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Subject: **Response to Portion of NRC Request for Additional Information Letter No. 33 Related to ESBWR Design Certification Application – Engineered Safety Features – RAI Numbers 6.2-48 through 6.2-51, 6.2-53 through 6.2-57, and 6.2-64 through 6.2-74**

Enclosure 1 contains GE's response to the subject NRC RAI transmitted via the Reference 1 letter.

If you have any questions about the information provided here, please let me know.

Sincerely,

Kathy Sedney for

David H. Hinds
Manager, ESBWR

D068

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 – Response to Portion of NRC Request for Additional Information Letter No. 33 Related to ESBWR Design Certification Application – Engineered Safety Features – RAI Numbers 6.2-48 through 6.2-51, 6.2-53 through 6.2-57, and 6.2-64 through 6.2-74

cc:	WD Beckner	USNRC (w/o enclosures)
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	GB Stramback	GE/San Jose (with enclosures)
	eDRF	0000-0055-4622

ENCLOSURE 1

MFN 06-215

Response to Portion of NRC Request for

Additional Information Letter No. 33

Related to ESBWR Design Certification Application

Engineered Safety Features

RAI Numbers 6.2-48 through 6.2-51, 6.2-53 through 6.2-57,

and 6.2-64 through 6.2-74

NRC RAI 6.2-48

DCD Tier 2, Rev. 1, page 6.2-12 refers to References 6.2-3 and 6.2-4. These references are not included in DCD Rev 1, Section 6.2.9. Include these references in the DCD.

GE Response

These references are listed in the following and will be included in the revised DCD, Section 6.2.9.

Ref. 6.2-3 MFN 05-105, Letter from David H. Hinds to U.S. Regulatory Commission, *TRACG LOCA SER Confirmatory Items (TAC # MC 8168)*, Enclosure 2, *Reactor pressure Vessel (RPV) Level Response for the Long Term PCCS Period, Phenomena Identification and Ranking Table, and Major Design Changes from Pre-Application Review Design to DCD Design*, October 6, 2005.

Ref. 6.2-4 MFN 06-094, Letter from David H. Hinds to U.S. Regulatory Commission, *Revised Response – GE Response to Results of NRC Acceptance Review for ESBWR Design Certification Application – Item 2*, March 28, 2006.

DCD Section 6.2-9 will be revised in the next update to include the above references.

NRC RAI 6.2-49

DCD Tier 2, Rev. 1, page 6.2-23, under "Break Size and Location,"the second item refers to "a., above." It is not clear what "a." refers to. Explicitly identify the item by DCD Section and bullet number if applicable. Include this information in the DCD Tier 2.

GE Response

"a., above," refers to the statement immediately before this line. The paragraph will be revised as follow:

" - The choice of break locations and types is discussed in Subsection 6.2.1.1.3.
 - Of several breaks postulated on the basis stated above, the break selected as the reference case yields the highest containment pressure consistent with the criteria for establishing the break location and area."

DCD Section 6.2.1.3 will be revised in the next update to include the above discussion.

NRC RAI 6.2-50

DCD Tier 2, Rev. 1, page 6.2-23 it is stated that "[i]n general,calculations of the mass and energy release rates for a [loss of coolant accident] LOCA are performed in a manner that conservatively establishes the containment internal design pressure..." Clarify this statement (i.e., what is meant by "in general"). Include this information in the DCD Tier 2.

GE Response

The statement "In general, calculation of the mass and energy release…" will be replaced by the following statement:

"Following the procedure documented in Reference 6.2-1, calculations of the mass and energy release rates for a [loss of coolant accident] LOCA are performed in a manner that conservatively establishes the containment internal design pressure..."

DCD Section 6.2.1.3 will be revised in the next update to include the above discussion.

NRC RAI 6.2-51

Regarding the passive containment cooling system (PCCS) description in DCD Tier 2, Rev. 1, on page 6.2-19, "the return condensate goes to the [reactor pressure vessel] RPV via an intermediate holding tank," this should be corrected; as the condensate goes to the gravity driven cooling system (GDCS) pools. Include this information in the DCD Tier 2.

GE Response

DCD Section 6.2.1.1.10.2 will be revised in the next update as noted in the following markup.

"(8) Passive Containment Cooling System (PCCS)
The PCCS system is designed to remove decay heat from the containment. The PCC heat exchangers receive a steam-gas mixture from the drywell atmosphere, condense the steam and return the condensate to the RPV via the GDCS pool and GDCS injection lines. The non-condensable gas is drawn to the suppression pool through a submerged vent line driven by the differential pressure between the drywell and wetwell."

NRC RAI 6.2-53

Provide a discussion of the containment response to the feedwater line break (FWLB) using the DCD version of the TRACG model, particularly with respect to the movement of non-condensable gases, mixing and stratification, throughout the containment. Include this information as an update to NEDC-33083P-A, "TRACG Application for ESBWR."

GE Response

The containment responses to a postulated feedwater line break (FWLB) are discussed in the following paragraphs and figures. The nominal case (DCD Rev. 1, Figures 6.2-9 to 6.2-11) is used in these discussions. These discussions will be included in the Supplement in DCD Section 6.2.

Figure 6.2-53_1 shows the RPV, DW and WW pressures, and Figures 6.2-53_1a and _2 show the DW and WW pressures at different time and pressure scales.

Following the postulated LOCA, the drywell pressure increased rapidly leading to the clearing of the PCC and main vents. The peak drywell pressure for this case was about 341 kPa (49.5 psia) (Figure 6.2-53_1a), and occurred at 78 seconds shortly after the opening of DPVs. This peak pressure is below the design pressure of 60 psia with a large margin. The DW pressure increase is terminated at around 0.05 hrs (Figure 6.2-53_1a), when most of the non-condensable gases in the DW have been purged into the WW (Figure 6.2-53_9a). The DW pressure turns over when the GDCS initiates at about 300 s. The subcooled GDCS water continues flowing into the vessel, reduces the steaming from the RPV and the DW pressure. At around 0.38 hrs, the DW pressure drops below the WW pressure, causing the openings of vacuum breakers and allowing some non-condensable gases to flow back into the DW. Consequently, the system pressures drop to a value of about 210 kPa.

Figures 6.2-53_5 through _12 show the non-condensable (NC) gas pressures at different elevations in the DW. Figure 6.2-53_9a shows the NC gas pressure at Level 31 (same elevation level as the vacuum breaker/DW-WW leakage hole) with a short-term time scale (from 0 to 1 hrs). The short-term responses at other levels are similar to that shown in Figure 6.2-53_9a. Most of the NC gases in the DW were purged into the WW within 0.02 hrs. At around 0.38 hrs, some NC gases flow back to DW after the opening of the vacuum breakers.

Subsequently, decay heat overcomes the subcooling of the GDCS water and steaming resumes (at ~ 0.45 hrs, Figure 6.2-53_1a). The resumption of RPV steaming causes the drywell pressure to increase again from 0.45 to about 9.5 hours. The drywell pressure reaches a second peak of 295 kPa (43 psia) (Figure 6.2-53_1). At about 9.5 hours, the PCCs are able to remove all the decay heat (Figure 6.2-53_3), resulting in a sharp drop in the drywell and RPV pressures.

During the period from 0.45 to 9.5 hrs, the DW pressure is higher than the WW pressure. The PCCS takes steam/NC gas mixture from the DW and purges the NC gases into the WW. Part of the NC gases return to the DW because of vacuum breaker openings, most of it is recycled back into the WW in about 3 hrs (Figures 6.2-53_5 through _12). At 10 hrs, the DW pressure drops below the WW pressure, causing the re-openings of vacuum breakers and allowing some non-condensable gases to flow back into the DW. At this time, the DW annulus is filled with water up to an elevation at 10.65 m (Figure 6.2-53_4). In the TRACG nodalization, cells in the DW from Levels 22 to 28 are filled with water. The NC gas pressure spike shown in Figures 6.2-53_5 and _6 at around 10 hrs is of no significance, because the void fractions in these levels are zero and there are no NC gases in these levels.

During the time period from 10 to 72 hrs, the PCCS continues to take steam/NC gas mixture from the DW and discharges the NC gases into the WW. The steam from the RPV to the DW is flowing through the FW line break and the DPVs, which are located at Levels 33 and 34. The NC gases at Levels 33 through 34 remain at very low concentration due to PCCS action. The NC gases at Levels 29 through 32 are not effectively participating in the PCCS purging process due to lack of steam mixing within these levels.

Figure 6.2-53_3 compares the total heat removal by the PCCs with the decay heat. After the first 9.5 hours, the PCCs are able to remove all the decay heat with some margin to spare. From this point on, all the decay heat generated by the core is transferred to the PCC pools, which are located outside of the containment.

Figure 6.2-53_4 compares the water levels in the drywell annulus and suppression pool. The drywell annulus water level rises due to the break flow discharges from the RPV and from the broken feedwater piping (from the feedwater heaters). In about 2 hours, the drywell annulus water level reaches the elevation of 10.65 m, where the spillover pipes are connected to the drywell annulus. The hot water in the drywell annulus starts flowing into the bottom of the suppression pool via the spillover pipes, causing the suppression pool level to increase and the pool water to heat up. After 9.5 hours, the levels in the drywell annulus and the suppression pool reach an equilibrium position at about 11.2 m.

