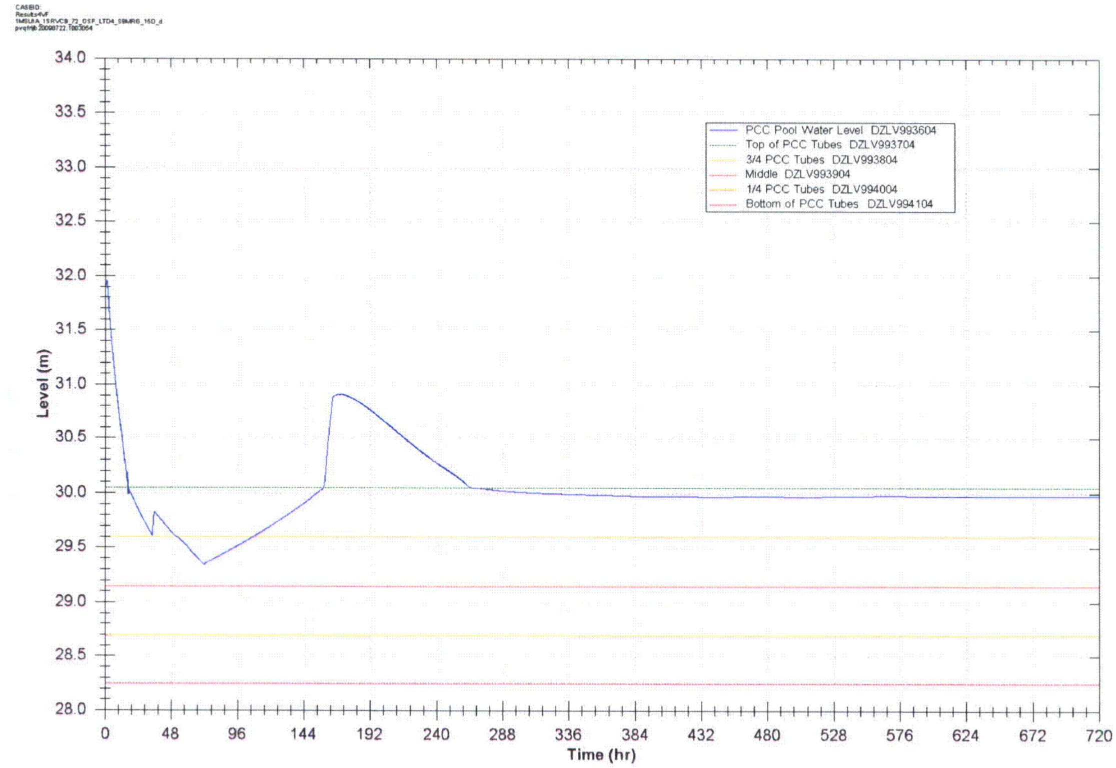


Figure 6.2-140 S05-D11 Main Steam Line Break, 1DPV Failure (Bounding Case), PCC Pool 2 Phase Level (30 Days).

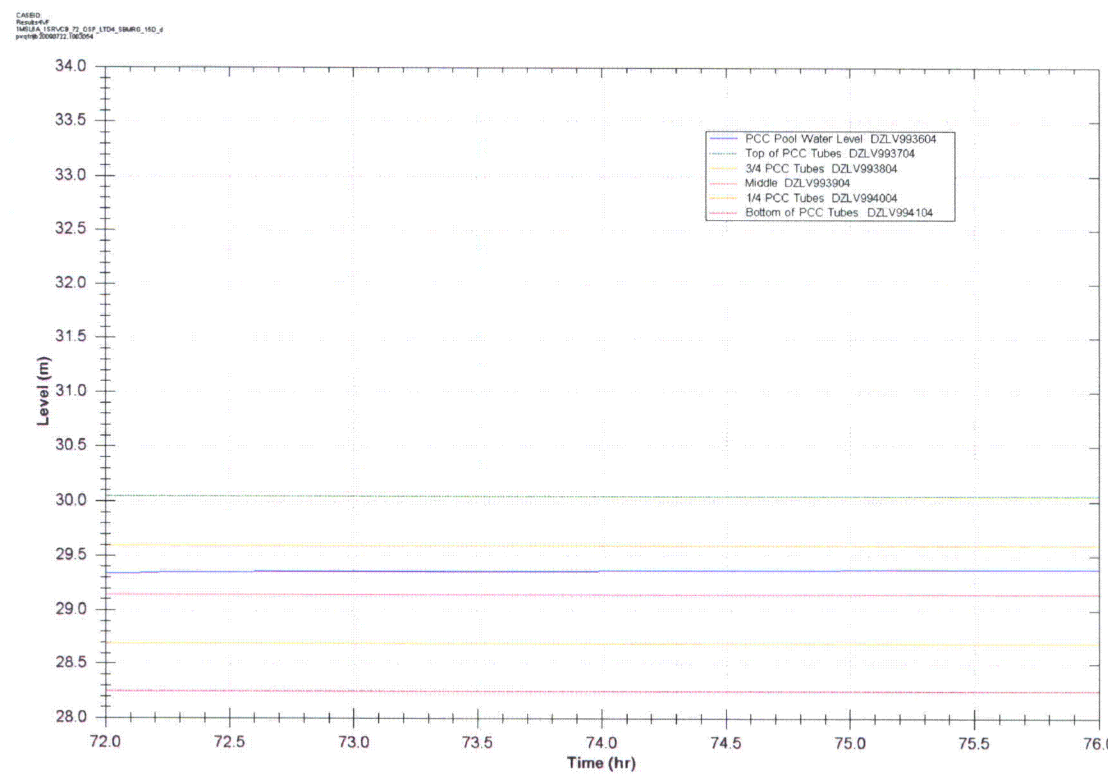


Figure 6.2-140 S05-D11a Main Steam Line Break, 1DPV Failure (Bounding Case), PCC Pool 2 Phase Level (72 hr-76 hr).

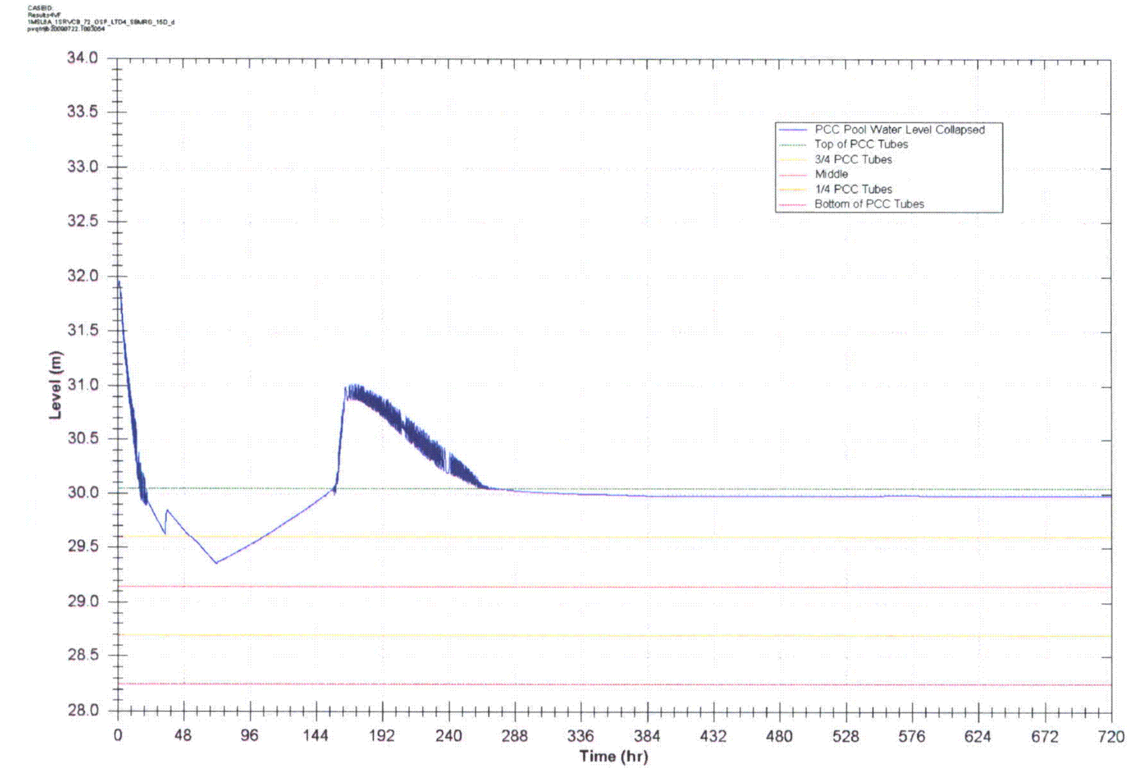


Figure 6.2-140 S05-D12 Main Steam Line Break, 1DPV Failure (Bounding Case), PCC Pool Level Collapsed (30 Days).

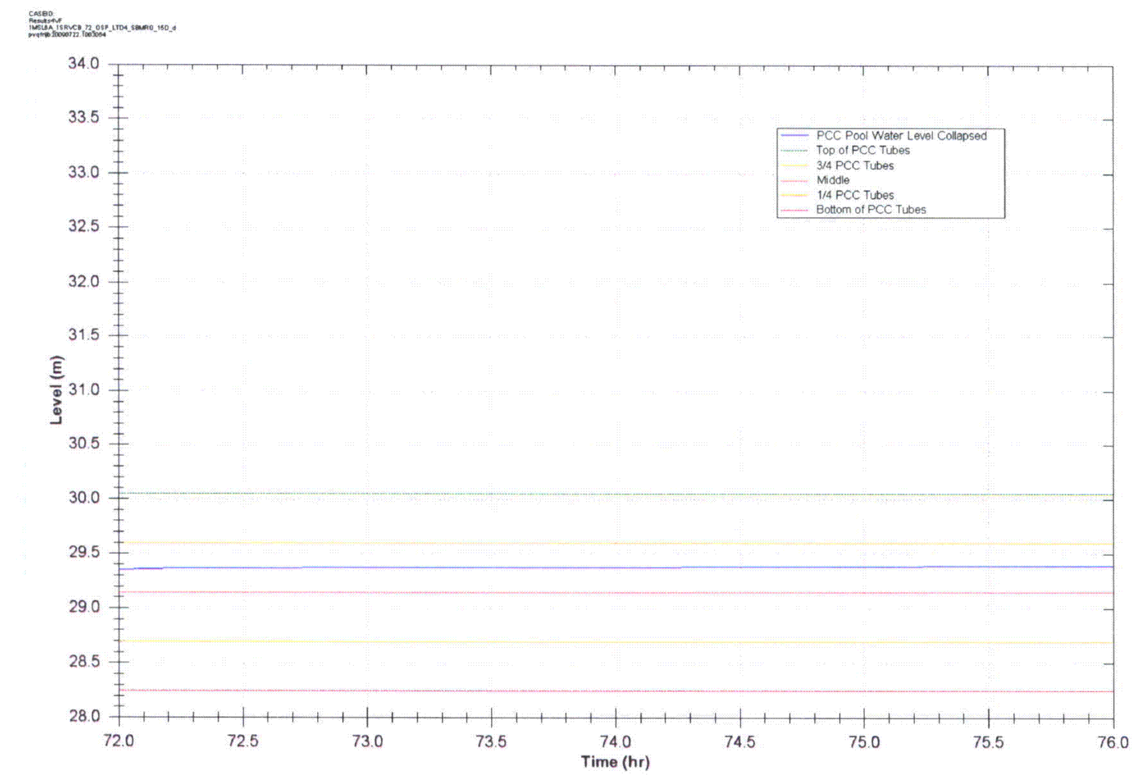


Figure 6.2-140 S05-D12a Main Steam Line Break, 1DPV Failure (Bounding Case), PCC Pool Level Collapsed (72 hr-76 hr).

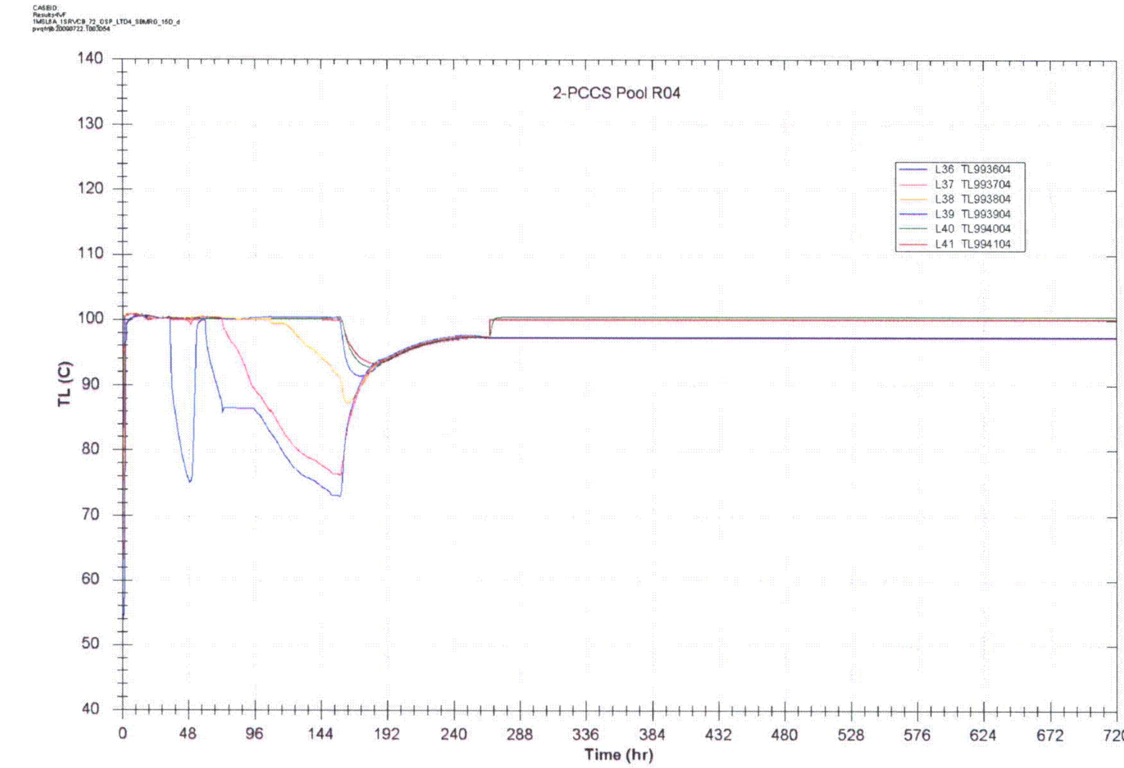


Figure 6.2-140 S05-D13 Main Steam Line Break, 1DPV Failure (Bounding Case), PCC Pool Water Temperature (2-PCCS Pool) (30 Days).

