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Subject: Response to Portion of NRC Request for Additional Information Letter No. 111 Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-98 S01 Revision 1

Enclosure 1 contains the GE Hitachi Nuclear Energy (GEH) response to the remaining portion of the subject NRC RAI transmitted via the Reference 1 letter. The other portions of this RAI were previously responded to in the Reference 2 letter.

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

Sincerely,

Richard E. Kingston

Richard E. Kingston
Vice President, ESBWR Licensing

D068
NRO

References:

1. MFN 07-556, Letter from U.S. Nuclear Regulatory Commission to Robert E. Brown, *Request for Additional Information Letter No. 111 Related to ESBWR Design Certification Application*, October 15, 2007
2. MFN 08-011, Letter from James C. Kinsey to U.S. Nuclear Regulatory Commission, *Response to Portion of NRC Request for Additional Information Letter Nos. 33 and 68 Related to ESBWR Design Certification Application - Containment Systems - RAI Numbers 6.2-56 S01 and 6.2-98 S01*, January 9, 2008

Enclosures:

1. MFN 08-454 - Response to Portion of NRC Request for Additional Information Letter No. 111 Related to ESBWR Design Certification Application - Containment Systems - RAI Number 6.2-98 S01 Revision 1

cc:	AE Cubbage	USNRC (with enclosures)
	DH Hinds	GEH/Wilmington (with enclosures)
	GB Stramback	GEH/San Jose (with enclosures)
	RE Brown	GEH/Wilmington (with enclosures)
	eDRF	0000-0083-3695

Enclosure 1

MFN 08-454

Response to Portion of NRC Request for Additional Information Letter No. 111 Related to ESBWR Design Certification Application

Containment Systems

RAI Number 6.2-98 S01 Revision 1

This revision provides a response to only a portion of NRC RAI 6.2-98 S01. The other portions of this RAI were previously responded to in letter MFN 08-011, dated January 9, 2008, and this previous response is not repeated here.

NRC RAI 6.2-98 S01 Revision 1:

RAI 6.2-98 was a followup to RAI 6.2-53 (MFN 06-215). The intent of these RAIs was to understand the TRACG calculation for the bounding scenario. ESBWR DCD Tier 2 provides limited information that is insufficient to understand the analyses. These RAIs focused on key phenomena-the trapping and transient distribution of noncondensable gases in the drywell and subsequent transport to the wetwell.

(E) During a phone call with the staff on September 24, 2007, GEH discussed a potential design change to add a drywell gas recirculation system to the PCCS which will start operating three days after the initiation of a LOCA to improve the PCCS's ability to remove thermal energy from the containment. In your response, please address the effect of the drywell gas recirculation system and any other systems that you plan to credit in your analyses.

GEH Response:

(E) At three days after the initiation of a loss-of-coolant accident (LOCA), several mitigating measures would be in place to reduce the containment pressure and temperature, and to maintain them at reduced levels well below design limits. These measures are (1) to provide Isolation Condenser (IC)/Passive Containment Cooling (PCC) pool makeup water to improve the PCC condenser efficiency, (2) to activate the PCC vent fans (drywell gas recirculation system) to enhance the heat exchanger efficiency by removing the accumulation of non-condensable (NC) gases from the PCC condensers and circulating these gases to the Gravity-Driven Cooling System (GDCS) pool space and back to the drywell (DW), and (3) to take credit of the Passive Autocatalytic Recombiner System (PARS) in the analyses after three days. The effects of these measures on the containment pressure response have been analyzed and the key results are discussed in the response to RAI 6.2-139 (MFN 08-357, dated April 19, 2008). The response to RAI 6.2-139 also describes the PCC vent fan system, including functional arrangement and schematic diagram.

The following paragraphs provide additional discussions on the transient distribution of NC gases in the DW and GDCS pool space and subsequent transport to and from the wetwell (WW), before and after the activation of the PCC vent fans.