During the process of filling water in the DW annulus for the first 2 hrs, the NC gases located in the lower DW region are effectively pushed upward to the upper DW and mixed with steam from the RPV.

From 3 to 9.5 hrs, the DW annulus level is lower than the suppression pool level (Figure 6.2-53_4), corresponding to the pressure difference between the DW and WW (Figure 6.2-53_1).

Figure 6.2-53_13 compares the liquid temperatures at DW annulus, spillover pipe entrance and suppression pool bottom. From 2 to 9.5 hrs, the hot water in the drywell annulus flows into the bottom of the suppression pool via the spillover pipes, causing the suppression pool level to increase and the pool water to heat up. After 9.5 hrs, the

spillover flow is intermittent in nature through the rest of the 72 hrs transient. The forced suppression pool stratification model is not turned on for the FWLB because there is significant mass flow to the bottom of the suppression pool. This allows the piped DW annulus hot water to mix with the suppression pool water at upper levels, and includes the effects of the piped DW hot water on the suppression pool surface temperature and on the partial steam pressure in wetwell.

After 9.5 hours, the pressure difference between the DW and WW is oscillatory in nature (Figures 6.2-53_2), causing the flow in the spillover pipe to oscillate in flow direction. The DW hot water, via the spillover pipes, continues to heat up the suppression pool water near the bottom. At 72 hours, the suppression pool bottom temperature reaches the maximum value of 88 °C.

Figure 6.2-53_14 compares the liquid temperatures of the DW annulus, and at various suppression pool elevations. Initially, the pool water heats up due to the main vent and SRV discharge. After the main vents close, the upper levels are impacted by the PCC vent discharge for the first 9.5 hours where the decay heat exceeds the PCC heat removal capacity. For the first 2 hrs, Figure 6.2-53_14 shows the pool temperature stratification due to various heating processes. After 2 hrs, the DW hot water via the spillover pipes flows into the suppression pool bottom, and heats up the suppression pool water through the mixing process. At 72 hours, the suppression pool temperatures at the surface and bottom reach the maximum value of 88 °C.

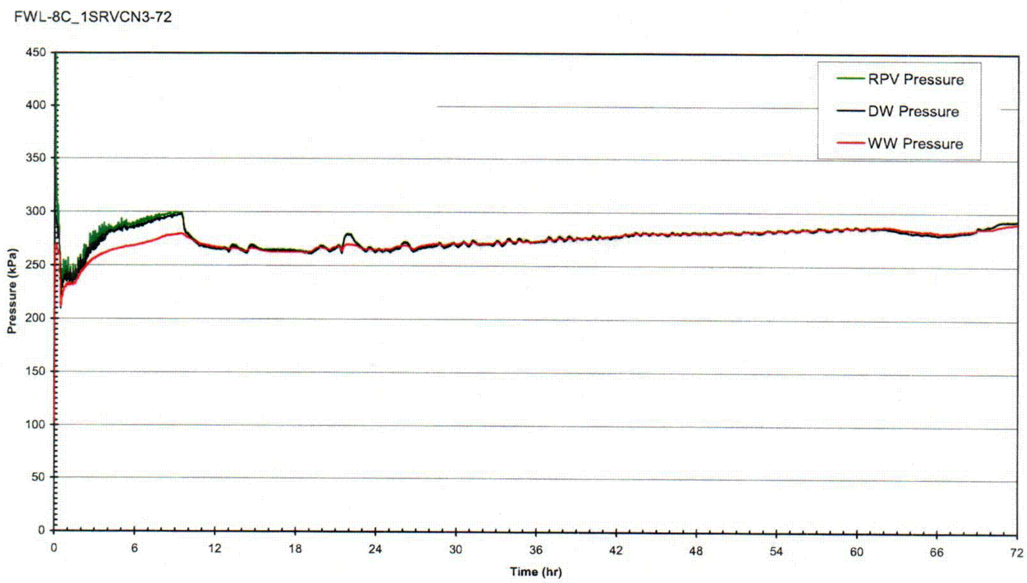


Figure 6.2-53_1: Containment Pressure Response

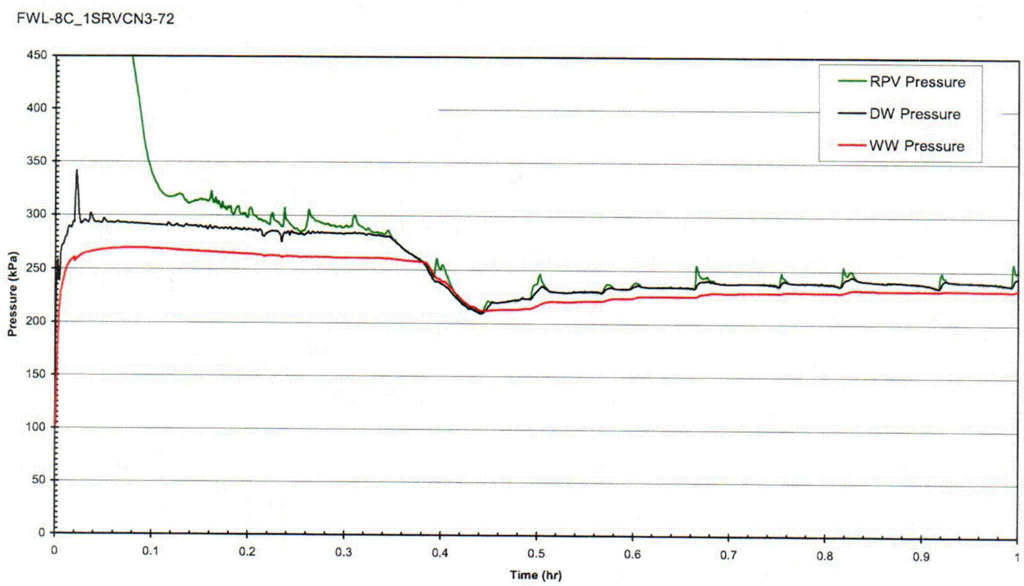


Figure 6.2-53_1a: Containment Pressure Response (Short-term time scale)

C-01

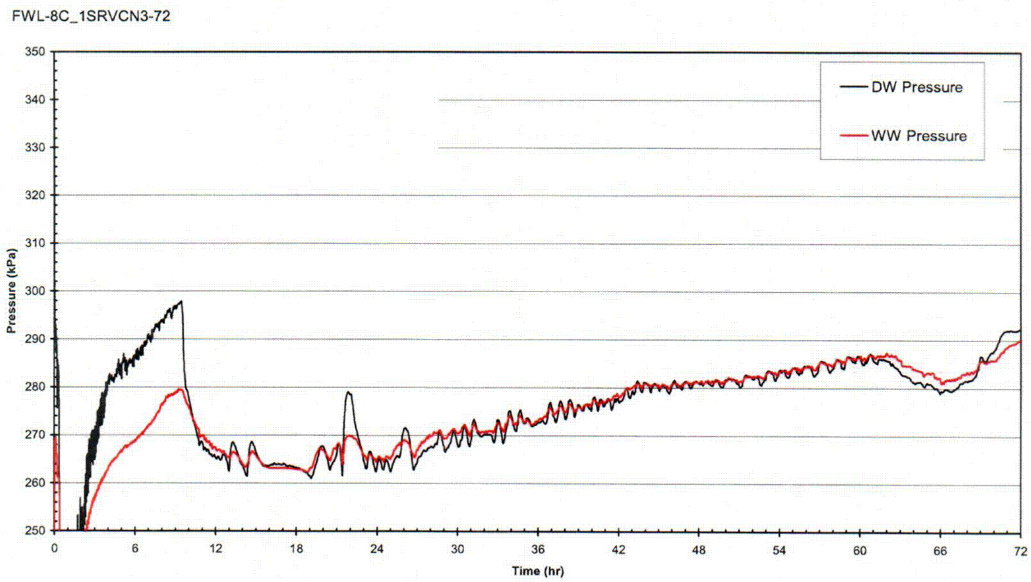


Figure 6.2-53_2: Containment Pressure Response (with enlarged Pressure scale)