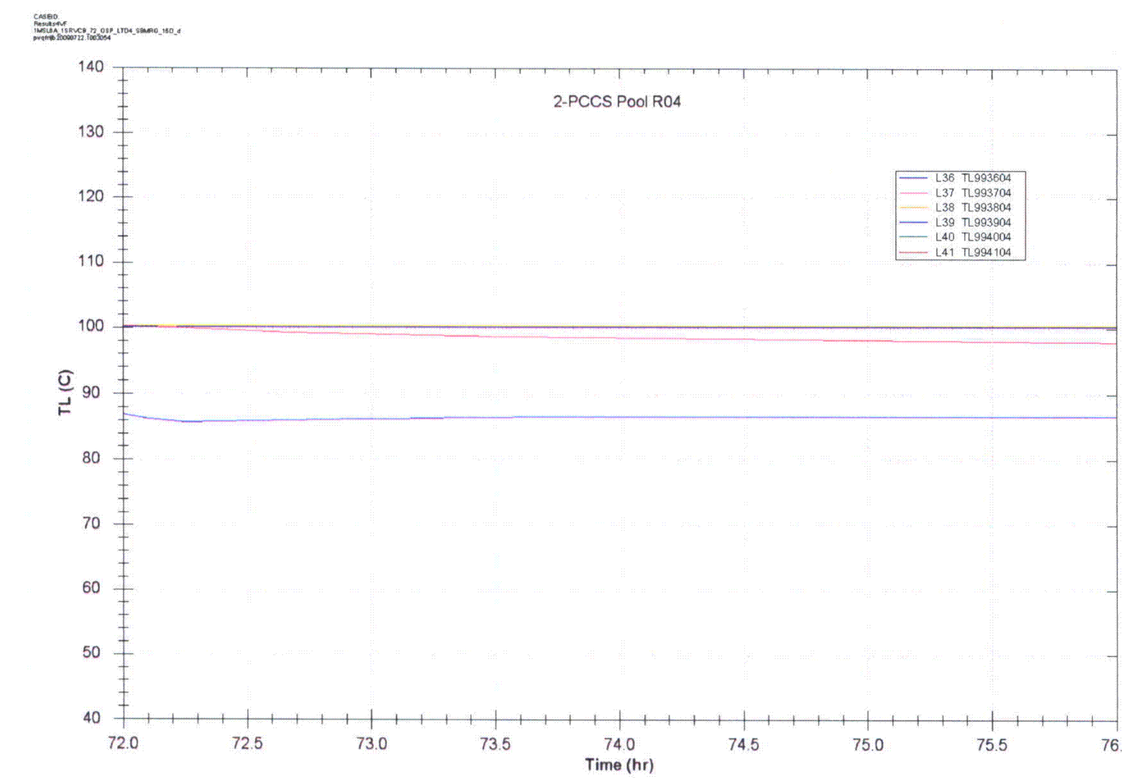


Figure 6.2-140 S05-D13a Main Steam Line Break, 1DPV Failure (Bounding Case), PCC Pool Water Temperature (2-PCCS Pool) (72 hr - 76 hr).

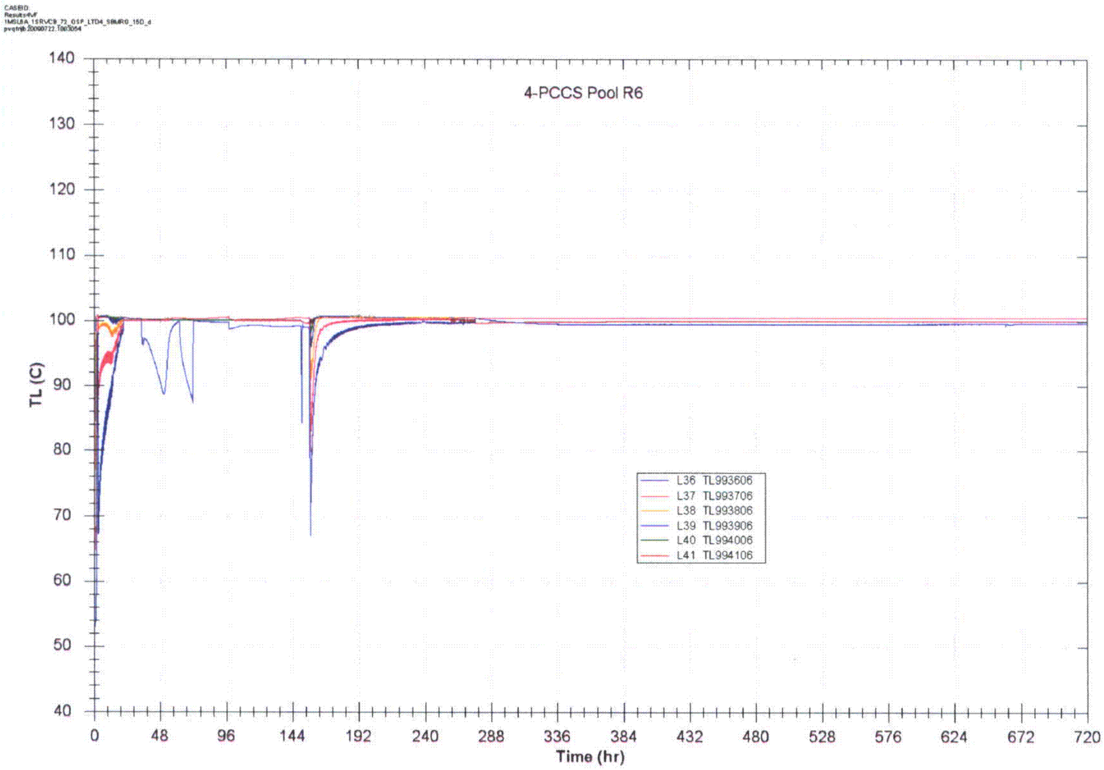


Figure 6.2-140 S05-D14 Main Steam Line Break, 1DPV Failure (Bounding Case), PCC Pool Water Temperature (4-PCCS Pool) (30 Days).

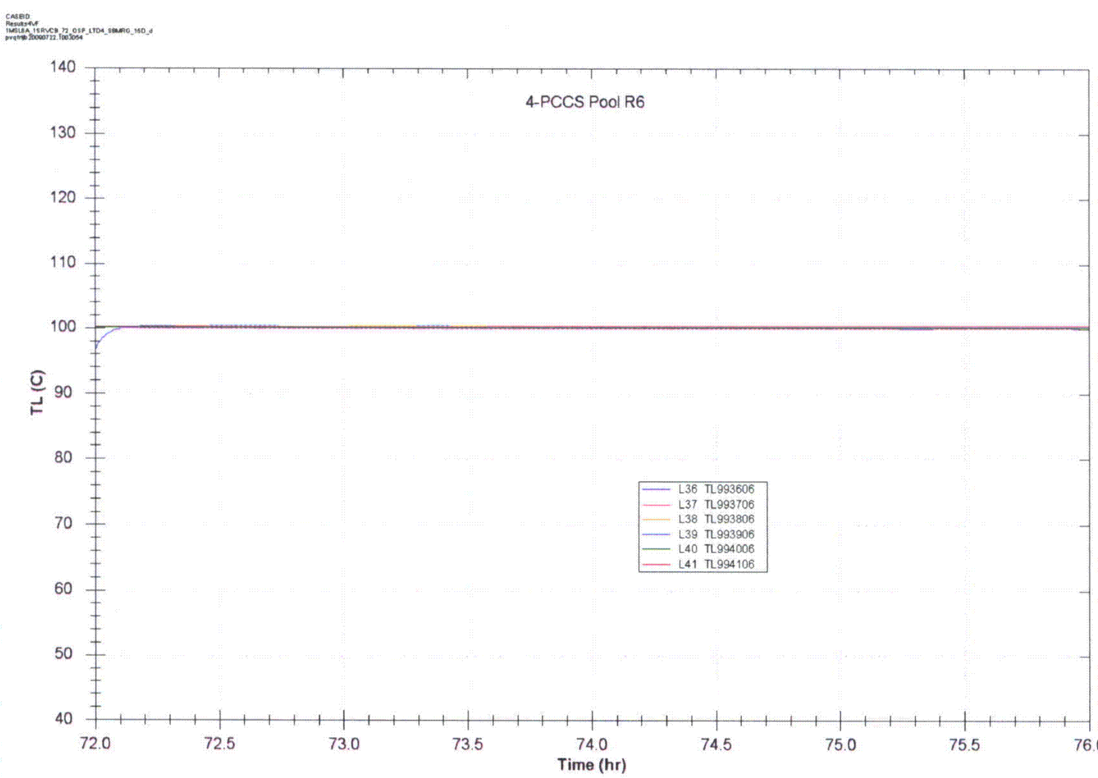


Figure 6.2-140 S05-D14a Main Steam Line Break, 1DPV Failure (Bounding Case), PCC Pool Water Temperature (4-PCCS Pool) (72 hr-76 hr).

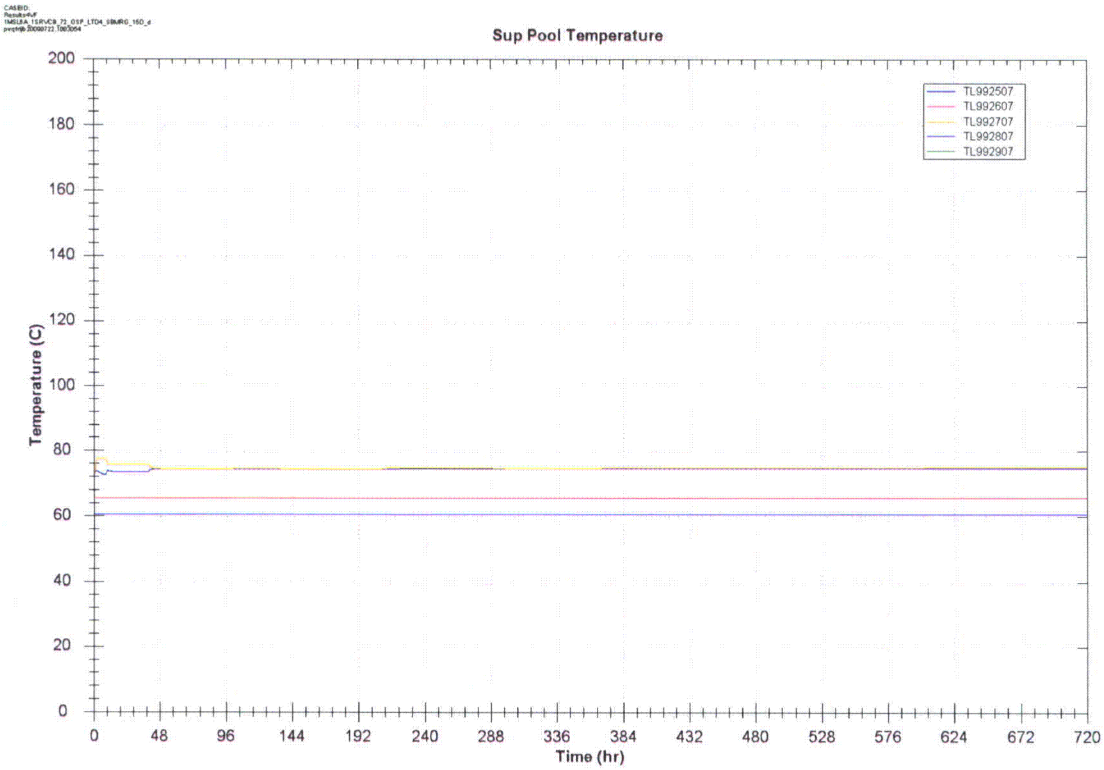


Figure 6.2-140 S05-D15 Main Steam Line Break, 1DPV Failure (Bounding Case), Suppression Pool Temperature (R7) (30 Days).

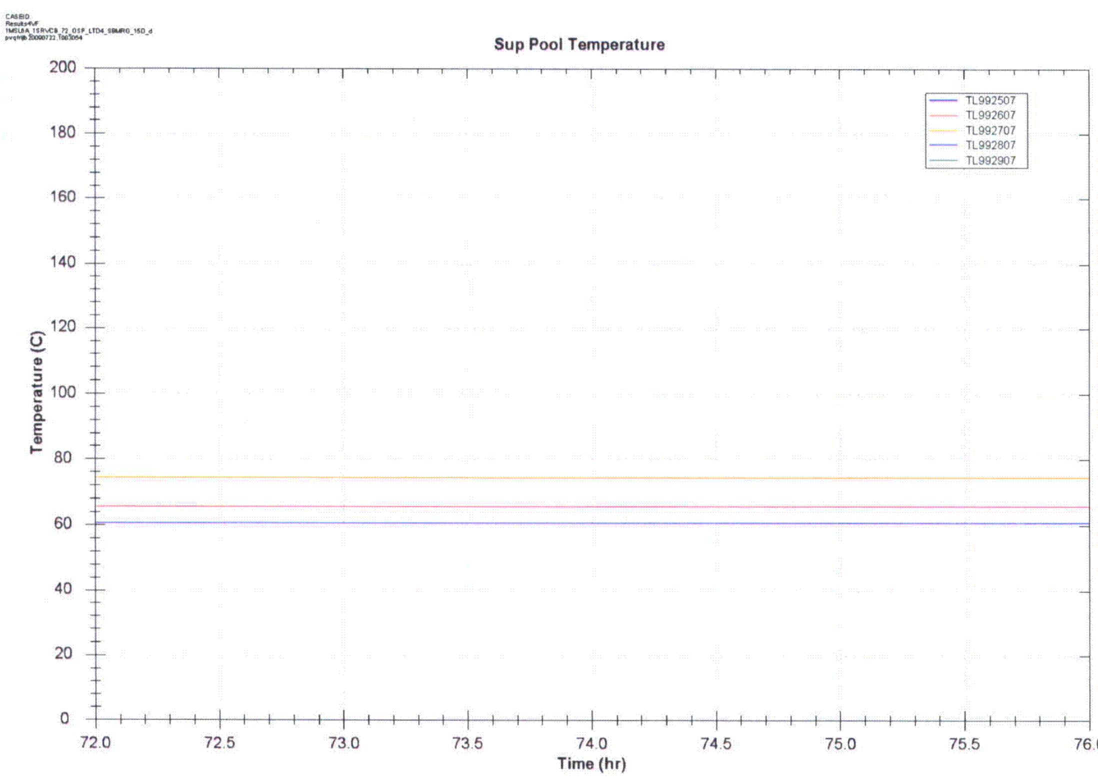


Figure 6.2-140 S05-D15a Main Steam Line Break, 1DPV Failure (Bounding Case), Suppression Pool Temperature (R7) (72 hr - 76 hr).

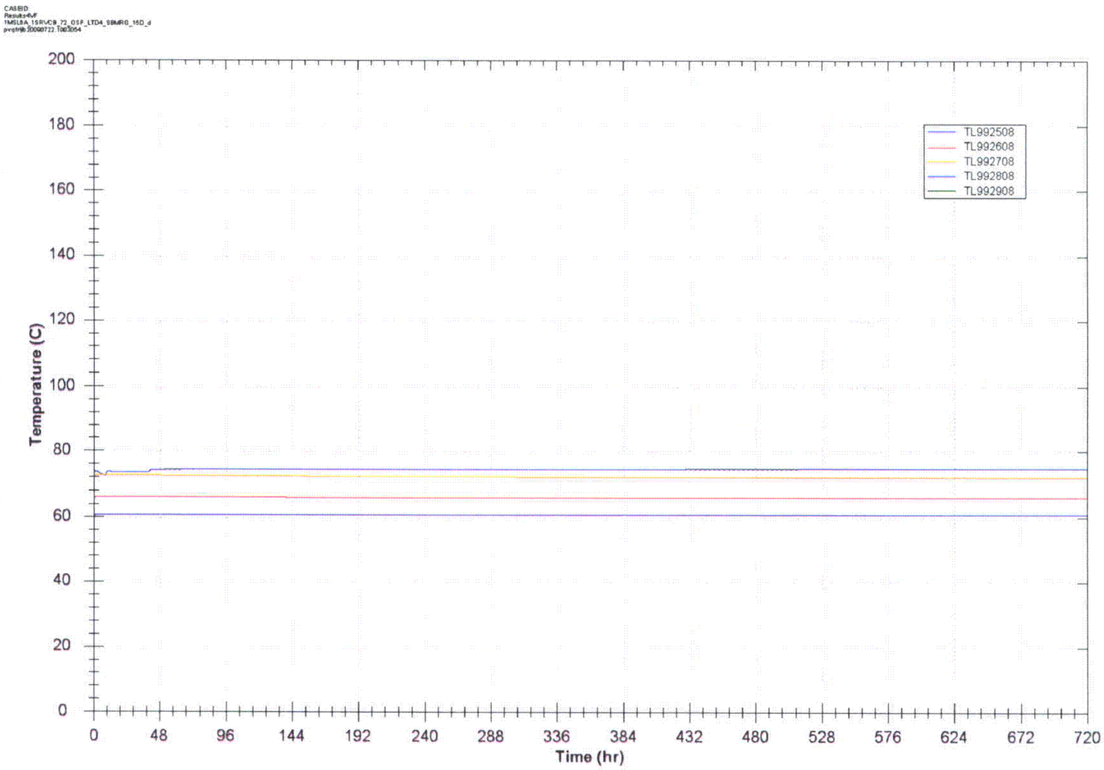


Figure 6.2-140 S05-D16 Main Steam Line Break, 1DPV Failure (Bounding Case), Suppression Pool Liquid Temperature (R8) (30 Days).