(1) Description of the Cases

The base case for this evaluation is a guillotine break in the main steam line under bounding conditions. For all cases described in this response, the steam bypass leakage area between the DW and WW is assumed to be the

nominal value of 1 cm^2, with a single depressurization valve (DPV) failure-to-open occurrence.

The following paragraphs discuss the effect of the PCC vent fans, based on an assumption of a nominal bypass leakage area of 1 cm^2. After the activation of PCC vent fans and IC/PCC pool refilling at 72 hours following a LOCA, the DW pressure drops to and remains at or below the value of WW pressure. The impact of steam bypass leakage on the containment pressure becomes very small or non-existent. Consequently, the effect of the PCC vent fans for the case with bypass leakage area of 2 cm^2 (licensing basis) is expected to be similar to those discussed below that assume a bypass leakage area of 1 cm^2.

From 0 to 72 hours following a LOCA, the analyses assume no credit from the PARS, PCC vent fans, or any other active systems. This part of the analyses is described in DCD Revision 3, Section 6.2, as the Main Steam Line Break bounding case ("MSL3_1DPVCB_NL2Pa-72").

From three to seven days following a LOCA, the analyses continue from the above calculation with no credit from the PARS. However, the IC/PCC pools are continuously refilled starting at 72 hours following a LOCA with 201 gpm of water at 100°F. Two cases are performed, one case with six PCC vent fans, (i.e., one PCC vent fan for each of the six PCC vent lines), and the other case with four PCC vent fans, (i.e., one PCC vent fan for each of the first four PCC vent lines, no vent fan for the other two PCC vent lines).

For these two cases, the PCC vent fans discharge the NC gases into the DW annulus. The effect of PCC vent fan discharge location on the DW pressure is discussed in Item (4) below. The effect of additional credit from the PARS on the DW pressure is discussed in Item (5) below.

(2) Discussions of the Key Transient Responses

Figure 6.2-98S01R01-1 and Figure 6.2-98S01R01-2 show the pressure and NC gas mass responses in the DW and WW from 0 to seven days (0 to 168 hours). Figure 6.2-98S01R01-3 shows the NC gas mass responses in the DW head and GDCS gas spaces from 0 to seven days (0 to 168 hours).

The key transient responses from 0 to 72 hours are discussed in Item (A1) of the response to RAI 6.2-139 (MFN 08-357, dated April 19, 2008). During the first three days of the transient, the IC/PCC pool level drops due to boil-off by the decay heat. At the end of 72 hours, the IC/PCC pool water covers about 65% of the PCC condenser tube length. At 72 hours, the PCC vent fans and the IC/PCC pool refilling are initiated. The PCC vent fans remove the accumulated NC gases from the bottom portion of the PCC condenser tubes and discharge them into the DW. The IC/PCC pool refilling continuously increases the portion of the PCC condenser tube that is covered by the IC/PCC pool water. Both actions enhance the PCC condenser heat removal rate, condensing more DW steam. As a result, the DW pressure drops rapidly shortly after the activation of these actions (Figure 6.2-98S01R01-1). Shortly after 72 hours, the DW pressure drops below the WW pressure,

resulting in vacuum breaker (VB) openings and reversed leakage flow (i.e., from the WW to the DW). The gas mixture (mostly NC gases) flows back from the WW to the DW through the VBs and leakage path (Figure 6.2-98S01R01-4). This continued relocation of NC gases from the WW to the DW results in continued pressure reduction in the WW (Figure 6.2-98S01R01-1).

Transient Responses for the Case using Six PCC Vent Fans

Prior to 72 hours, there is a very small amount of NC gases remaining in the DW, DW head, and GDCS gas spaces (Figure 6.2-98S01R01-2 and Figure 6.2-98S01R01-3). After 72 hours, the gas mixture (mostly NC gases) flows from the WW to the DW through the VBs and the leakage path. While inside the DW, the NC gases mix with the steam (from the DPVs and break pipe) in the DW and enters into the PCC condensers. The PCC condensers condense the steam and the condensate drains to the GDCS pools. The PCC vent fans remove the NC gases accumulation from the bottom of the PCC condenser tubes, discharging them back into the DW (instead of purging the NC gases into the WW). This process results in steady accumulation of NC gases in the DW, DW head, and GDCS gas spaces. Correspondingly, the NC gas mass in the WW is reduced by the same amount that is transferred to the DW. The WW and DW pressures (Figure 6.2-98S01R01-1) decrease as the NC gas mass in the WW is reduced (and by the increased steam mixture flow through the PCC condensers caused by the increased differential pressure across the PCC condensers). The pressure reduction is proportional to the total amount of NC gases that are removed from the WW (and the differential pressure across the PCC condensers).