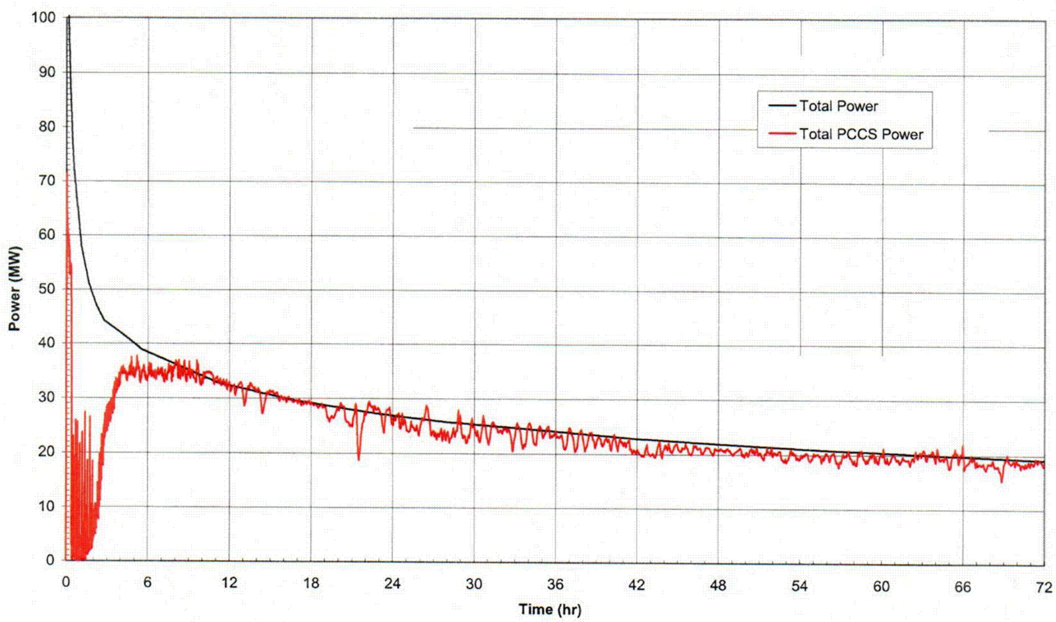


Figure 6.2-53_3: PCCS Heat Removal versus Decay Heat

C-02

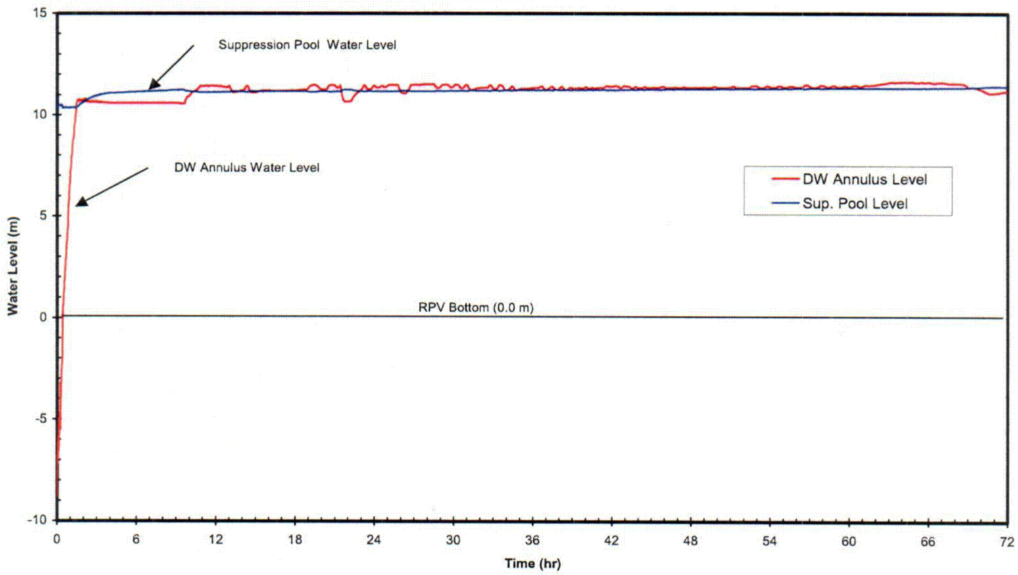


Figure 6.2-53_4: Drywell Annulus and Suppression Pool Levels

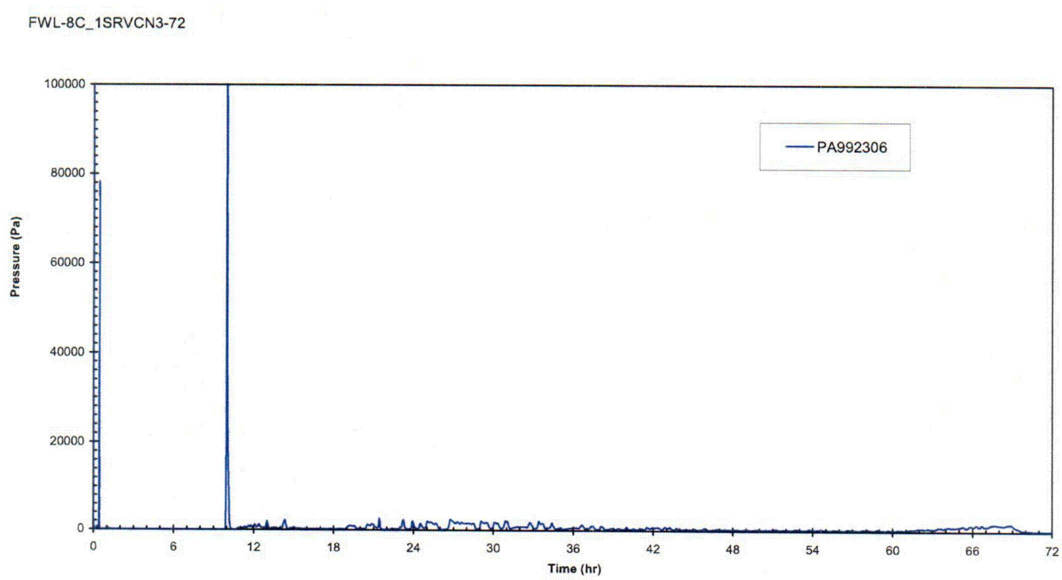


Figure 6.2-53_5: DW NC Gas P at Level 23 (1 Level above DW Bottom Floor)

C-03

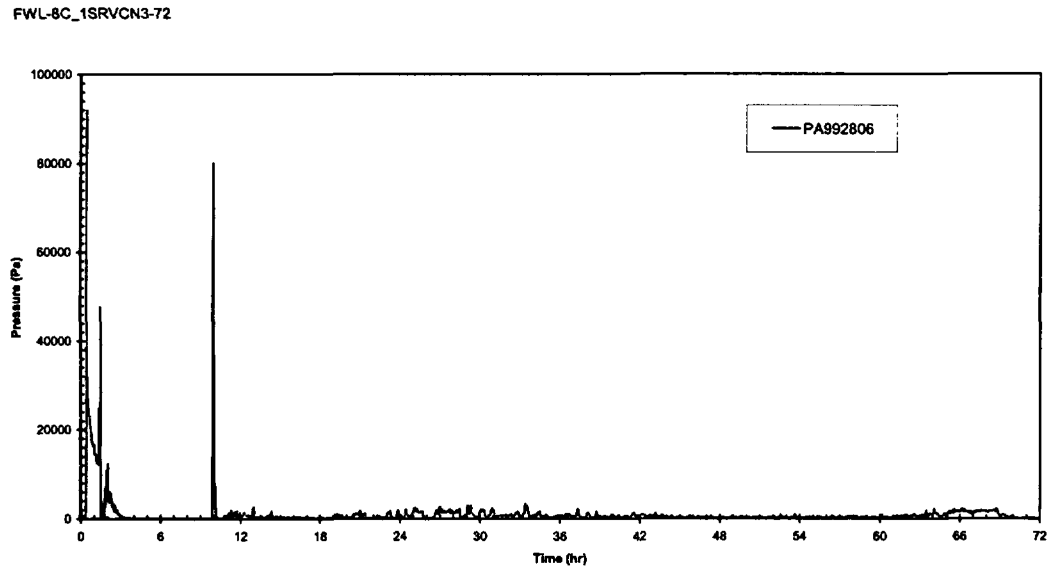


Figure 6.2-53_6: DW NC Gas P at Level 28 (3 Levels below DW-WW Leakage Hole)

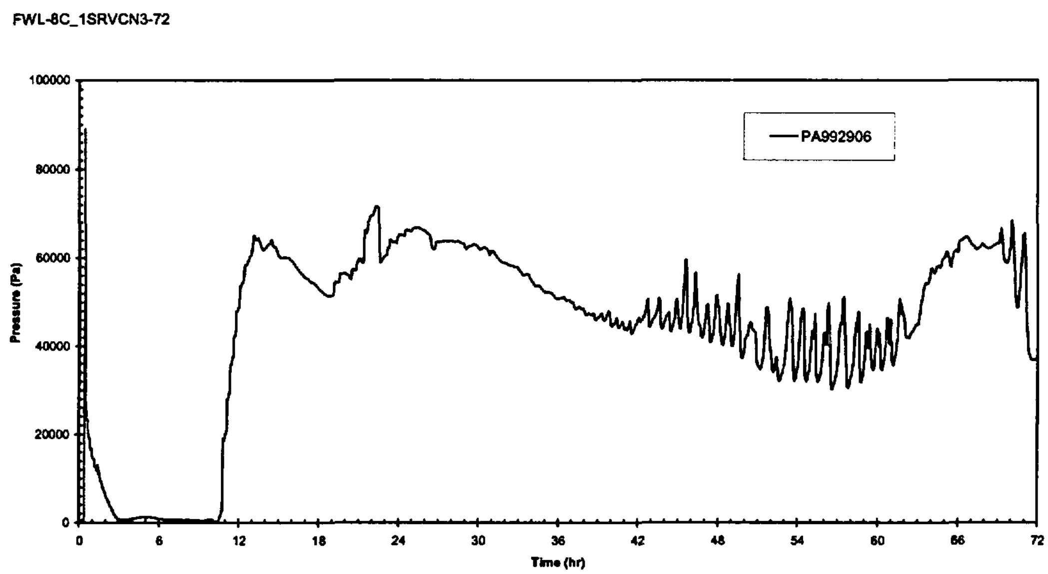


Figure 6.2-53_7: DW NC Gas P at Level 29 (2 Levels below DW-WW Leakage Hole)