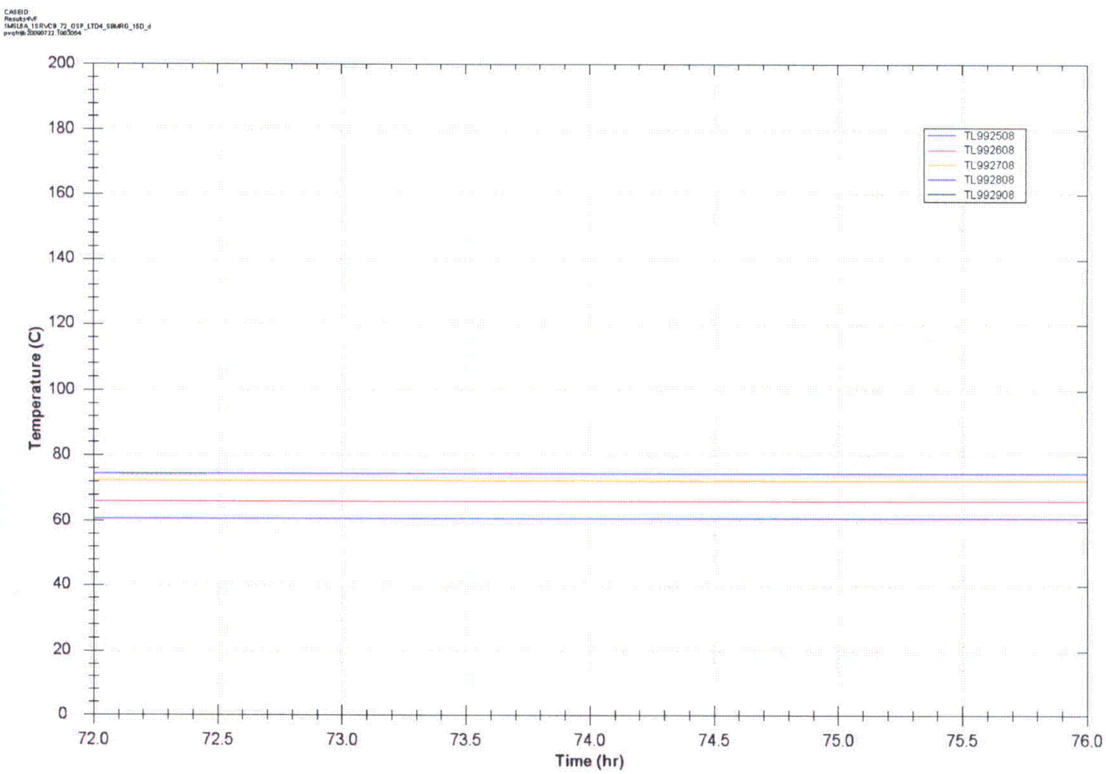


Figure 6.2-140 S05-D16a Main Steam Line Break, 1DPV Failure (Bounding Case), Suppression Pool Liquid Temperature (R8) (72 hr-76 hr).

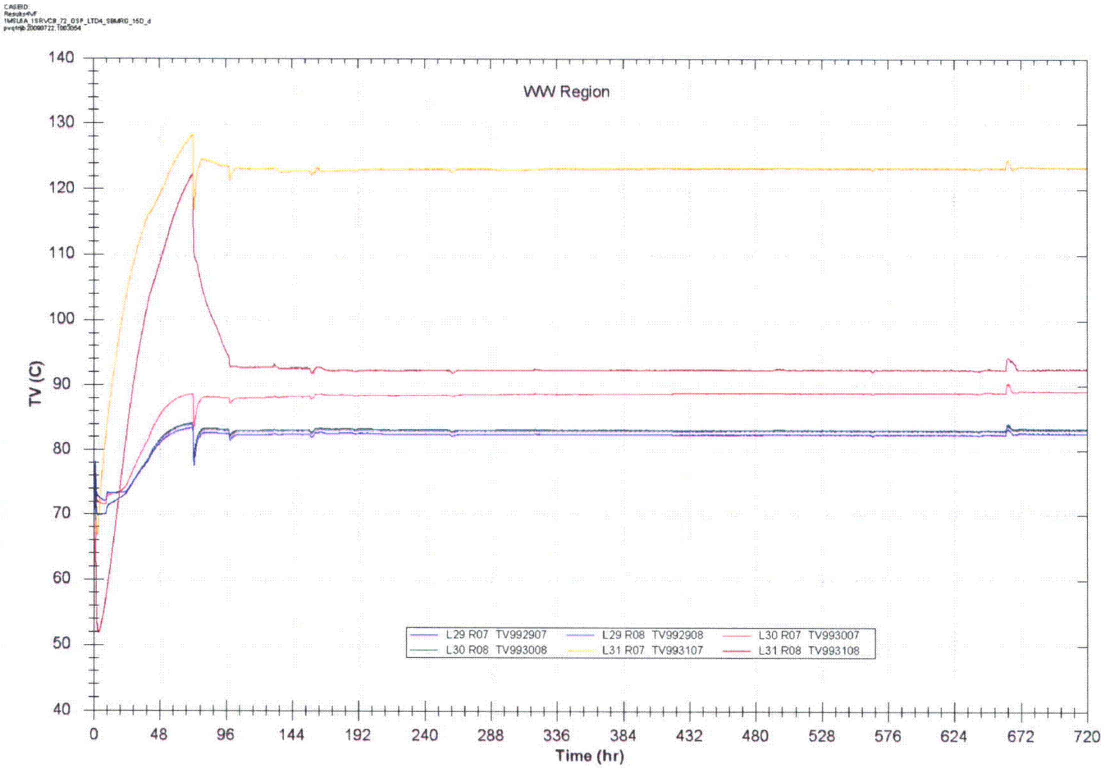


Figure 6.2-140 S05-D17 Main Steam Line Break, 1DPV Failure (Bounding Case), Wetwell Airspace Vapor Temperature (L29-L31) (30 Days).

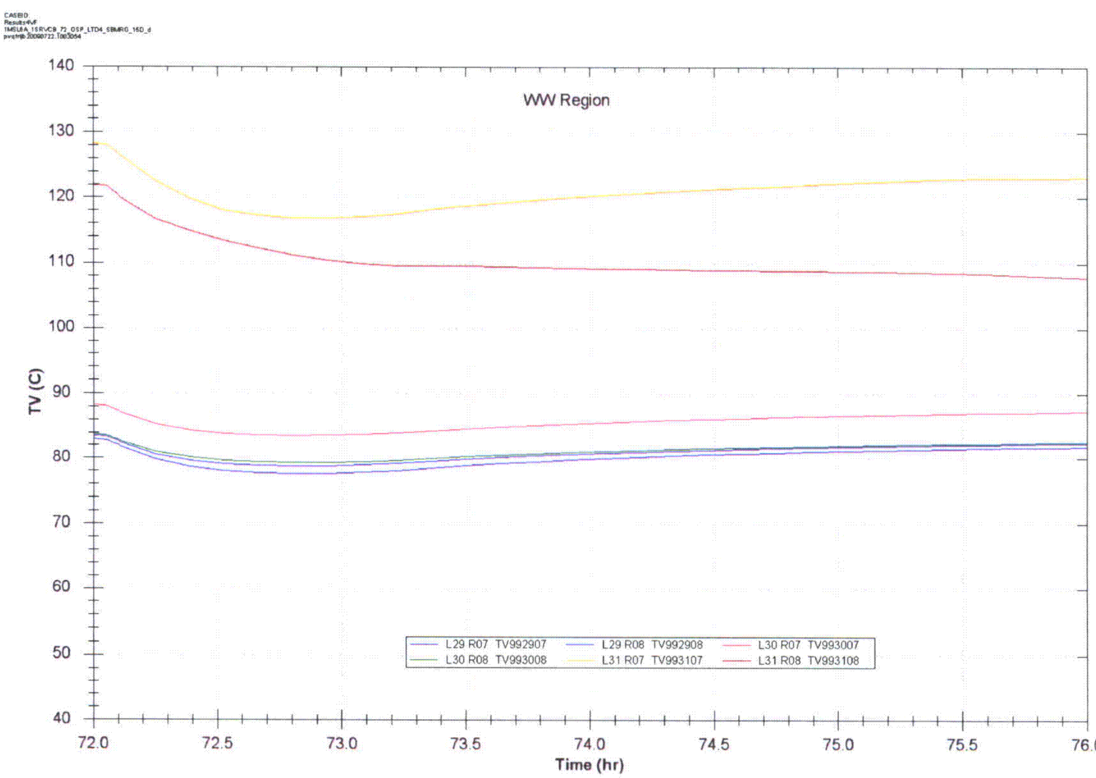


Figure 6.2-140 S05-D17a Main Steam Line Break, 1DPV Failure (Bounding Case), Wetwell Airspace Vapor Temperature (L29-L31) (72 hr-76 hr).

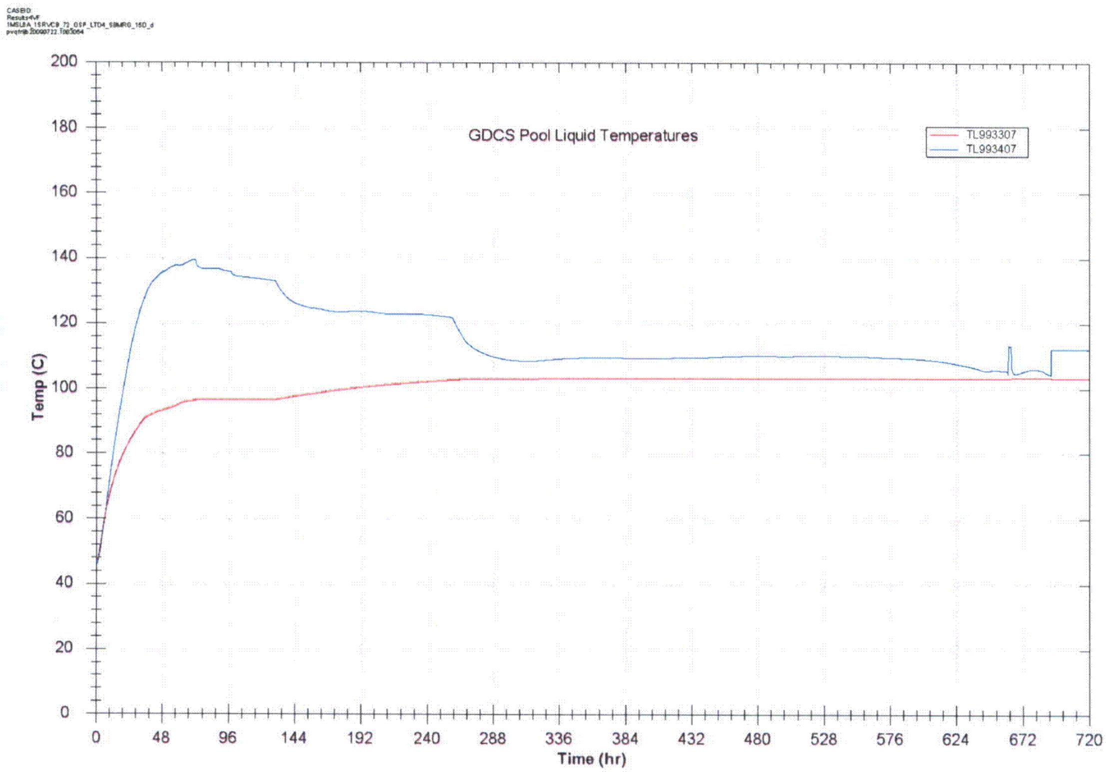


Figure 6.2-140 S05-D18 Main Steam Line Break, 1DPV Failure (Bounding Case), GDCS Liquid Temperature (R7) (30 Days).

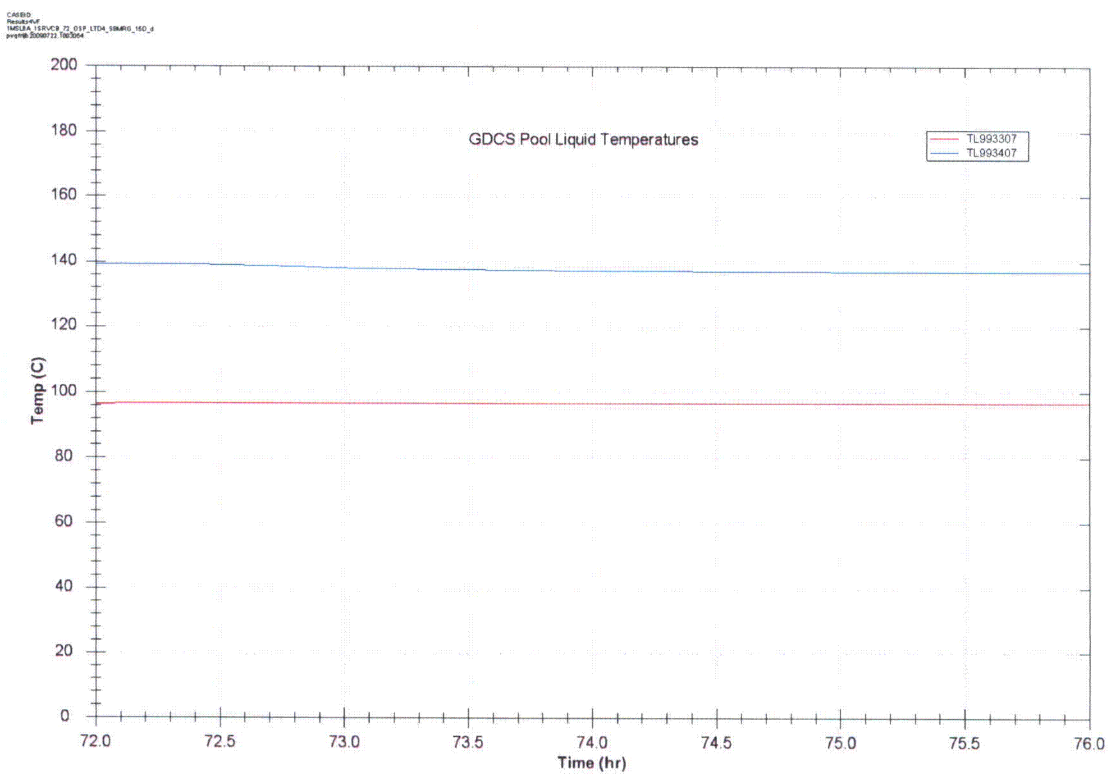


Figure 6.2-140 S05-D18a Main Steam Line Break, 1DPV Failure (Bounding Case), GDCS Liquid Temperature (R7) (72 hr - 76 hr).