With the operation of PCC vent fans, the PCC condenser heat removal capacity depends on the steam mixture flow rate and the NC gas mass fraction at the inlet of the PCC condensers. For a fixed flow rate, the heat removal capacity is reduced as the PCC condenser inlet NC gas fraction is increased. The inlet NC gas fraction is increased as the amount of NC gas mass in the DW is increased. After 144 hours, the DW NC gas mass reaches a quasi-equilibrium level. At this level, the PCC condenser heat removal capacity matches the steaming rate into the DW. As a result, the DW pressure also reaches a quasi-equilibrium level at about 310 kPa (Figure 6.2-98S01R01-1).

Figure 6.2-98S01R01-5 shows the comparison between the decay heat and the PCC condenser heat removal rate for the case using six PCC vent fans. The six PCC condenser units are modeled as two separate components in the TRACG model; one component models two PCC condenser units and the other one models four PCC condenser units. This figure shows heat removal rates for the total and for the individual components. The heat loads are evenly distributed among these PCC components. At 72 hours, there is a surge of heat removal rate due to the initiation of PCC vent fans and IC/PCC pool refilling (negligible contribution from the refilling in such a short period of time).

Transient Responses for the Case using Four PCC Vent Fans

This case is analyzed using four PCC vent fans, (i.e., one PCC vent fan for each of the first four PCC vent lines, no vent fan for the other two PCC vent lines). Figure 6.2-98S01R01-1 to Figure 6.2-98S01R01-3 show the pressure and NC gas mass responses. Figure 6.2-98S01R01-6 shows the comparison between the decay heat and the PCC condensers heat removal rate for the case using four PCC vent fans.

The pressure drop responses are similar in pattern to that for the case using six PCC vent fans. At 72 hours, the DW and WW pressures drop rapidly shortly after the activation of the PCC vent fans and IC/PCC pool refilling. From 72 to 168 hours, the DW pressure remains at or below the WW pressure (Figure 6.2-98S01R01-1). During this time period, there are no PCC vent fans or pressure difference (DW – WW) to drive the steam gas mixture flowing through the component that models the two PCC condenser units with no PCC vent fans. As a result, NC gases are accumulated inside the PCC condenser tubes and shuts off these two PCC condenser units. The heat removal capacity of the two PCC components decreases to zero shortly after 72 hours (Figure 6.2-98S01R01-6).

Consequently, the four PCC components pick up the total heat load from the decay heat (Figure 6.2-98S01R01-6). On the basis of per unit of PCC in the four PCC component case, the heat load for the case using four PCC vent fans is about 50% higher than that for the case using six PCC vent fans. To achieve higher heat removal rate, the inlet NC gas mass fraction is necessary to remain at a lower value, and therefore lower NC gas mass can be stored in the DW. Figure 6.2-98S01R01-2 shows that the total amount of NC gas mass that can be redistributed back into the DW. This amount is proportional to the total PCC vent fan capacity. Similarly, the overall pressure reduction (Figure 6.2-98S01R01-1) is proportional to the total PCC vent fan capacity, because it depends on the total amount of NC gases that are removed from the WW and the pressure differential developed across the PCC condensers.

(3) Effect of Total PCC Vent Fan Capacity

Item (2) in this response discusses the transient responses for the cases using six PCC vent fans and using four PCC vent fans. The total amount of NC gas mass that can be redistributed back into the DW is proportional to the total PCC vent fan capacity (Figure 6.2-98S01R01-2). Similarly, the overall pressure reduction (Figure 6.2-98S01R01-1) is proportional to the total PCC vent fan capacity, because it depends on the total amount of NC gases that are removed from the WW and the pressure differential developed across the PCC condensers.