FWL-8C_1SRVCN3-72

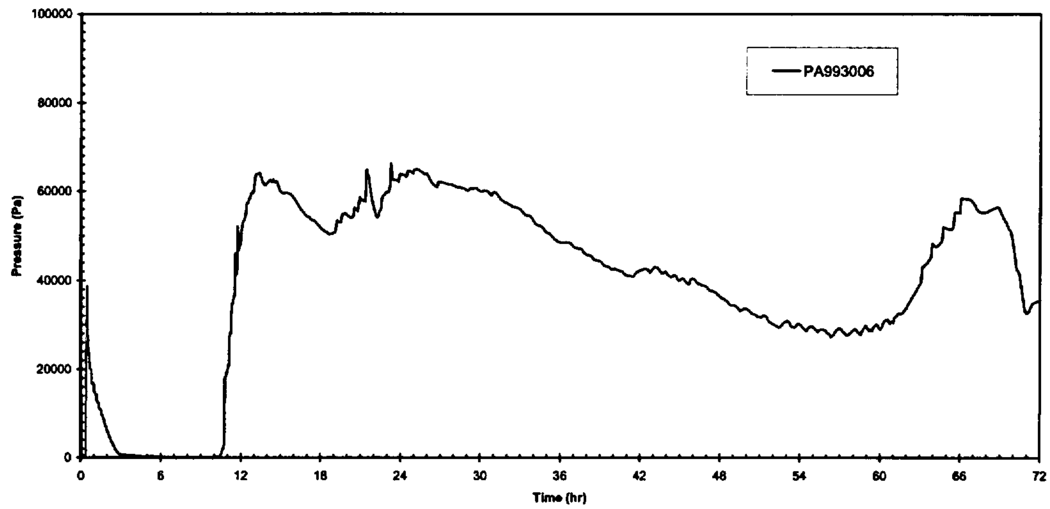


Figure 6.2-53_8: DW NC Gas P at Level 30 (1 Levels below DW-WW Leakage Hole)

FWL-8C_1SRVCN3-72

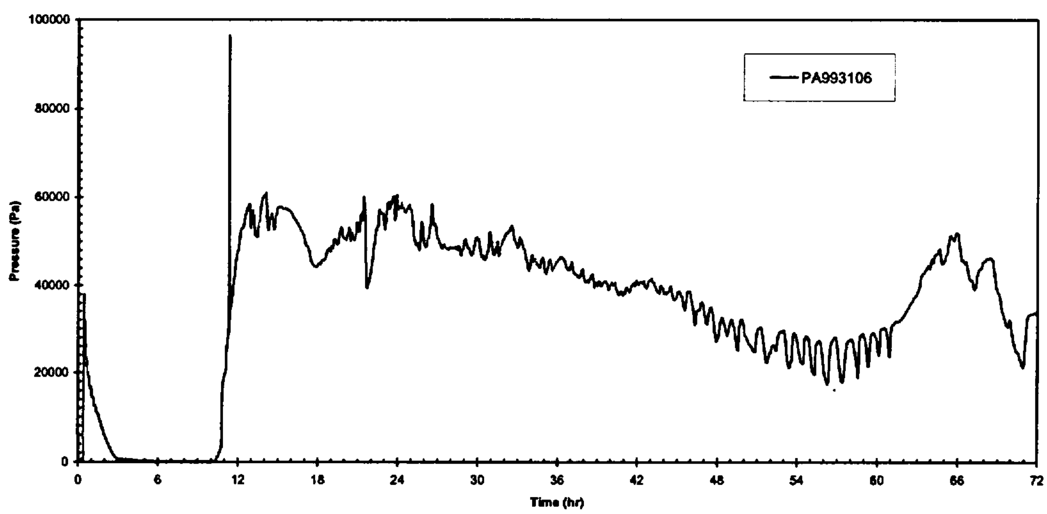


Figure 6.2-53_9: DW NC Gas P at Level 31 (Same Level as the DW-WW Leakage Hole)

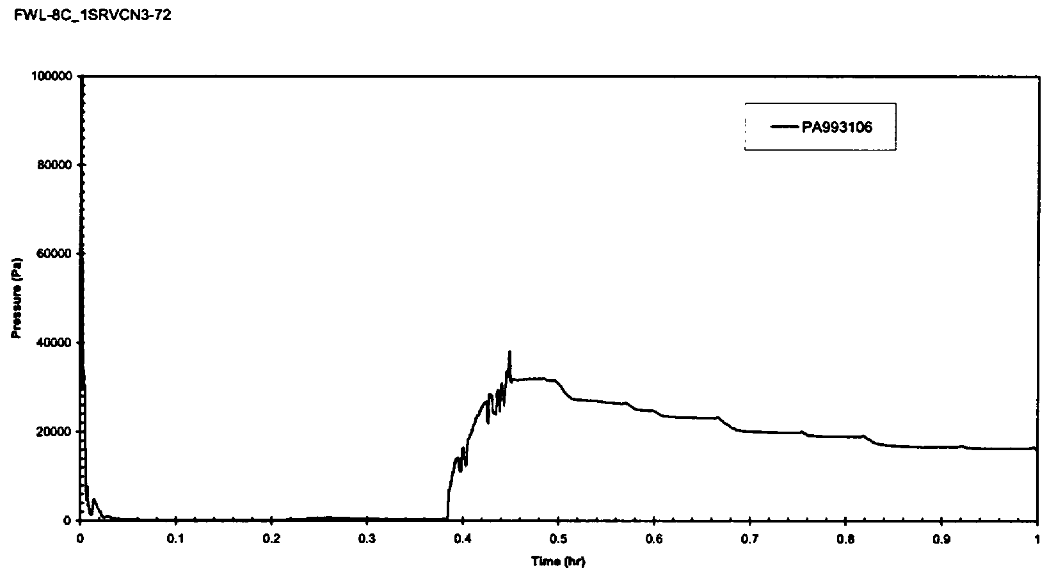


Figure 6.2-53_9a: DW NC Gas P at Level 31 (Same Level as the DW-WW Leakage Hole) (short-term time scale)

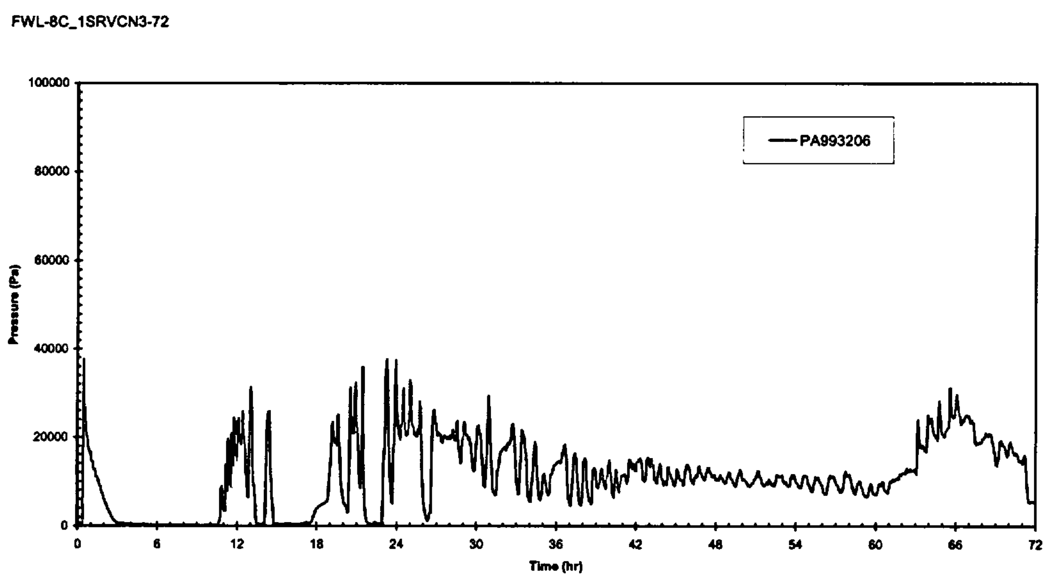


Figure 6.2-53_10: DW NC Gas P at Level 32 (1 Level above DW-WW Leakage Hole)