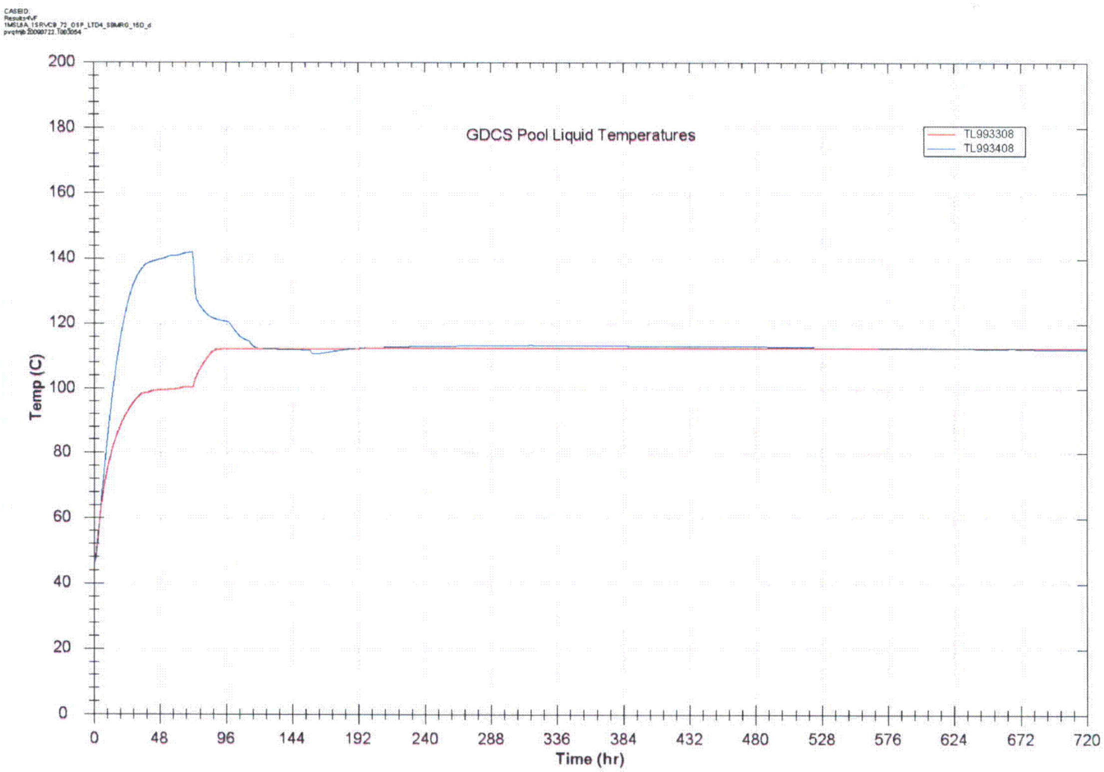


Figure 6.2-140 S05-D19 Main Steam Line Break, 1DPV Failure (Bounding Case), GDCS Liquid Temperature (R8) (30 Days).

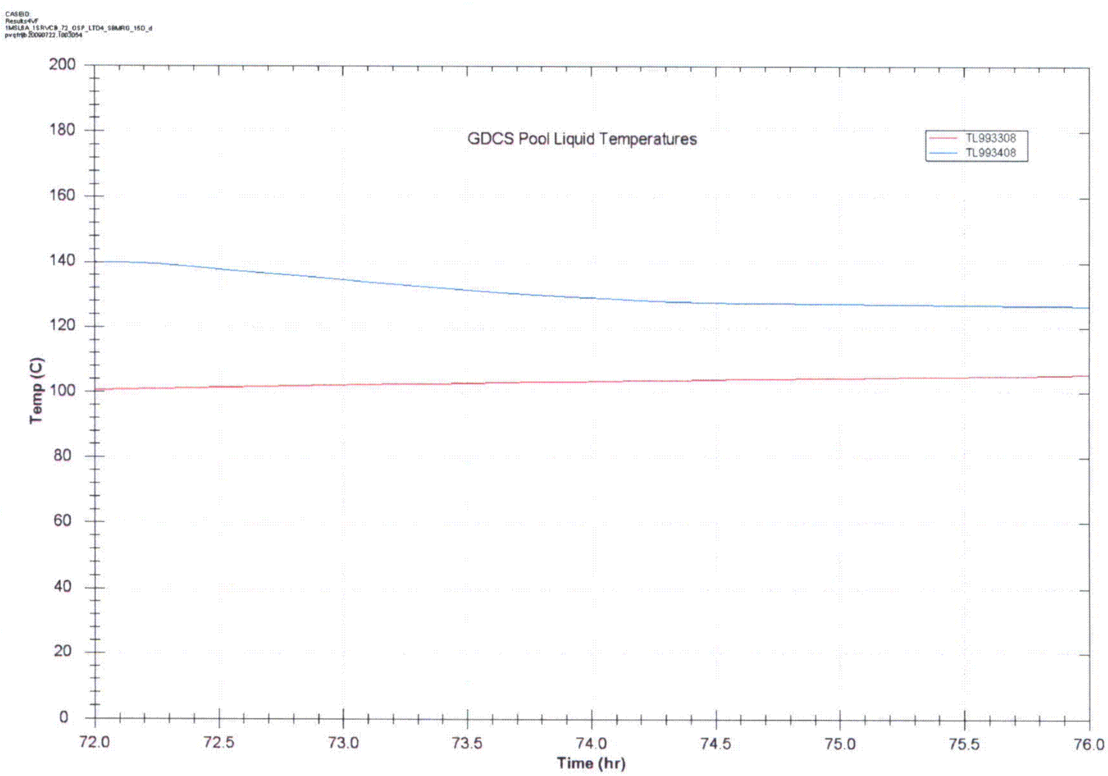


Figure 6.2-140 S05-D19a Main Steam Line Break, 1DPV Failure (Bounding Case), GDCS Liquid Temperature (R8) (72 hr-76 hr).

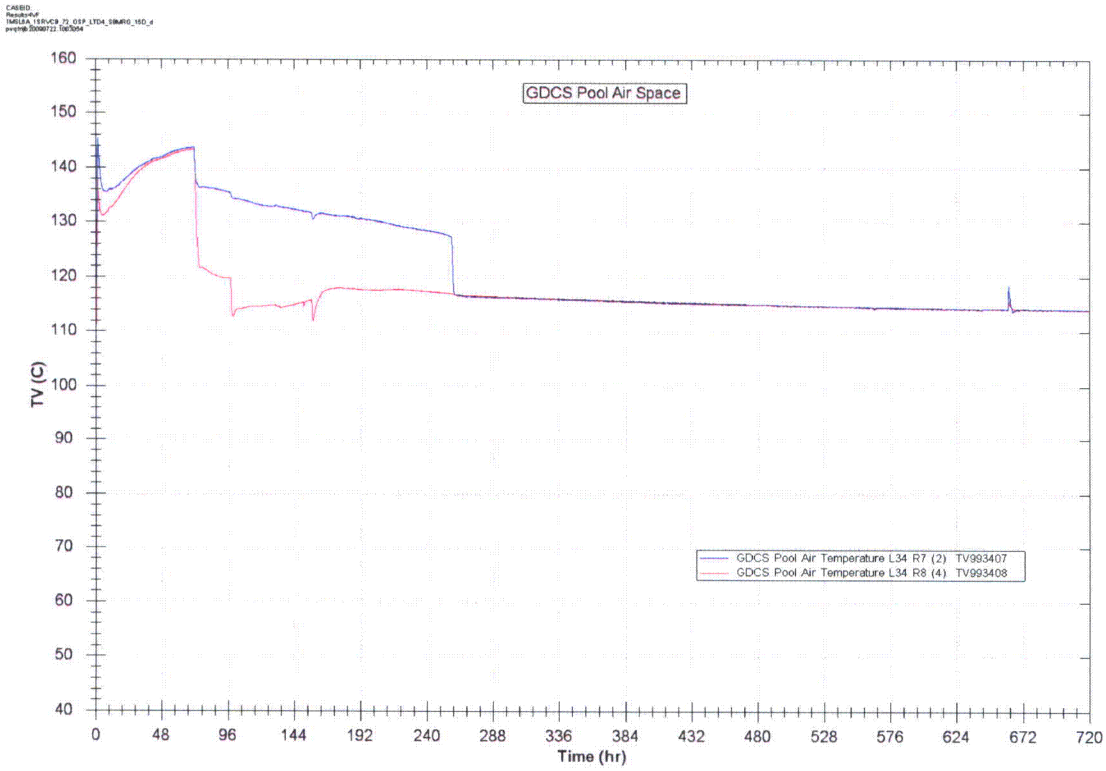


Figure 6.2-140 S05-D20 Main Steam Line Break, 1DPV Failure (Bounding Case), GDCS Air Space Vapor Temperature (30 Days).

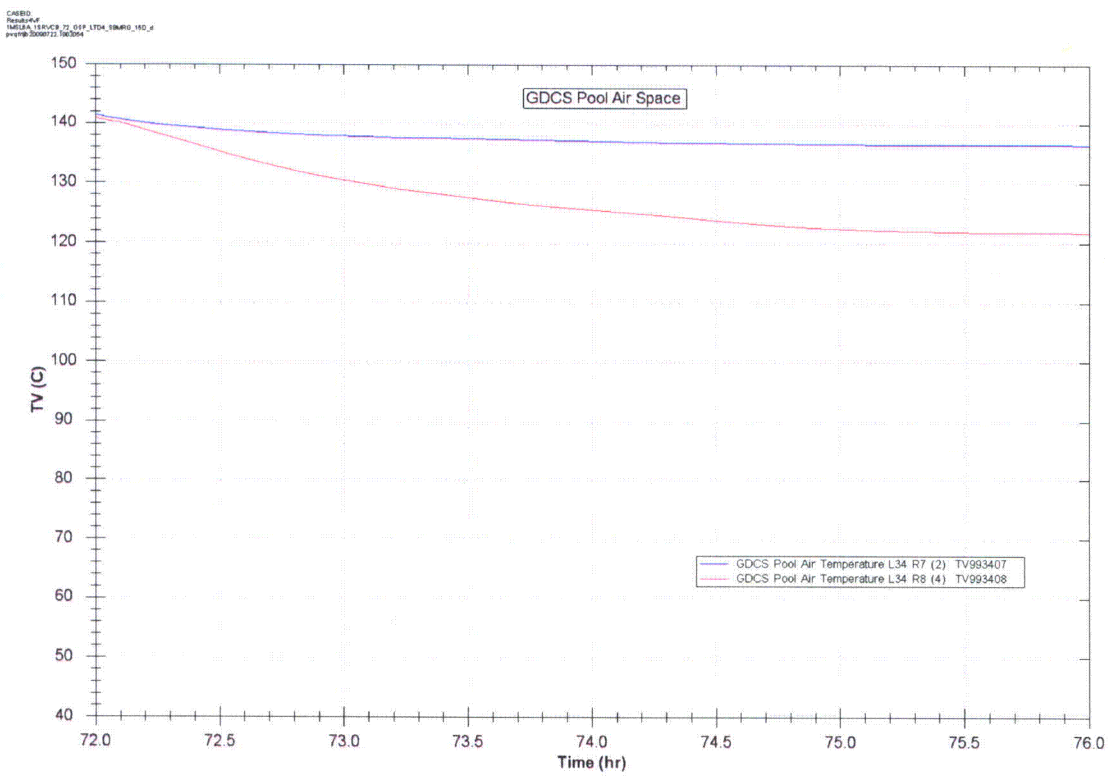


Figure 6.2-140 S05-D20a Main Steam Line Break, 1DPV Failure (Bounding Case), GDCS Air Space Vapor Temperature (72 hr - 76 hr).

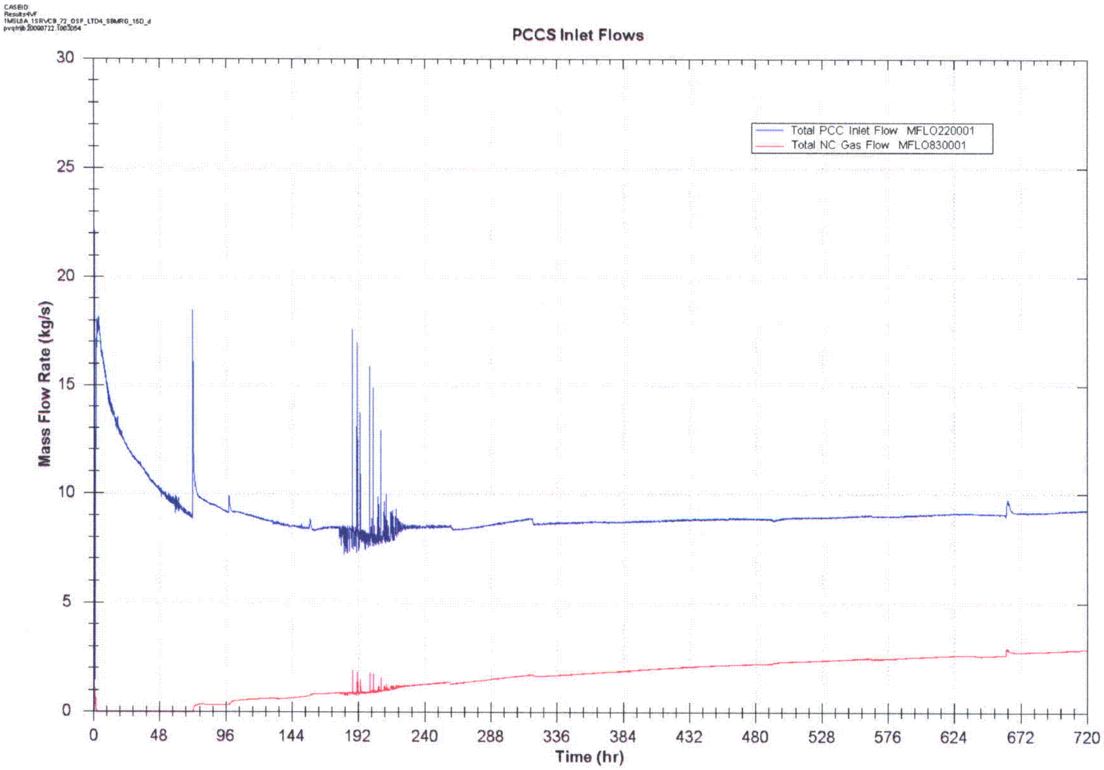


Figure 6.2-140 S05-D21 Main Steam Line Break, 1DPV Failure (Bounding Case), Total PCCS Inlet Flow Rates (30 Days).