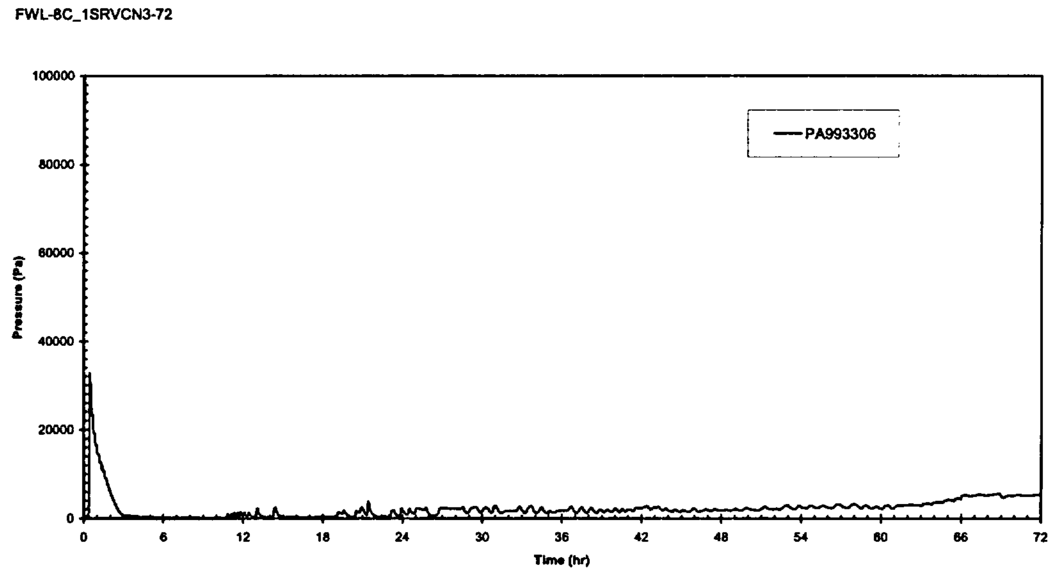


Figure 6.2-53_11: DW NC Gas P at Level 33 (2 Levels above DW-WW Leakage Hole)

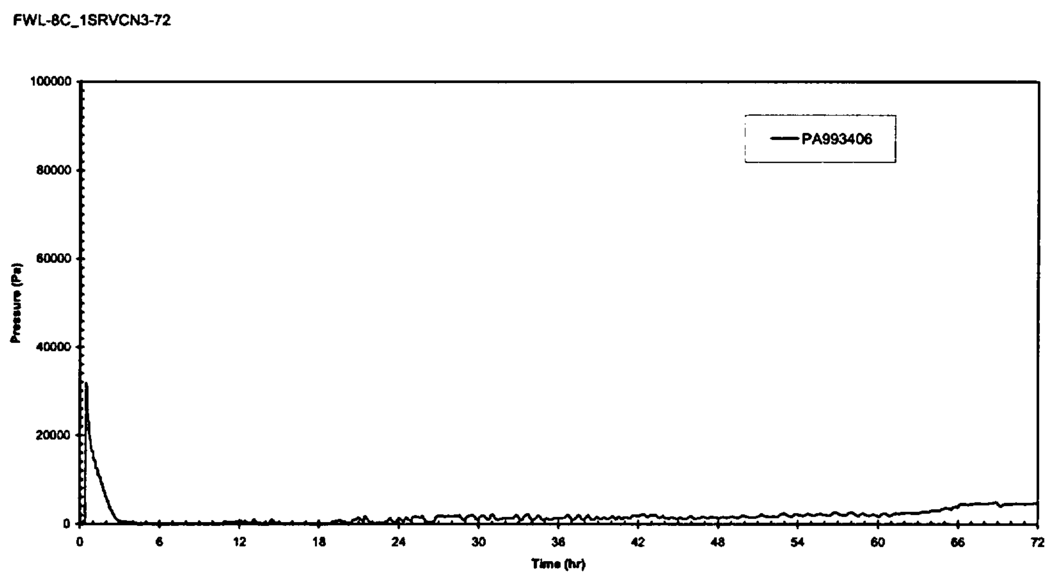


Figure 6.2-53_12: DW NC Gas P at Level 34 (3 Levels above DW-WW Leakage Hole)

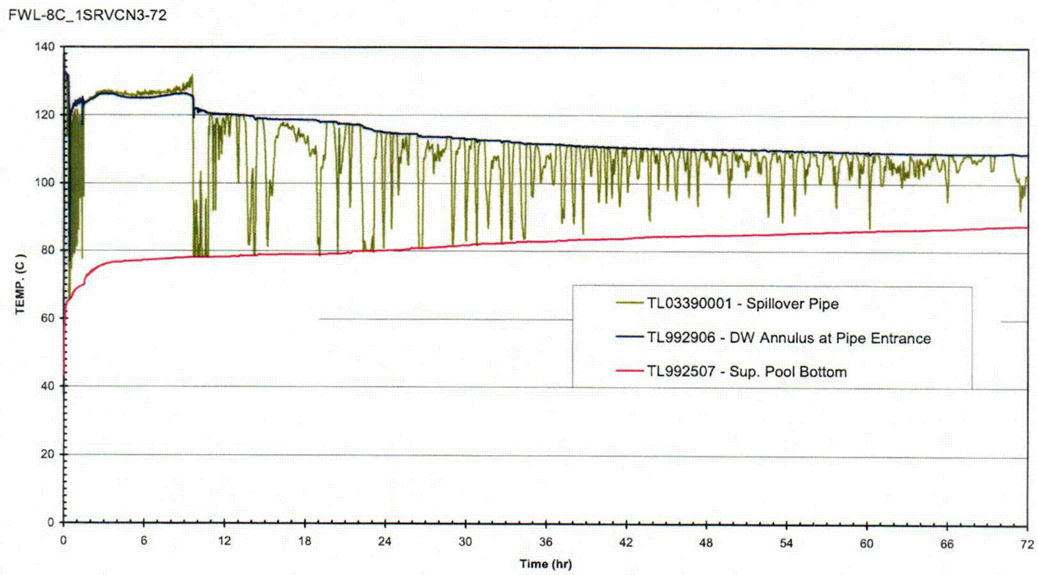


Figure 6.2-53_13: Liquid Temperatures at DW Annulus, Spillover Pipe Entrance and Suppression Pool Bottom

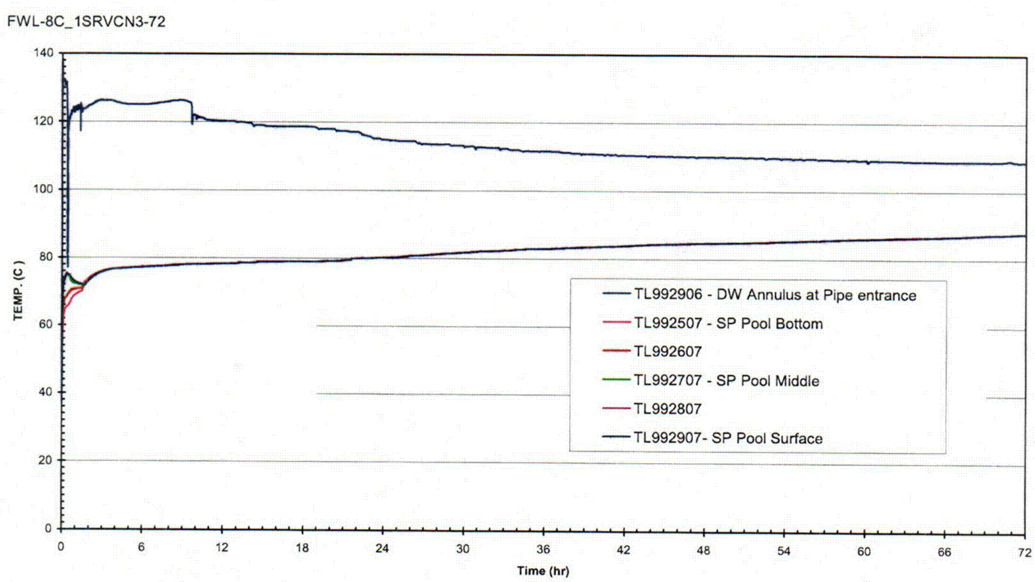


Figure 6.2-53_14: Suppression Pool Liquid Temperatures

C-04

<u>NRC RAI 6.2-54</u>

An additional axial node was added to the upper wetwell in the DCD version of the TRACG model compared to the preapplication model. In the preapplication TRACG model, the treatment of the upper wetwell limited mixing to conservatively assess the wetwell gas space temperature. Include this information as an update to NEDC-33083P-A, "TRACG Application for ESBWR."

A. Is the same conservative approach applied to the DCD TRACG model?
B. Is the gas space temperature still treated in a conservative manner?
C. What was rationale for adding the additional axial node?

<u>GE Response</u>

(A) Yes, the same conservative approach described in the "Pre-application Model" is applied to the DCD TRACG model.

(B) Yes, the gas space temperature is still treated in a conservative manner as described in the "Pre-application Report". An irreversible loss coefficient is applied at the interface between the cells in the top two gas space levels. This introduces forced stratification thereby restricting flow between cells in the top two gas space levels.

(C) There are 24 I-Beams located at the top of the wetwell to support the diaphragm floor. An additional axial node (Level # 30 located at 15.8 m, 0.1 m below the bottom of I-beams) is added to the wetwell to refine the simulation of the trapped gas space between the I-beams.

These discussions will be included in the Supplement in DCD Section 6.2.

<u>NRC RAI 6.2-55</u>

In the preapplication TRACG model, the suppression pool heatup was conservatively addressed for the containment design basis accident (DBA). Is the same conservative approach used in the DCD version of the TRACG model? The model description should include text explaining the features used to ensure a conservative containment response evaluation. Include this information as an update to NEDC-33083P-A, "TRACG Application for ESBWR."

<u>GE Response</u>

In general, the conservative approach described in the "Pre-application Model" (Section 3.3.1.1.1, NEDC-33083P-A, this restricts the flow area in the suppression pools cells below the source of energy addition) is used in the DCD calculations, however for the Feed Water Line Break (FWLB) energy addition from spillover pipe continues in the long term heatup, so the flow area restriction is not applied.

The FWLB simulates the break flows from both the RPV side and the turbine building side. The feed water line initially contains about 1100 m^3 of water at medium pressure. After the pipe break, this large amount of hot water (together with the GDCS water spilling over from the RPV) floods the drywell annulus to 10.65m, the elevation of the pipe entrance to the spillover pipes. The drywell hot water (in the order of a few hundred cubic meters) is then piped to the bottom of the suppression pool via the spillover pipes. The spillover flow is significant from 2.0 to 9.5 hrs. After 9.5 hrs, the spillover flow is intermittent in nature through the rest of the 72 hrs transient. The forced suppression pool stratification model is not turned on for the FWLB because there is significant mass flow to the bottom of the suppression pool. This allows the piped drywell hot water to mixed with the water at upper levels, to include the effects of the piped drywell hot water on the suppression pool surface temperature and on the partial steam pressure in wetwell.

These discussions will be included in the Supplement in DCD Section 6.2.

NRC RAI 6.2-56

The DCD version of the TRACG model adds an additional node to the upper drywell. Provide a discussion of the containment response using the DCD TRACG model, particularly with respect to the movement of non-condensable gases, mixing and stratification, throughout the containment, as compared to the approved pre-application model. Include this information as an update to NEDC-33083P-A, "TRACG Application for ESBWR."

GE Response

The DCD version of the TRACG model adds an additional node to the upper drywell. This additional node (the inner 4 cells) models the gas space inside the drywell head, with appropriate volume, and flow areas/losses between the drywell head and the upper drywell. In the "Pre-application Model", the drywell head gas space volume is lumped as part of the upper drywell gas volume.

The discussion on the movement of non-condensable gases, mixing and stratification throughout the containment is provided in Response to RAI 6.2-53.

These discussions will be included in the Supplement in DCD Section 6.2.

NRC RAI 6.2-57

For each break type (FWLB, MSLB, GDCS line, and bottom drain line) provide a discussion of the treatment of non-safety systems as they affect the mass and energy releases into the containment, and describe how they are treated in the response calculations. Include this information in the DCD Tier 2.

GE Response

The ECCS and Containment analyses take no credit for the non-safety systems in the ESBWR. The following table summarizes the non-safety systems, their functions and impact on the LOCA responses if they are available.

Summary of Non-safety Systems
(Not Credited in the ECCS/Containment LOCA Analyses)

System, Structure or Component (SSC)	Function	Impact (When SSC is available)
HP_CRD	Provide high-pressure makeup water to the RPV	Increase RPV inventory; Increase water level and increase margin to core uncovery
RWCU/SDC	Provide additional decay heat removal capability	Cooldown RPV to atmospheric conditions; Increase margin to containment design pressure
FAPCS – Suppression pool cooling and cleanup	Provide suppression pool cooling for accident recovery	Decrease WW and DW pressure; Increase margin to containment design pressure
FAPCS – Drywell Spray	Spray cooled water to DW air space	Reduce DW pressure; Increase margin to containment design pressure
FAPCS - LPCI	Inject cooled water from suppression pool into RPV via FW loop A	Increase RPV inventory; Increase water level and increase margin to core uncovery
Fire Protection System	Provide emergency backup source of makeup water to IC/PCC pools	Increase IC/PCC pool level and decay heat removal rate; Increase margin to containment design pressure

DCD Section 6.2.1.1.3 will be revised in the next update to include the above discussion.

NRC RAI 6.2-64

The nominal drywell temperature is listed as 135 °F (Table 6.2-2). The reported DBA analyses were done at 115 °F (Table 6.2-6). Provide an explanation of the temperature used to ensure a conservative evaluation. Include this information in the DCD Tier 2.

GE Response

The expected operating range of drywell temperature is from 115 °F to 135 °F. Results from a previous sensitivity study on SBWR design (Figure 4.3-2, NEDE-32178P, Rev.1, "Application of TRACG Model to SBWR Licensing Safety Analysis") showed that increasing initial drywell temperature caused a decrease in the long-term drywell pressure. Cooler initial temperature represents more initial inventory for the non-condensable gases, and consequently higher long-term containment pressure. Therefore, the reported DBA analyses were performed at 115 °F to ensure conservative peak drywell pressure.

DCD Section 6.2.1.1.3 will be revised in the next update to include the above discussion.

NRC RAI 6.2-65

The nominal drywell humidity is listed as 100% (Table 6.2-2). The reported DBA analyses were done at 20% (Table 6.2-6). Provide an explanation of the humidity used to ensure a conservative evaluation. Include this information in the DCD Tier 2.

GE Response

The lower bound on the relative humidity in the drywell is 20%. The lower bound value was selected, because a lower initial drywell relative humidity results in more non-condensable gases available to be transferred to the wetwell and higher containment pressures following the LOCA.

DCD Section 6.2.1.1.3 will be revised in the next update to include the above discussion.

NRC RAI 6.2-66

The PCCS temperature and level (initial volume) are not listed in DCD Tier 2, Table 6.2-2. The reported DBA analyses were done at 110 °F (Table 6.2-6), with no reference to level (volume). Provide an explanation of the temperature (under certain conditions the temperature could be 115 °F) and level used to ensure a conservative evaluation. Provide a system diagram for the PCCS which discusses the temperature control system and provide a discussion on the allowable temperature range and level for continued operation. (DCD Tier 2, Rev. 1 did not contain Technical Specifications (TS), DCD Tier 2 Rev. 0 TS 3.6.2.3 and 3.6.2.3 do address these items.) Include this information in the DCD Tier 2.

GE Response

The water volumes and levels for various PCCS pools are provided in Response to RAI 6.2-74. The Technical Specifications (TS), (DCD Tier 2 Rev. 1, TS 3.7.5) identify the following Surveillance Requirements (SR):

SR 3.7.5.1	Verify water levels in the IC/PCC expansion pools are ≥ 4.8 meters (15.75 feet).
SR 3.7.5.2	Verify water levels in the equipment pool and reactor well are ≥ 6.7 meters (22.0 feet).
SR 3.7.5.3	Verify average water temperature in IC/PCC pools is ≤ 43.3 °C (110 °F).

The reported DBA analyses were done at maximum IC/PCC pool water temperature and minimum water levels in the TS to assure conservative evaluation.

The cooling and level control of the PCC/IC pools is done by a separate subsystem within the FAPCS system. DCD Rev. 1, Figure 9.1-1 shows the system diagram, and DCD Rev. 1, Tables 9.1-1, -2 and –3 provide the system data.

DCD Section 6.2.1.1.3 will be revised in the next update to include the above discussion.

NRC RAI 6.2-67

The suppression temperature in hot standby is listed as 130 °F in DCD Tier 2, Table 6.2-2. The reported DBA analyses were done at 110 °F (Table 6.2-6), with 110 °F the maximum under normal operation. Include this information in the DCD Tier 2.

A. Provide an explanation of the temperature used to ensure a conservative evaluation.

B. Provide a discussion of the impact of operation at less than 100% power (plus calorimetric uncertainty) with respect to the stored energy and mass in the primary system which would be released to containment during a DBA, and include the containment conditions for these situations. Is there a mode of operation which would result in a higher calculated DBA containment pressure or temperature?

GE Response

(A) The suppression pool average temperature during normal operation is ≤ 110 °F, and the maximum pool temperature of 110 °F is used in the safety analyses.

According to the Technical Specifications (DCD Chapter 16, Section 3.6.2.1), the reactor is required to reduce thermal power to ≤ 1% of rated thermal power when the suppression pool temperature ≥ 110 °F, and the reactor will be switched to shutdown mode immediately when the suppression pool temperature ≥ 120 °F.

(B) For operation at less than 100% power, the integrated blowdown energy (the decay heat is the key contributor) from the primary system to the containment during a DBA will be smaller comparing to the case operating at 100% power.

For the feedwater line break, the maximum drywell pressure occurs at about 80 seconds during the blowdown period (DCD Tier 2, Rev.1, Table 6.2-7). Smaller integrated blowdown energy is expected to result in lower peak drywell pressure.

The long-term containment pressure depends on the wetwell partial steam pressure, which depends on the amount of blowdown energy that is discharged into the suppression pool. Figure 6.2-11 (DCD Tier 2, Rev.1, Section 6.2.1.1.3.1) compares the total PCC heat removal versus the decay heat. For the first ~9 hours of the transient, the decay heat is greater than the PCC removal power. The amount that is not removed by the PCC will end up in the suppression pool and will increase the pool temperature accordingly. For operation at less than 100% power, the decay heat is lower and the equilibrium point between the decay heat and the PCC removal power will occur sooner. Consequently, there will be less heatup on the pool water, resulting in lower drywell pressure.

According to the above discussion, it is expected that the DBA conditions result in the maximum calculated containment pressure or temperature.

DCD Section 6.2.1.1.3 will be revised in the next update to include the above discussion.

NRC RAI 6.2-68

Include in DCD Tier 2, Table 6.2-2, the GDCS pool data (both water and gas space temperatures) for normal operation and used for the accident analyses to ensure a conservative evaluation. Provide an explanation of the temperature used to ensure a conservative evaluation. Include this information in the DCD Tier 2.