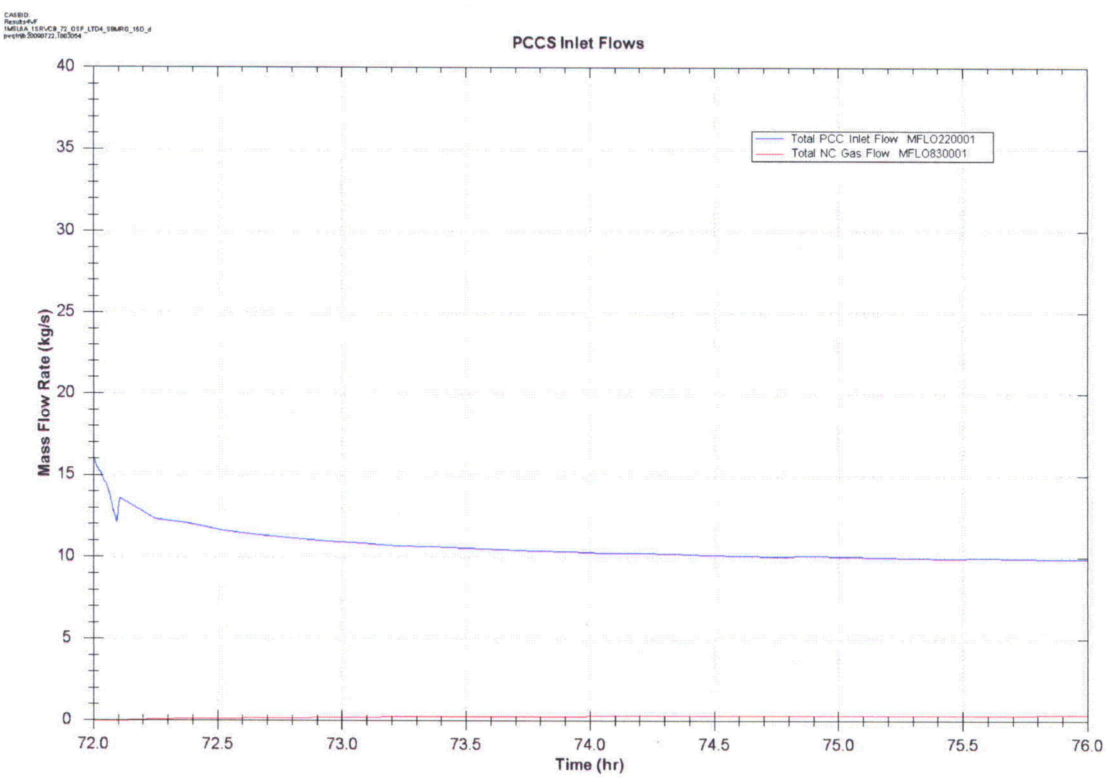


Figure 6.2-140 S05-D21a Main Steam Line Break, 1DPV Failure (Bounding Case), Total PCCS Inlet Flow Rates (72-76 hr).

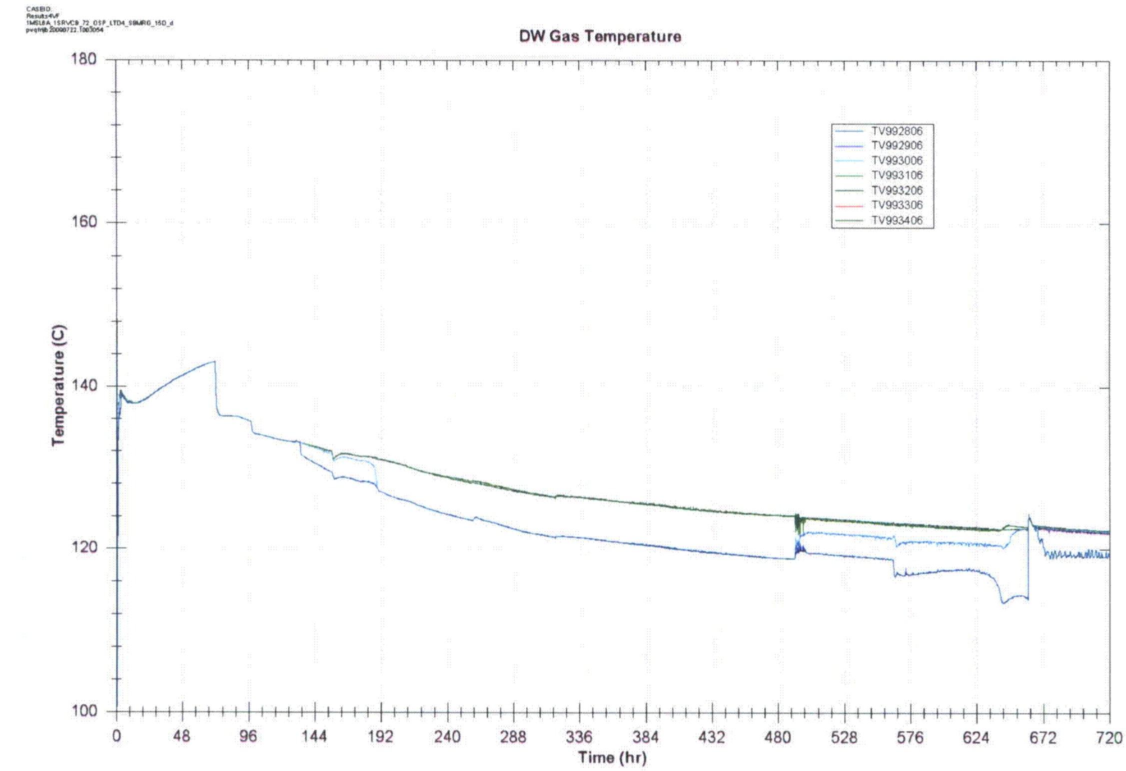


Figure 6.2-140 S05-D22 Main Steam Line Break, 1DPV Failure (Bounding Case), Upper Drywell Temperatures (R6) (30 Days).

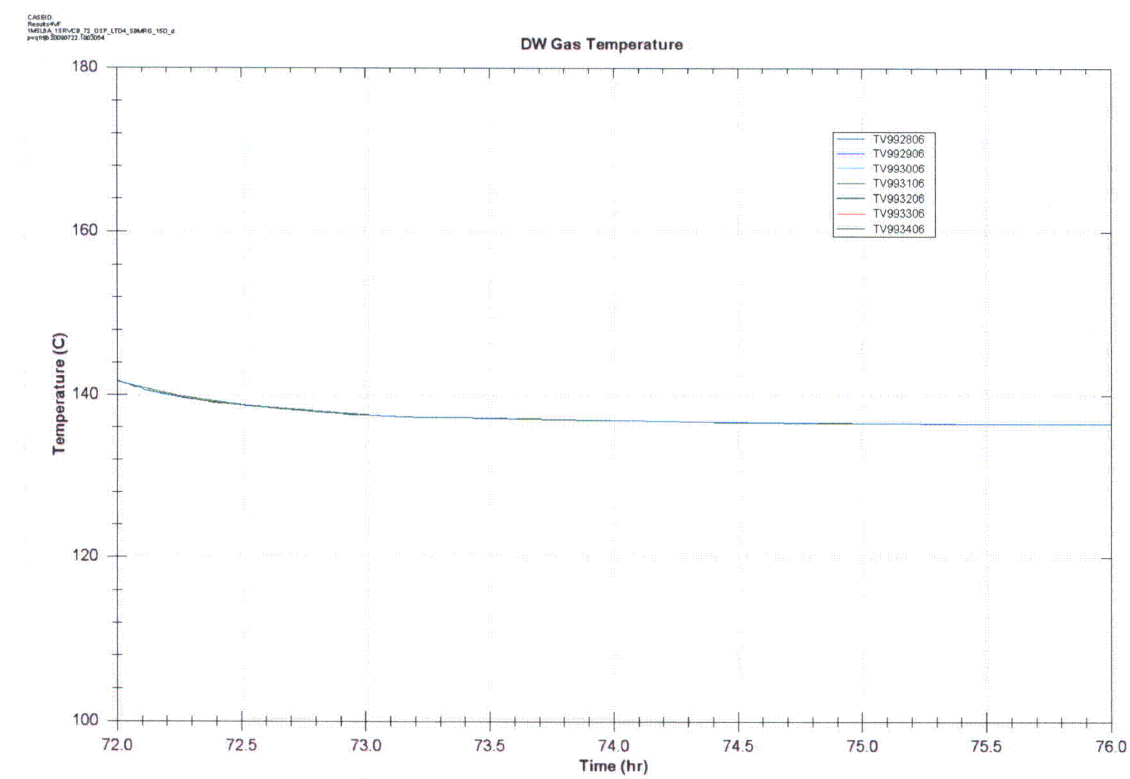


Figure 6.2-140 S05-D22a Main Steam Line Break, 1DPV Failure (Bounding Case), Upper Drywell Temperatures (R6) (72 hr -76 hr).

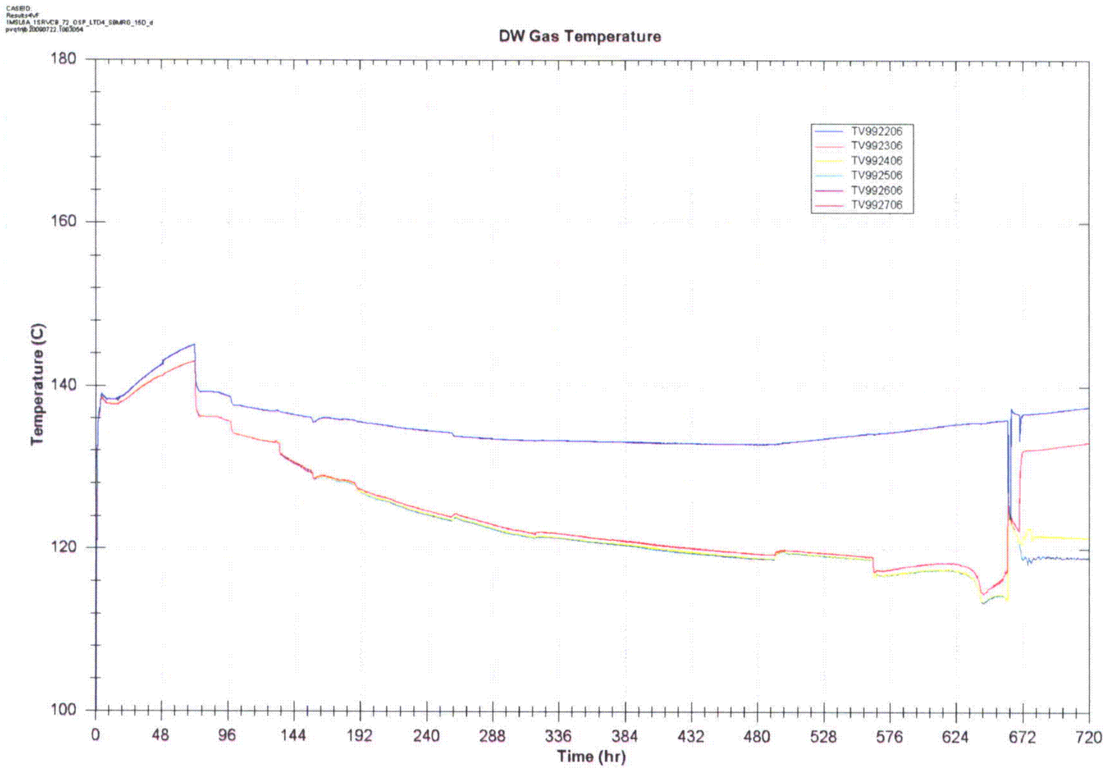


Figure 6.2-140 S05-D23 Main Steam Line Break, 1DPV Failure (Bounding Case), Lower Drywell Temperatures (R6) (30 Days).

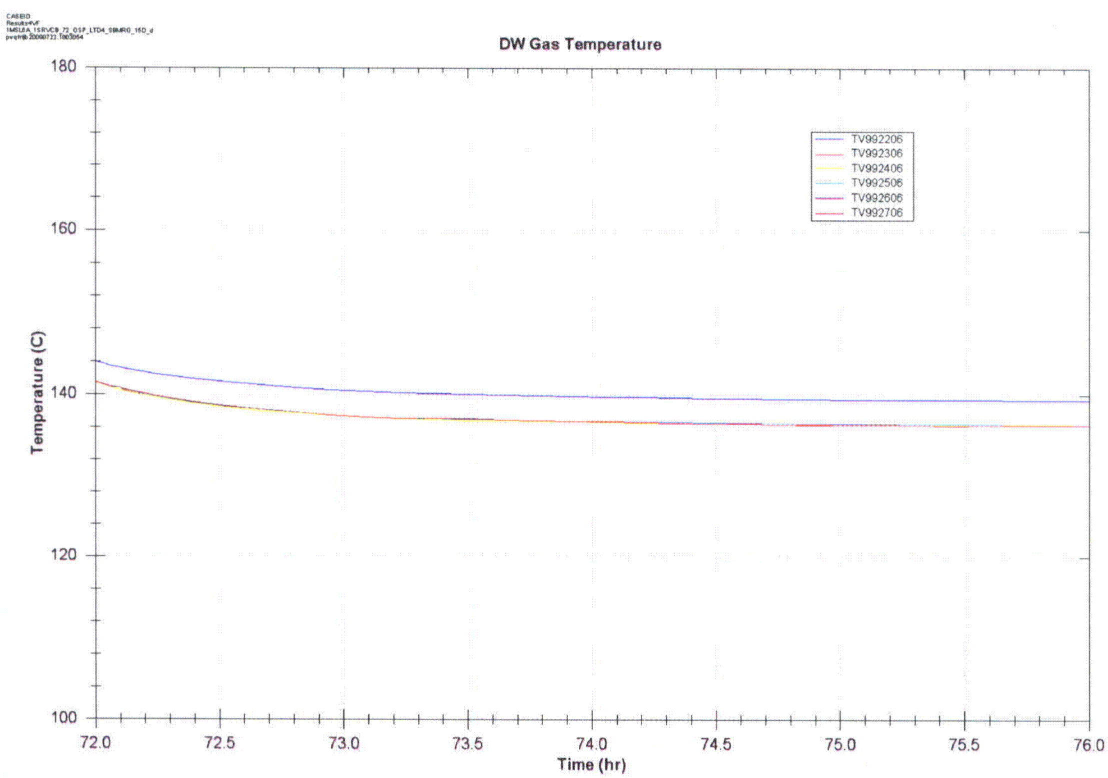


Figure 6.2-140 S05-D23a Main Steam Line Break, 1DPV Failure (Bounding Case), Lower Drywell Temperatures (R6) (72 hr-76 hr).

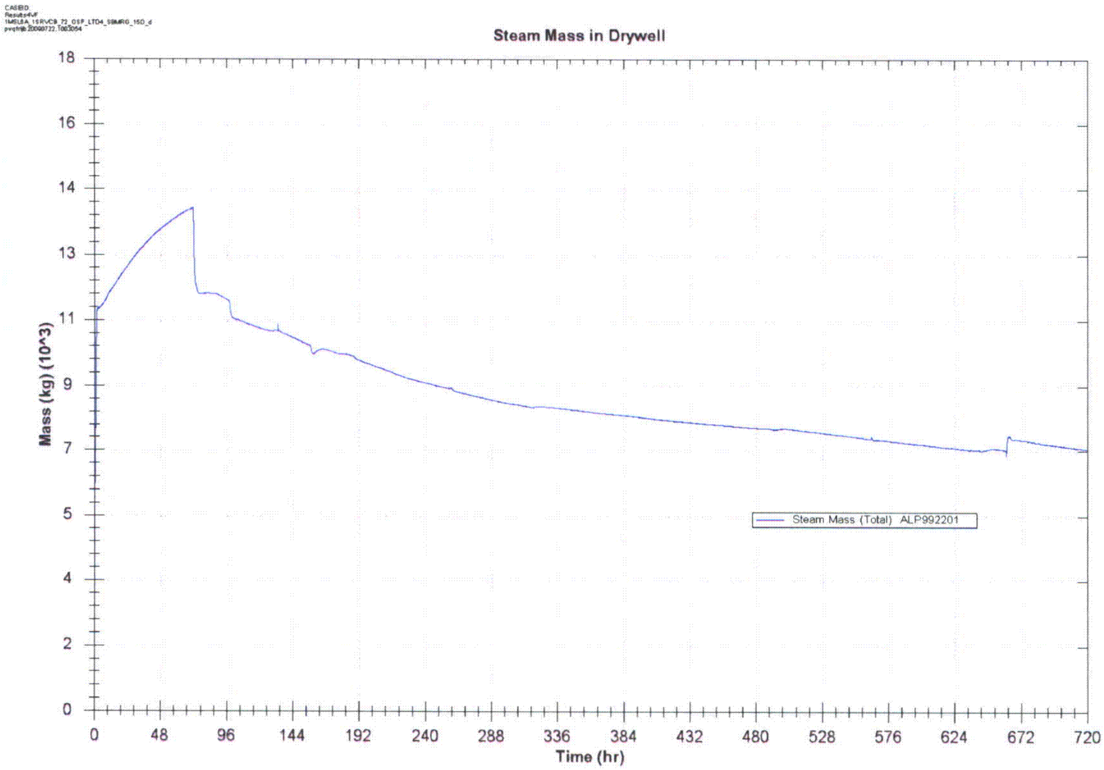


Figure 6.2-140 S05-D24 Main Steam Line Break, 1DPV Failure (Bounding Case), DW Steam Mass (30 Days).