GE Response

The gas space above the GDCS pools is in open communication with the upper drywell. The initial GDCS pool water and gas space temperatures are assumed to be the same as that in the drywell. The reported DBA analyses were performed at 115 °F for both the drywell gases and the GDCS pool water. Response to RAI 6.2-64 discusses how this results in conservative peak drywell pressure.

DCD Tier 2, Table 6.2-2 will be revised in the next update as noted in the above discussion.

<u>NRC RAI 6.2-69</u>

Provide a discussion of how the various containment volumes (gas space in drywell, wetwell and GDCS pool, water volume in the suppression and GDCS pools) were evaluated to ensure a conservative evaluation of the containment response to DBAs. Include this information in the DCD Tier 2.

<u>GE Response</u>

The net drywell gas space volume is calculated by subtracting the displaced volumes occupied by equipment and structures that are located inside the drywell from the gross drywell volume. The gross drywell volume is calculated from the available arrangement drawings. The displaced volumes of equipments and structures, including the RPV, reactor shield wall, GDCS pool structures, RPV support brackets, FMCRDs, and the protective layer on basemat, are calculated from the design drawings. Other piping, equipment and miscellaneous structures are assumed to displace a total of 1% of the gross volume. This 1% assumption is based on engineering judgment and is judged to be smaller than the actual value when the final design drawings are available. This assumption results in more initial drywell gas mass and higher long-term containment pressure.

The net wetwell gas space volume is calculated by subtracting the displaced volume occupied by the equipment hatches that are located in this region from the gross volume. The displaced volume by the equipment hatch is assumed to be 0.1% of the total gross volume. The net gas space volume above the GDCS pools is calculated from the gross volume. Other equipments and structures located in these regions are assumed to be insignificant as comparing to the total gross volumes. The gross drywell volumes are calculated from the available arrangement drawings.

The net GDCS pool water volumes (total volume and non-drainable volume) are calculated from the available arrangement drawings and GDCS drain pipe suction elevation. The net suppression pool water volume is calculated from the available arrangement drawings. Other equipments and structures located in these regions are assumed to be insignificant as comparing to the total gross volumes.

DCD Section 6.2.1.1.3 will be revised in the next update to include the above discussion.

NRC RAI 6.2-70

A. Provide a discussion of how the various primary system volumes and heat structures (piping, reactor pressure vessel, etc.) were evaluated to ensure a conservative evaluation of the containment response to DBAs. How does this treatment relate to the emergency core cooling system (ECCS) analysis in DCD Tier 2, Section 6.3? Include this information in the DCD Tier 2.

B. The reactor power and reactor pressure are provided for the bounding case. What is the reactor temperature during normal operation and what is the temperature used to ensure a conservative containment calculation? Include this information in DCD Tier 2, Table 6.2-6. Include this information in the DCD Tier 2.

GE Response

A. The volumes in various regions inside the reactor pressure vessel are calculated from the available design drawings. The heat structures for the reactor internal components (such as steam dryer, chimney partitions, shroud, top guide, fuel support, core plate, and feedwater spargers) are simulated by appropriate lumped heat masses or double-sided heat slabs in the TRACG model. The vessel bottom head, top head and vertical cylindrical wall are simulated by appropriate lumped heat masses. The volumes and heat masses of steam separators, guide tubes, fuel and fuel assemblies are modeled as separate TRACG components and are based on available drawings.

The volumes of other piping and systems that are external to the vessel (such as main steam lines, feedwater lines, IC system, PCCS system, and GDCS lines) are also calculated from available drawings. However, the heat masses of these structures are not simulated in the DCD TRACG model.

The same DCD TRACG model is used for analyses reported in both Sections 6.2 and 6.3. For ECCS/LOCA analyses, the focus or figure of merit is the minimum chimney static head during the first 2000 seconds following the LOCA initiation. The vessel volumes and heat masses are two of the few key parameters that would affect the short-term water inventory, and they are simulated in the TRACG model in detail.

For Containment/LOCA analyses, the focus or figure of merit is the peak drywell pressure. The limiting case is the Feedwater Line Break and the peak drywell occurs at about 80 seconds. Again, the vessel internal heat masses are simulated in detail to calculate the short-term stored energy and the short-term peak drywell pressure.

The heat structures of piping and systems external to the vessel are not simulated in the DCD TRACG model. Results of parametric study (NEDC-33083P-A, Response to RAI 298) show that the heat slab in the drywell has a very small impact on the containment response. An increase of 25% vertical DW heat slab area results in a change of 0.04 psi in the long-term containment pressure.

B. For a specified set of power and dome pressure, the TRACG model is performed with a steady-state initialization run to assure the appropriate initial conditions (such as pressures, temperatures, void fractions, flows, etc…) prior to the LOCA initiation. The reactor dome temperature corresponds to the saturation temperature at the specified dome pressure. DCD Tier 2, Table 6.2-6 will be revised to include these temperatures in the next update.

DCD Section 6.2.1.1.3 will be revised in the next update to include the above discussion.

NRC RAI 6.2-71

Since the DCD version of the TRACG model is nodalized for the free volumes and pool regions, how are the temperatures combined to determine the values shown in the figures provided. Include this information as an update to NEDC-33083P-A, "TRACG Application for ESBWR."

GE Response

DCD Rev. 1, Figures 6.2-10 and 6.2-13 show the drywell gas temperature, wetwell gas temperature and suppression pool temperature. These temperatures represent the maximum envelope of the corresponding temperatures from all the cells residing in the interested region, and are calculated as follows. For example, there are 10 cells located in the suppression pool. At each time step, the combined suppression pool temperature selects the maximum liquid temperature from these 10 cells.

It should be mentioned that individual cell temperatures provide better description of the response to thermal stratification (such as that in the suppression pool and in the wetwell). Figures 6.2-10 and 6.2-13 will be replaced/or supplemented by individual cell temperatures in the next update to DCD Section 6.2.

These discussions will be included in the Supplement in DCD Section 6.2.

NRC RAI 6.2-72

Systems are identified as part of the DCD version of the TRACG model, but are not shown in the nodal scheme, therefore a more complete nodalization should be provided, including, for example, the ICS, SLCS and the feedwater system. Include this information in the DCD Tier 2.

GE Response

The TRACG nodalization schematic diagrams for the ICS and Feedwater system are shown in the following two figures. The SLCS is simulated via a FILL component (FILL0037) that injects boric liquid into the RPV at the mid-elevation of the outer bypass (RPV axial Level # 5, Ring # 3).

DCD Section 6.2.1.1.3 will be revised in the next update to include the above discussion.

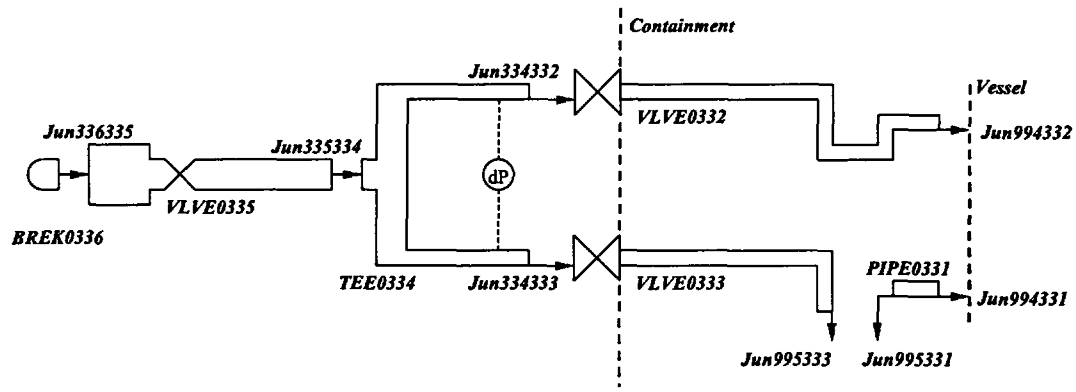
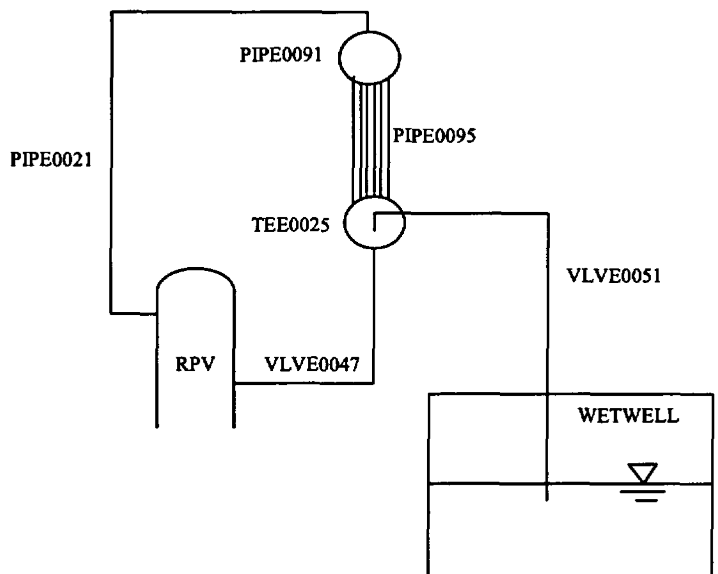


Figure 6.2-72_a Feedwater Line Model for FWL Break Analysis



Component	Description
PIPE0021	IC Steam Supply Line
PIPE0091	IC Steam Box
PIPE0095	IC Tube
TEE0025	IC Water Box
VLVE0051	IC Vent Line
VLVE0047	IC Drain Line

Figure 6.2-72_b TRACG Nodalization of the ESBWR IC System

NRC RAI 6.2-73

A. Does the critical flow factor (set to 1.19 in the bounding feedwater line break to account for the upper uncertainty range for choked flow, and set to 1.0 for the nominal case) applied to all lines, such as the SRVs, DPVs, both sides of the break, etc? Is the same factor used for other breaks (MSLB, GDCS and bottom drain line) and in the same manner? Include this information in the DCD Tier 2.