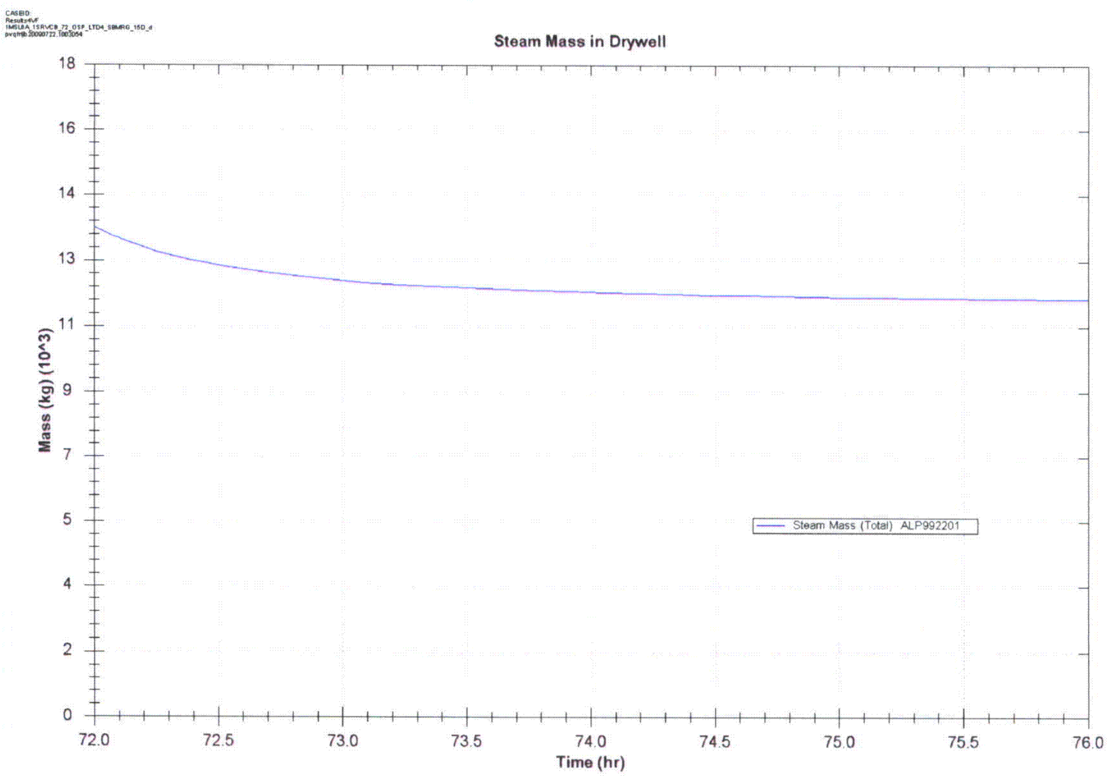


Figure 6.2-140 S05-D24a Main Steam Line Break, 1DPV Failure (Bounding Case), DW Steam Mass (72 hr - 76 hr).

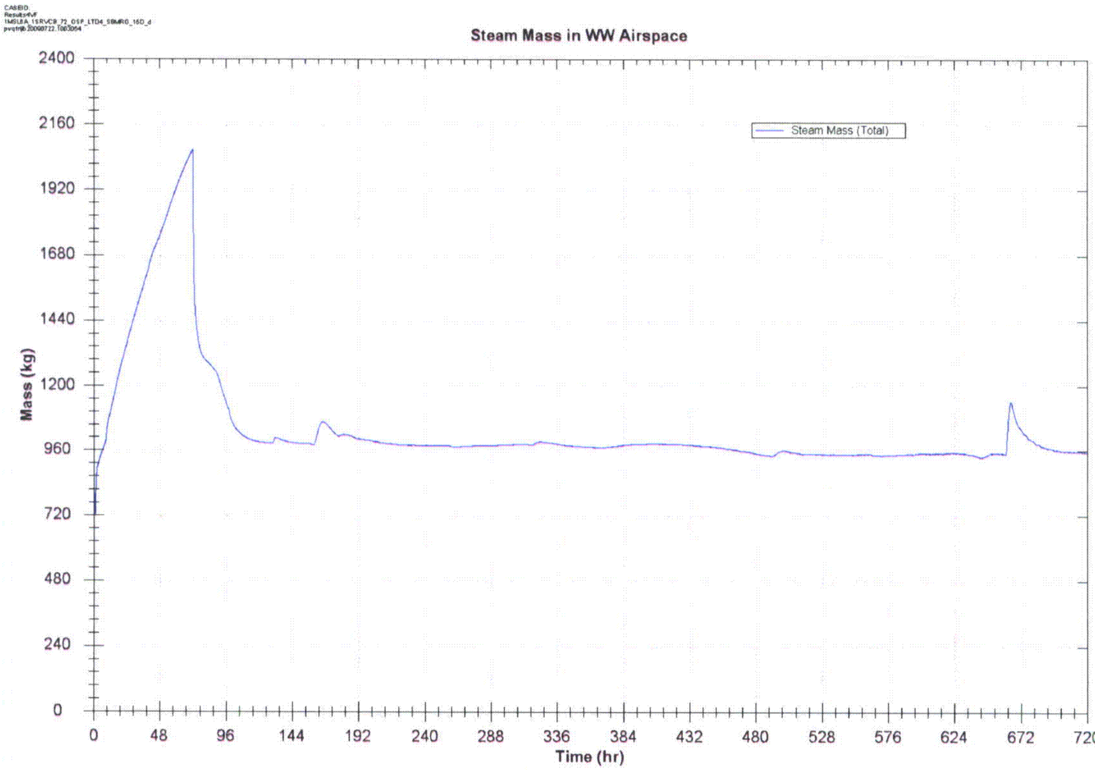


Figure 6.2-140 S05-D25 Main Steam Line Break, 1DPV Failure (Bounding Case), WW Steam Mass (30 Days).

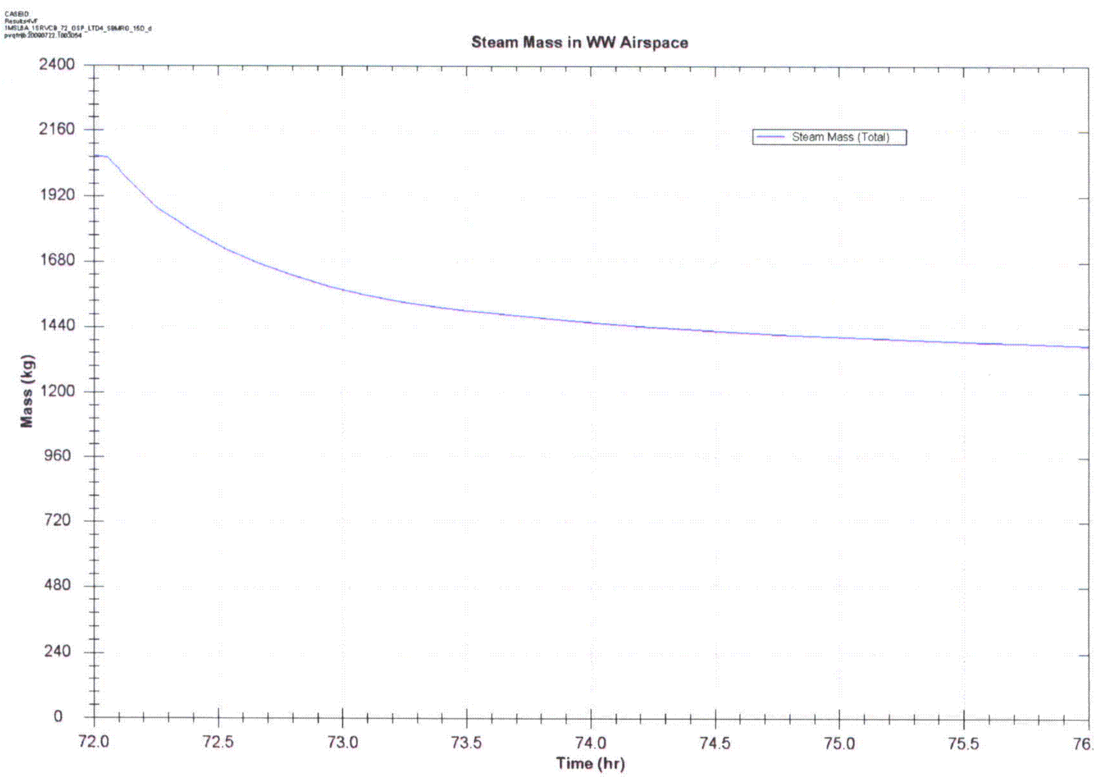


Figure 6.2-140 S05-D25a Main Steam Line Break, 1DPV Failure (Bounding Case), WW Steam Mass (72 hr - 76 hr).

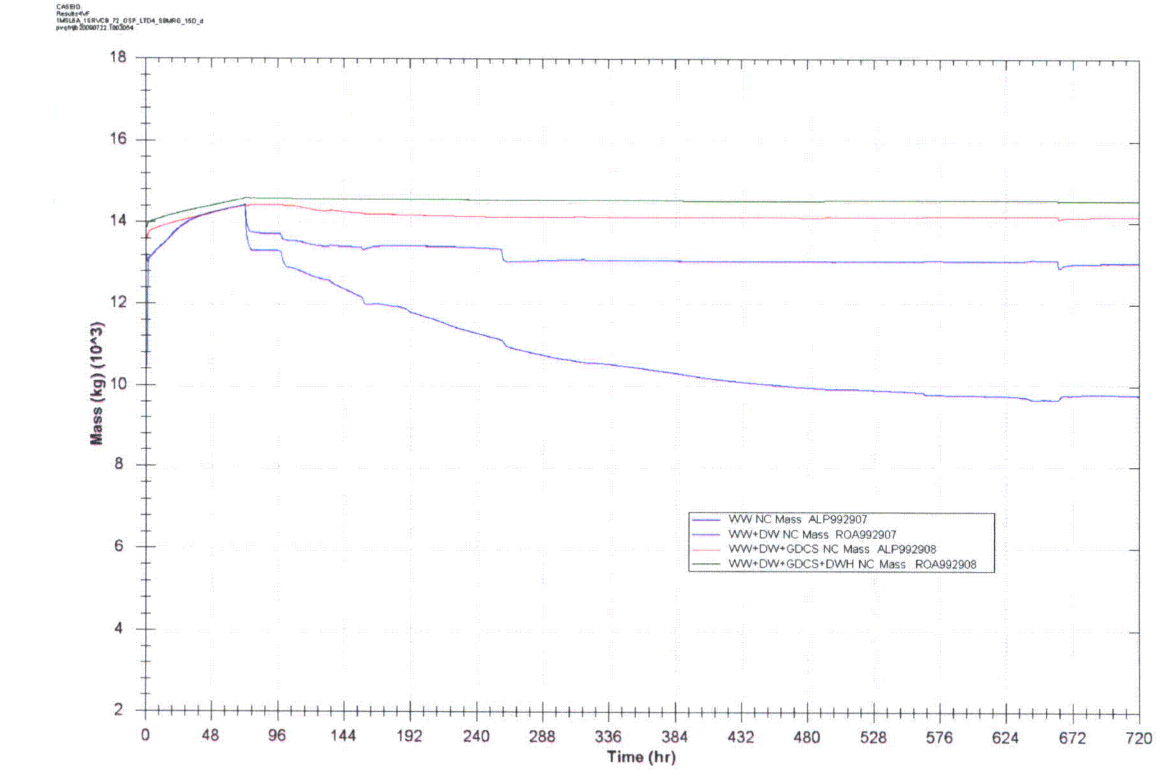


Figure 6.2-140 S05-D26 Main Steam Line Break, 1DPV Failure (Bounding Case), Noncondensable Gas Mass (30 Days).

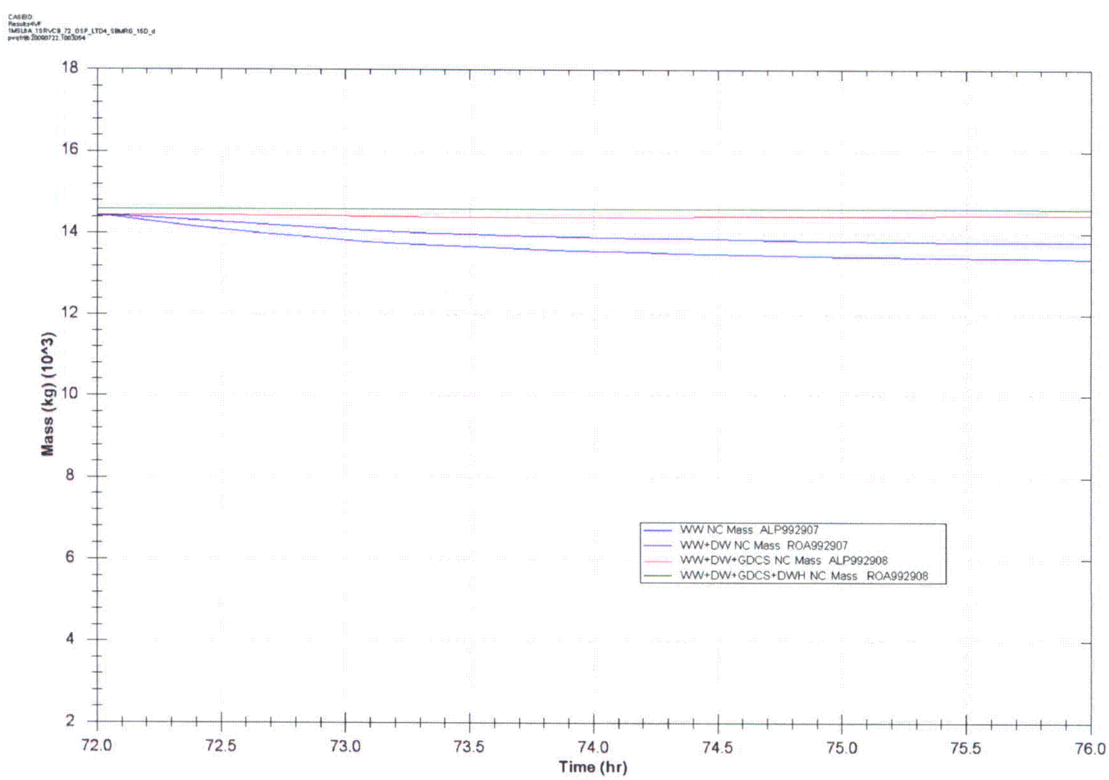


Figure 6.2-140 S05-D26a Main Steam Line Break, 1DPV Failure (Bounding Case), Noncondensable Gas Mass (72 hr - 76 hr)

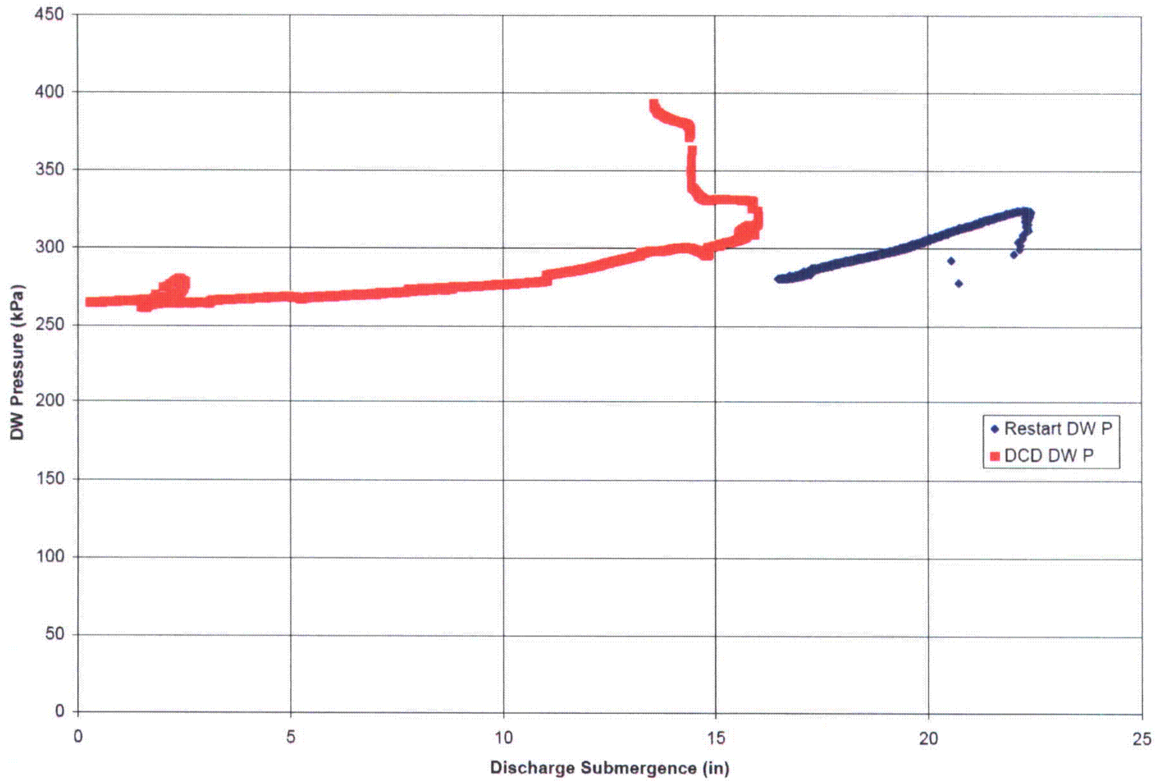


Figure 6.2-140S05-1 DW Pressure as a Function of PCC Vent Fan Submergence

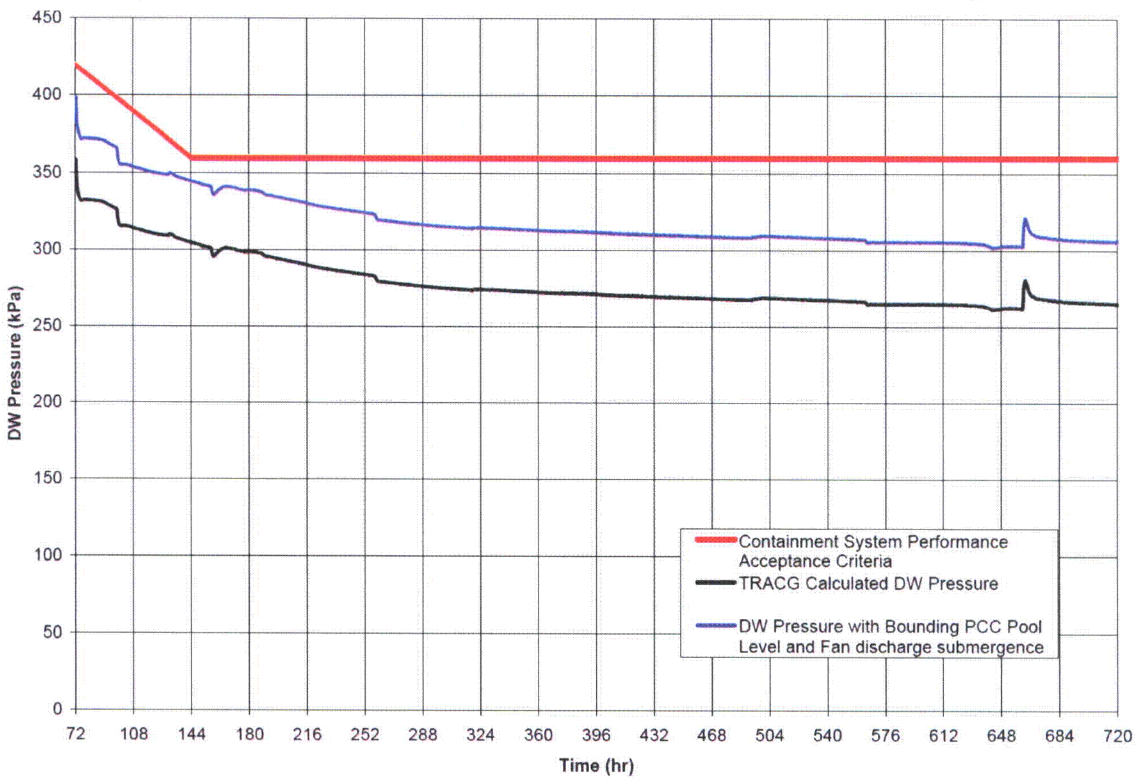


Figure 6.2-140S05-2 ESBWR DW Pressure with Appropriate Safety Adders

DCD Impact

The following DCD Sections will be revised as noted in the attached markup:

- DCD Tier 1, Table 2.15.4-2
- DCD Tier 2, Section 6.2.1.1.3.5.1
- DCD Tier 2, Section 6.2.2.2.2
- DCD Tier 2, Figure 6.2-14e1
- DCD Tier 2, Figure 6.2-14e2
- DCD Tier 2, Figure 6.2-14e13
- DCD Tier 2, Table 6.2-49

Enclosure 2

MFN 09-023 Supplement 3

Response to Portion of NRC Request for

Additional Information Letter No. 375

Related to ESBWR Design Certification Application

Engineered Safety Features

RAI Number 6.2-140 S05

Markups to ESBWR DCD

Tier 1 and Tier 2 Section 6.2

Table 2.15.4-2

ITAAC For The Passive Containment Cooling System

Design Commitment	Inspections, Tests, Analyses	Acceptance Criteria
11. The PCCS vent fans flow rate is sufficient to meet the beyond 72 hours containment cooling requirements following a design bases LOCA.	For each PCCS vent fan line, a flow rate test will be performed with the containment at pre-operational ambient conditions. Flow measurements will be taken on flow to the GDCS pools. An analysis of the test configuration will be performed.	• The tested and analyzed flow rates are greater than or equal to the flow rates of the design basis LOCA containment analysis model for the PCCS vent fan lines at containment pre-operational ambient conditions.
12. The PCCS vent fans can be remotely operated from the MCR.	PCCS vent fans will be started using manually initiated signals from the MCR.	The PCCS vent fans start when manually initiated signals are sent from the MCR.
13. The PCCS drain piping is installed to allow venting of non-condensable gases from the PCCS drain lines to the PCCS condenser vent lines to prevent collection in the PCCS drain lines.	Inspection(s) will be conducted of as-built PCCS drain piping to ensure there are no elevated piping loops or high-point traps in piping runs to the GDCS pools.	Based on inspection(s) of as-built PCCS drain piping, the as-built piping conforms to a design that allows venting of non-condensable gases from the PCCS drain lines to the PCCS condenser vent lines.
14. The elevation of the PCCS vent fan discharge point is submerged within the drain pan located in the GDCS pool at an elevation below the lip of the drain pan.	A visual inspection will be performed of the PCCS vent fan discharge point relative to the lip of the drain pan.	The elevation of the discharge on the PCCS vent fan line 24 cm (9.4 in) below the top of the drain pan lip with a tolerance of 1.4 cm (0.6 in)~~is > 9.5 in (± 0.5 in) and < 24 cm (±1 cm) below the top of the drain pan lip~~.

A loss of all power generation buses is not the limiting assumption and the effects of continued feedwater injection is more limiting, as it can potentially add water to the wetwell and compress the wetwell air space. The ESBWR design incorporates features that mitigate this challenge by isolating reactor inventory sources outside of containment and provides a method of GDCS initiation based on LOCA condition detection. These features ensure that containment remains within design pressure for the entire 72-hour event duration. These features also ensure acceptable performance for the full spectrum of LOCA events within containment, with or without the assumption of loss of external injection capability. Additionally, although power generation buses are considered available to add feedwater or High Pressure Control Rod Drive (HP CRD) injection, no credit is given for heat removal systems powered by these buses. Table 6.2-7h shows the sequence of events for the Main Steam Line Break with failure of one SRV and with offsite power available. Figures 6.2-14j1 through 6.2-14m3 show the pressure, temperature, DW and GDCS airspace pressure responses and PCCS heat removal for this analysis. The noncondensable mass and the void fraction in the DW and GDCS are presented in Figures 6.2-14n1 through 6.2-14o3. The detailed discussion on the chronology of progression is given in Appendix 6E.5. The cases analyzed without offsite power and water addition assume higher initial pressure, and result in higher pressure as shown in Table 6.2-5. The highest value of Maximum DW Pressure in Table 6.2-5 is the calculated peak containment internal pressure for the design basis loss of coolant accident.

6.2.1.1.3.5.1 Post-LOCA Containment Cooling and Recovery Analysis

For post-LOCA containment cooling and recovery, the Main Steam Line Break with failure of one DPV is selected. The analysis results are not sensitive to the event selection (failure of one DPV versus one SRV) due to the fact that these two cases are nearly the same in transient responses up to 72 hours and the containment pressure and temperature are rapidly reduced upon the activation of the nonsafety-related Structure, System, or Components (SSC).

After the first 72 hours of the accident, the following nonsafety-related SSCs are utilized to keep the reactor at safe stable shutdown conditions, to rapidly reduce containment pressure and temperature to a level where there is acceptable margin, and then to maintain these conditions indefinitely:

(1) SSCs to refill the IC/PCCS pools;

(2) PCCS Vent Fans;

(3) Passive Autocatalytic Recombiner System (PARS); and

(4) Power supplies to the PCCS Vent Fans and the IC/PCCS pool refill pumps.

Once a state of safe, stable reactor shutdown is reached, containment pressure and temperature are maintained with sufficient margin to containment design limits for a long period of time. Figure 6.2-14e1 through Figure 6.2-14e10a show key parameters for the long term pressure reduction and maintenance phase. PARS function at 72 hrs and 4 of 6 PCC vent fans are credited in the calculation. A containment system performance acceptance criteria ("Analytical Pressure Limit" curve) is shown on Figure 6.2 14e1 which considers variations in IC/PCC pool <u>from minimum to maximum and fan discharge submergence variations during the simulation.</u>

<u>To bound uncertainties and variations in the IC/PCC pool level from minimum to maximum and fan discharge submergence variations during the simulations, an adjustment is determined and</u>

added to the base results. Figure 6.2-14e13 compares the adjusted pressure to the containment system performance acceptance criteria. The containment pressure is reduced and remains below the acceptance criteria.

Other non-safety related, non-Regulatory Treatment of Non-safety Systems (RTNSS) SSCs can be placed in service to bring the reactor to cold shutdown conditions and to further reduce the containment pressure and temperature. These SSCs include the FAPCS as the preferred method, and the RWCU/Shutdown Cooling (SDC) system in the unlikely event there is fuel damage (Subsections 9.1.3 and 5.4.8, respectively). The RWCU/SDC and the FAPCS system are not part of the primary success path for post-LOCA containment cooling. Calculations of RWCU/SDC performance are provided here to show its ability to cooldown the reactor and containment. In the unlikely event of fuel damage, where the RWCU/SDC system is used, the Reactor Building HVAC Accident Exhaust Filter Units are a required support system for limiting onsite and offsite dose.

Containment pressure and temperature responses which represent a postulated accident recovery evolution, with RWCU/SDC (fuel damage assumed) providing the cold shutdown function are shown in Figures 6.2-14e11 and 6.2-14e12. These response curves are based on the RWCU/SDC operating in suppression pool cooling mode for 24 hours, beginning seven days after a LOCA, followed by vessel injection via the normal RWCU/SDC midvessel suction line, with suction from the suppression pool. The heat removal for this mode of RWCU/SDC operation is provided by the non-regenerative heat exchanger (NRHX). A conservative heat exchanger capacity was assumed which is well within the capability of the RWCU/SDC NRHX. Table 6.2-48 lists the RWCU/SDC NRHX data used in the analysis. There is no requirement to start the recovery actions at seven days, since the reactor is already in a safe stable shutdown condition, and containment pressure and temperature are in a non-upward trending state, with sufficient margin to containment design limits.

The accident recovery analysis shows that after being in suppression pool cooling for 24 hours and then injecting into the reactor vessel for approximately 10 hours, the suppression pool has equilibrated with the reactor bulk water temperature at cold shutdown conditions.

6.2.1.1.4 Negative Pressure Design Evaluation

During normal plant operation, the inerted WW and the DW volumes remain at a pressure slightly above atmospheric conditions. However, certain events could lead to a depressurization transient that can produce a negative pressure differential in the containment. A DW depressurization results in a negative pressure differential across the DW walls, vent wall, and diaphragm floor. A negative pressure differential across the DW and WW walls means that the RB pressure is greater than the DW and WW pressures, and a negative pressure differential across the diaphragm floor and vent wall means that the WW pressure is greater than the DW pressure. If not mitigated, the negative pressure differential can damage the containment steel liner. The ESBWR design provides the vacuum relief function necessary to limit these negative pressure differentials within design values. The events that may cause containment depressurization are:

- Post-LOCA DW depressurization caused by the ECCS (for example, GDCS) flooding of the RPV and cold water spilling out of the broken pipe or cold water spilling out of broken GDCS line directly into DW.

The PCCS condensers are located in a large pool (IC/PCCS pool) positioned above the ESBWR DW.

Each PCCS condenser is configured as follows (Figures 3G.1-71a and 3G.1-71b).

A central steam supply pipe is provided which is open to the DW airspace at its lower end. The open end of this pipe is provided with a debris filter with holes no greater than 25 mm (1 inch). The maximum inlet velocity during a LOCA is estimated to be no greater than 106 m/s (348 ft/s). The steam supply feeds two horizontal headers through two branch pipes at its upper end. Steam is condensed inside vertical tubes and the condensate is collected in two lower headers.

The vent and drain lines from each lower header are routed through the DW through a single passage per condenser module as shown on the figures.