B. Indicate the critical flow models (e.g., Moody, homogeneous equilibrium, etc.) used for choked paths such as the SRVs,DPVs, FWLB (RPV side), FWLB (BOP side), and DW main vents. Include this information in the DCD Tier 2.

GE Response

A. A model multiplier of 1.0 is applied to the critical flow for the nominal cases for all breaks. The choked flow uncertainty in the TRACG model has been determined to be $1\sigma = 0.095$, or $\pm 2\sigma = \pm 0.19$. For the bounding case, if the short-term peak pressure were the figure of merit (such as the feedwater line break case), a model multiplier of 1.19 is applied to the critical flow to account for the upper uncertainty range for choked flow. It should be mentioned that for the long-term containment pressure, the SBWR uncertainty analysis (NEDE-32178P Rev.1) shows that a smaller critical flow multiplier results in higher DW peak pressure. Hence, if the long-term peak pressure were the figure of merit (such as MSLB, GDCS and bottom drain line break cases), a model multiplier of 0.81 is applied to the critical flow for the bounding cases.

B. The TRACG critical flow model is applied to all flow paths at locations where the choking calculation are specified in the input model. These choked paths include the SRVs, DPVs, FWLB (RPV side), FWLB (BOP side), and DW main vents.

DCD Section 6.2.1.1.3 will be revised in the next update to include the above discussion.

NRC RAI 6.2-74

Provide a description, and drawings, of the PCCS and ICS upper pool volumes per unit (m3) with the location (elevation in meters) and areas (m2) of connective pathways, and other connected pool volumes (storage, etc.) with connective pathways.

GE Response

Figure 6.2-74 shows the plan view of the PCCS and ICS upper pools and Table 6.2-74 summarizes the water volume, water depth and area of these pools. The bottom floor of these pools is located at elevation 27.0 meters from the RPV bottom (0.0 m).

The Reactor Well (Pool # 18) and the Dryer/Separator Storage Pool (Pool # 17) are connected with a large opening during normal operation. The initial water depth of these pools is at 6.7 m, while water depth of other pools is at 4.8 m. There are two valves connecting the Dryer/Separator storage pool (Pool # 17) and the IC/PCC inner expansion pools (Pool # 3 and # 11). These valves are located at an elevation near the pool bottom. These valves are normally closed and will open when the water level in the PCC pool drops below the elevation of 29.6 m. At this elevation, the top ¼ portion of the IC/PCC tubes becomes uncovered.

Table 6.2-74 Summary of IC/PCC Pools Water Volume

Pool Description	Pool	Area	Water Depth	Water Volume	Equipment Displacement Volumes*	Total Water Volume
	#	(m^2)	(m)	(m^3)	(m^3)	(m^3)
Moisture Separator Pool A	1	34.3	4.8	164.6	-	164.6
IC/PCC Outer Expansion Pool A	2	148.0	4.8	710.4	-	710.4
IC/PCC Inner Expansion Pool Total	3	194.8	4.8	935.0	-	935.0
IC Heat Exchanger Room A	4	16.7	4.8	80.2	19.6	60.6
PCC Heat Exchanger Room A	5	25.4	4.8	121.9	20.6	101.3
PCC Heat Exchanger Room E	6	25.4	4.8	121.9	20.6	101.3
PCC Heat Exchanger Room B	7	25.4	4.8	121.9	20.6	101.3
IC Heat Exchanger Room B	8	16.7	4.8	80.2	19.6	60.6
Moisture Separator Pool B	9	34.3	4.8	164.6	-	164.6
IC/PCC Outer Expansion Pool B	10	148.0	4.8	710.4	-	710.4
IC/PCC Inner Expansion Pool B Total	11	194.8	4.8	935.0	-	935.0
IC Heat Exchanger Room C	12	16.7	4.8	80.2	19.6	60.6
PCC Heat Exchanger Room C	13	25.4	4.8	121.9	20.6	101.3
PCC Heat Exchanger Room F	14	25.4	4.8	121.9	20.6	101.3
PCC Heat Exchanger Room D	15	25.4	4.8	121.9	20.6	101.3
IC Heat Exchanger Room D	16	16.7	4.8	80.2	19.6	60.6
Total		973.4		4672.2	202.0	4470.2
Dryer/Separator Storage Pool	17	165.9	6.7	1111.7	-	1111.7
Reactor Well	18	148.8	6.7	997.2	298.0	699.2
Total				2108.9	298.0	1810.9
*Displaced volumes						

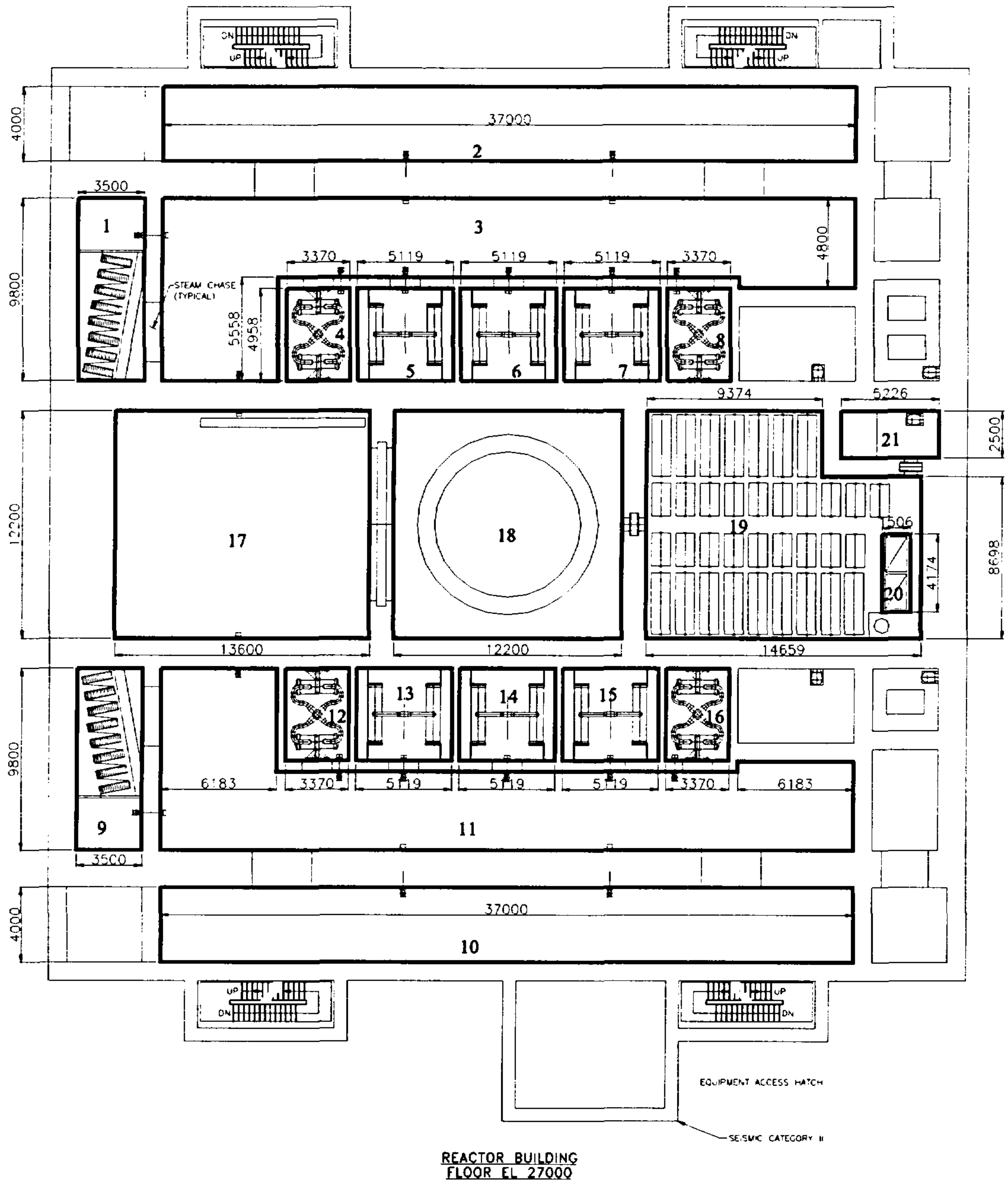


Figure 6.2-74 IC/PCC Pools Configuration