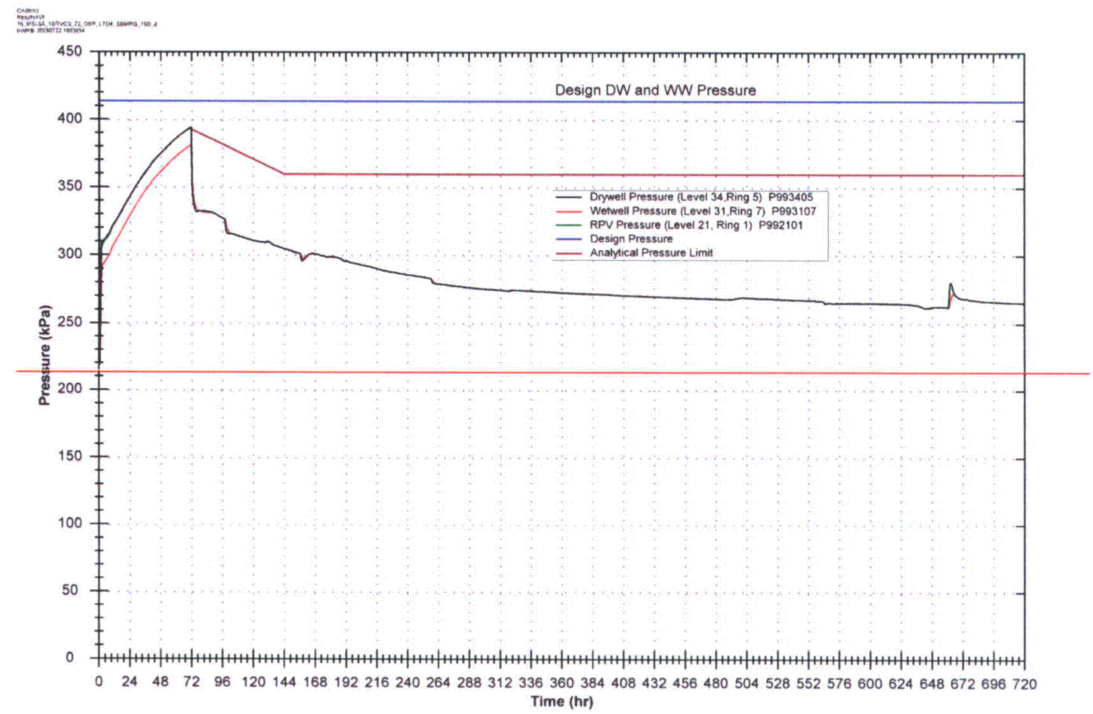
The condensate drains into an annular duct around the vent pipe and then flows in a line that connects to a large common drain line, which also receives flow from the other header. The vent line goes to the suppression pool and is submerged below the water level.

A Passive Containment Cooling vent fan is teed off of each PCCS vent line and exhausts to the GDCS pool. The fan aids in the long-term removal of noncondensable gas from the PCCS for continued condenser efficiency. The minimum fan performance requirements are shown in Table 6.2-49. The fans are operated by operator action and are powered by a reliable power source which has a diesel generator backed up by an ancillary diesel, if necessary, without the need to enter the primary containment. The discharge of each PCCS vent fan is submerged below the GDCS pool water level to prevent backflow that could otherwise interfere with the normal venting of the PCCS. The vent fan discharge line terminates in a drain pan within the GDCS pool so that the gas seal is maintained after the GDCS pool drains. The vent fan discharge line is 24 cm (9.4 in) below the top of the drain pan lip with a tolerance of 1.4 cm (0.6 in ~~≥ 0.22 m (9 in) and ≤ 0.25 m (10 in) below the top of the drain pan lip~~. To further prevent reverse flow through an idle fan, a check valve is installed downstream of the fan.

The PCCS condensers receive a steam-gas mixture supply directly from the DW. The PCCS condensers are initially driven by the pressure difference created between the DW and the suppression pool during a LOCA and then by gravity drainage of steam condensed in the tubes, so they require no sensing, control, logic or power-actuated devices to function. In order to ensure the PCCS can maintain the DW to WW differential pressure to a limit less than the value that causes pressure relief through the horizontal vents, the vent line discharge point is set at an elevation submerged below low water level and at least 0.85 m (33.5 in) and no greater than 0.900 m (35.4 in) above the top of the uppermost horizontal vent. The PCCS condensers are an integral part of the safety-related containment and do not have isolation valves.

The drain line is submerged in the GDCS pool to prevent back-flow of steam and gas mixture from the DW to the vent line, which would otherwise short circuit the flow through the PCCS condenser to the vent line. It also provides long-term operational assurance that the PCCS condenser is fed via the steam supply line. The drain line terminates in the same drain pan as the vent fan discharge to replace any evaporation loss in the drain pan after the GDCS pool drains.

Each PCCS condenser is located in a subcompartment of the IC/PCCS pool, and all pool subcompartments communicate at their lower ends to enable full use of the collective water inventory independent of the operational status of any given IC/PCCS sub-loop.



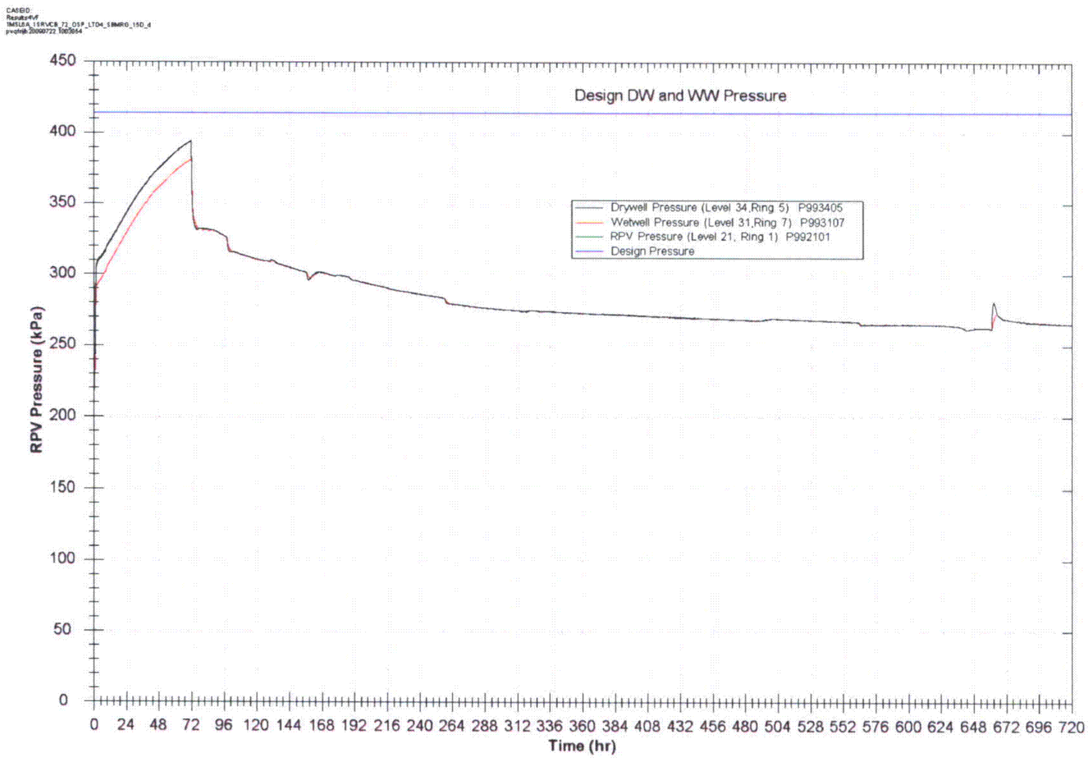
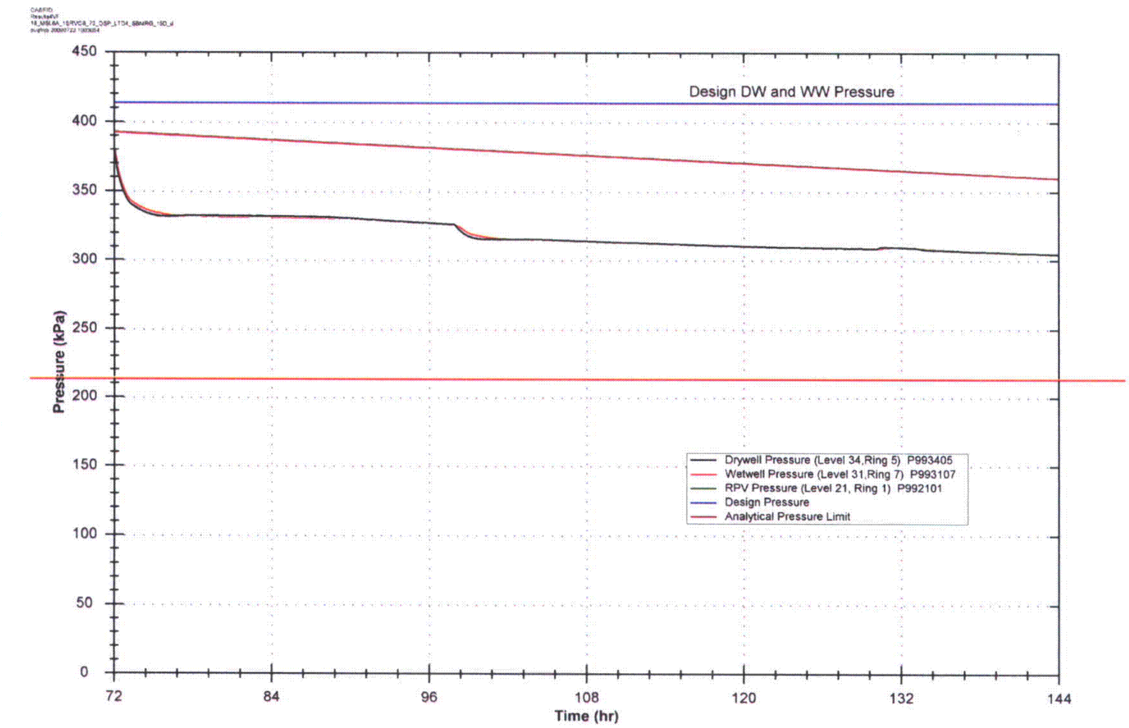


Figure 6.2-14e1. Drywell, Wetwell and RPV Pressures (720 hr)



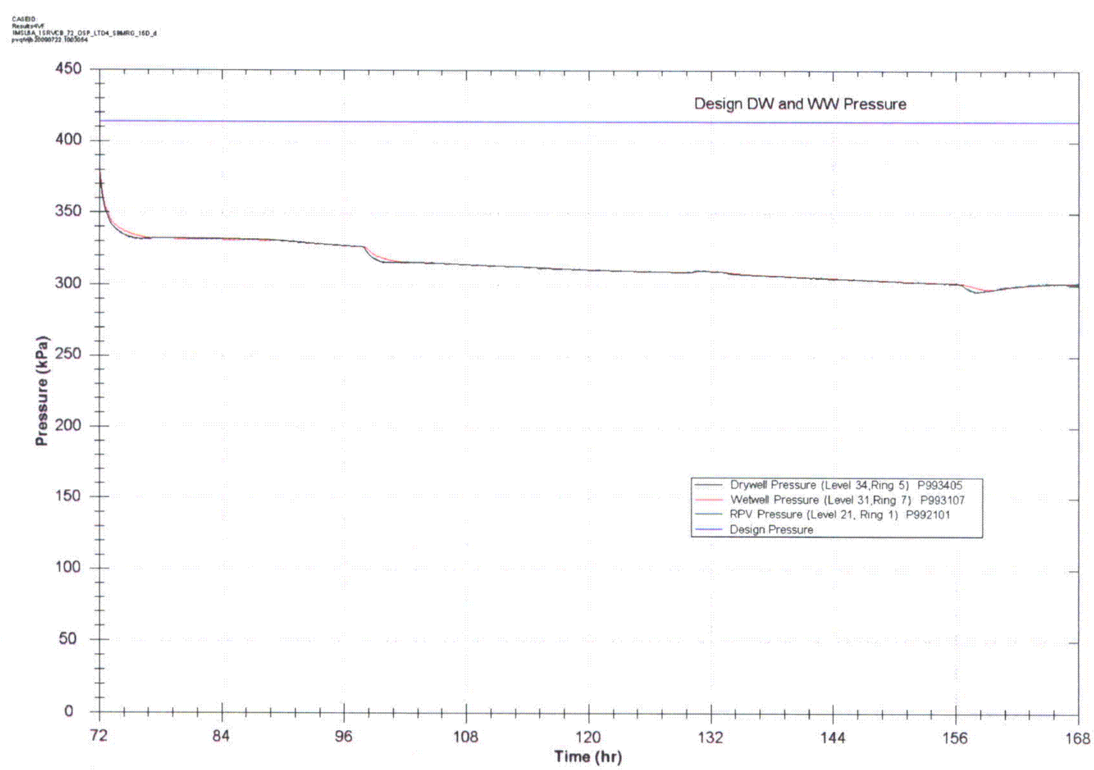


Figure 6.2-14e2. Drywell, Wetwell and RPV Pressures (72 – 144 hr)

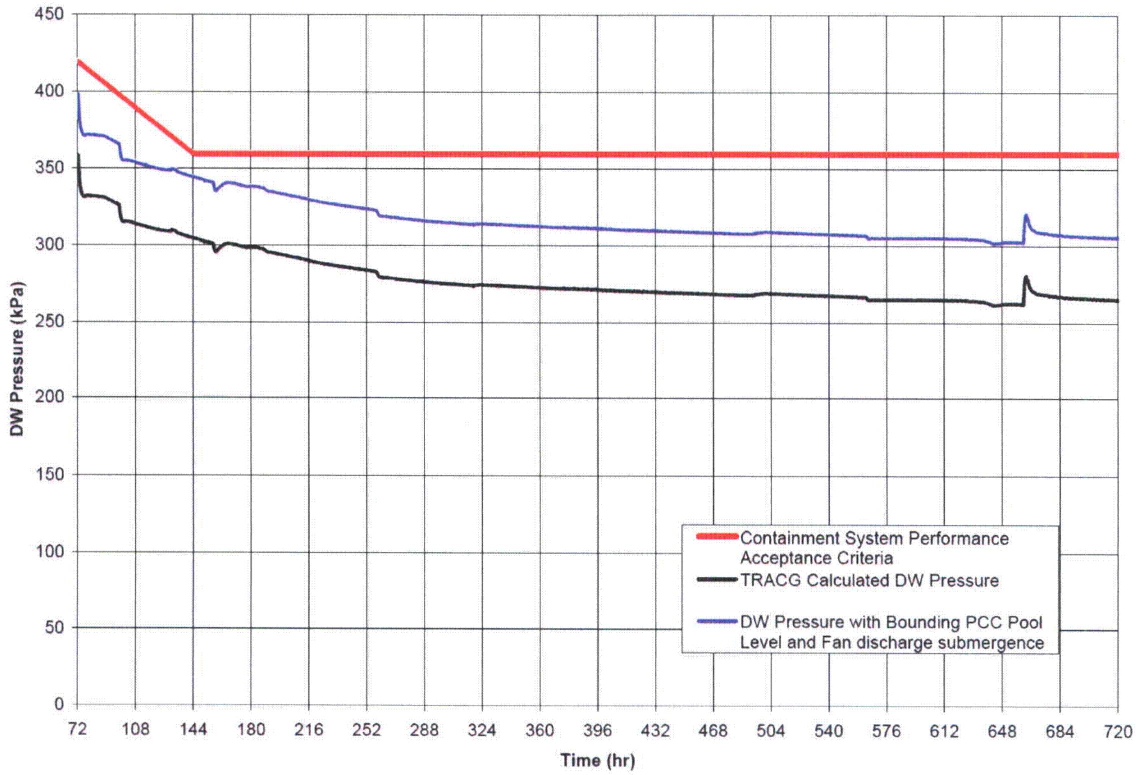


Figure 6.2-14e13. Drywell Pressure with Sensitivity to Vent Fan Submergence and PCC Pool Level (72 hr to 720 hr)

Table 6.2-49

PCCS Vent Fan Minimum Performance Requirements[1]

Normalized Fan Head $\Delta P/\rho$ m^2/s^2 (ft^2/s^2)	Flow m^3/s (CFM)
2,410 (25,900)	0.071 (150)
2,380 (25,600)	0.141 (300)
2,290 (24,600)	0.283 (600)
2,050 (22,100)	0.472 (1,000)
1,880 (20,200)	0.566 (1,200)
1,390 (15,000)	0.741 (1,570)

1. The inlet losses for the PCCS are described in Table 6.2-8, Item 4. The outlet losses shall not exceed a k/A^2 value of 1500 m^{-4} (174,000 ft^{-4}).