(4) Effect of PCC Vent Fan Discharge Location

The key transient responses discussed in Items (2) and (3) are from cases where the PCC vent fans discharge to the DW annulus. Parametric cases have been performed to assess the effect of PCC vent fan discharge location (Figure 6.2-139-4 in the response to RAI 6.2-139 (MFN 08-357, dated

April 19, 2008). The results show that there is a small improvement in the pressure response if the PCC vent fan discharge is relocated from the DW annulus to the GDCS pool compartment since some amount of NC gases is forced to reside in the GDCS pool space.

(5) Effect of PARS After the Activation of PCC Vent Fans

The key transient responses discussed in Items (2) and (3) are from cases with the PCC vent fans activated after 72 hours, but with no credit from the PARS. Parametric cases have been performed to assess the effect of PARS after the activation of PCC vent fans (Figure 6.2-139-5 in the response to RAI 6.2-139 (MFN 08-357, dated April 19, 2008)). When PARS is credited, the credit is simulated as the rate of production of NC gases equal to the rate of their recombination by the PARS. The results show that there is a small improvement in the pressure response when PARS is credited.

DCD Impact:

No DCD changes will be made in response to this RAI.

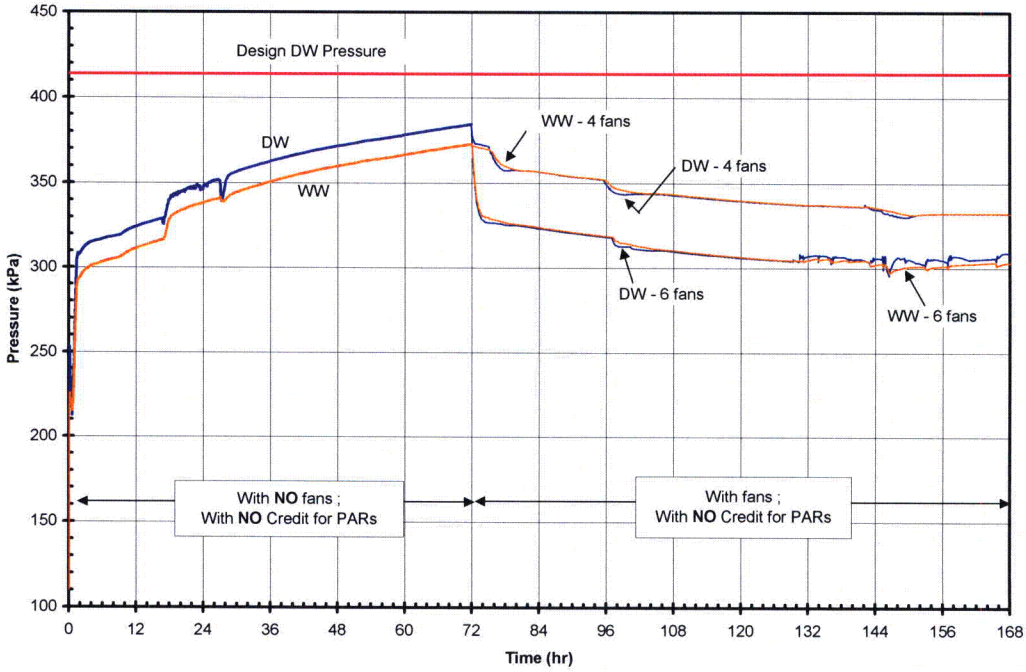

Figure 6.2-98S01R01-1. Pressure Responses in DW and WW

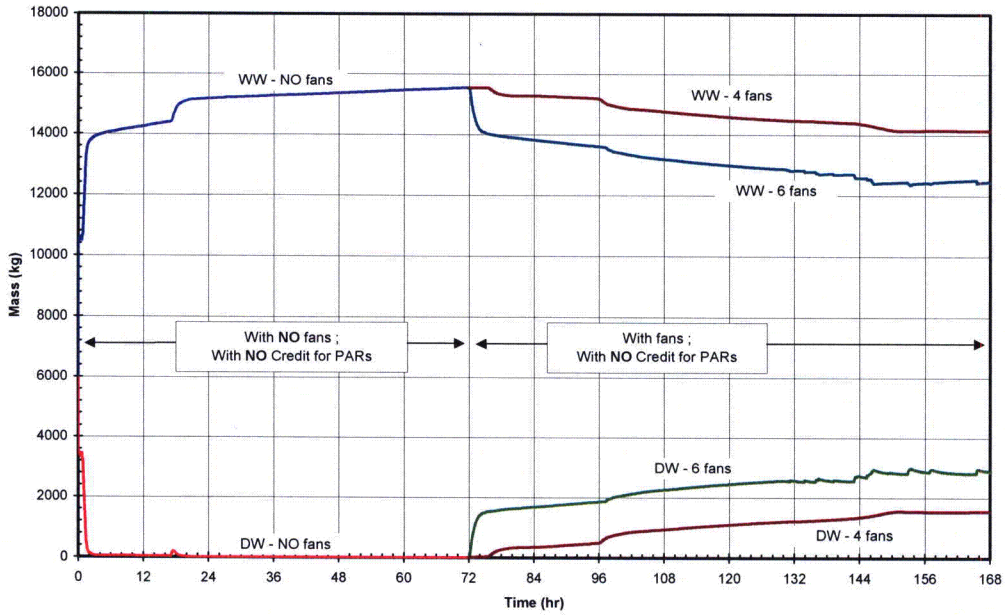

Figure 6.2-98S01R01-2. NC Gas Mass Responses in DW and WW

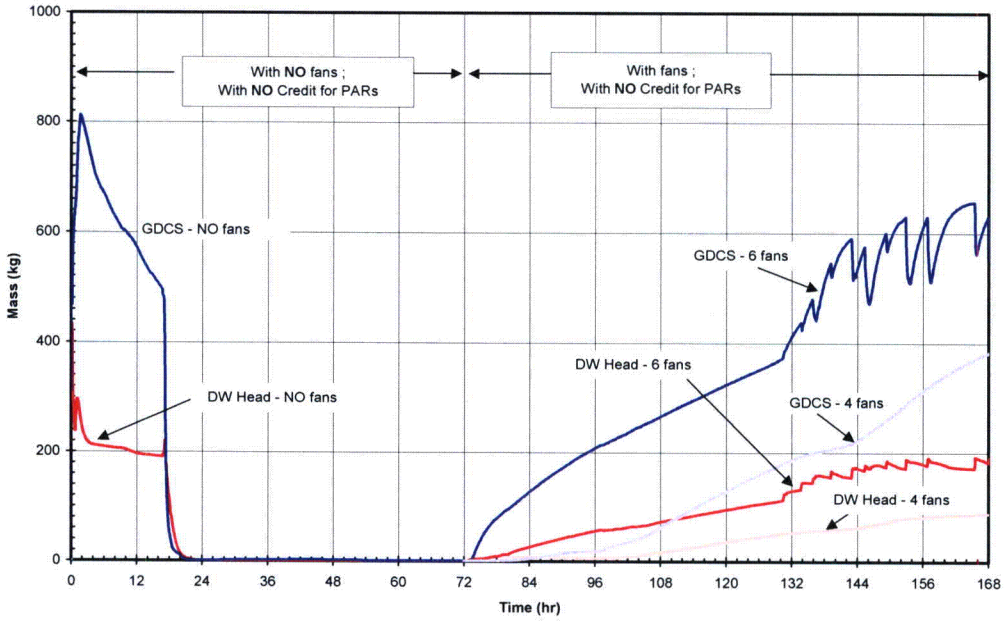

Figure 6.2-98S01R01-3. NC Gas Mass Responses in DW Head and GDCS Gas Spaces

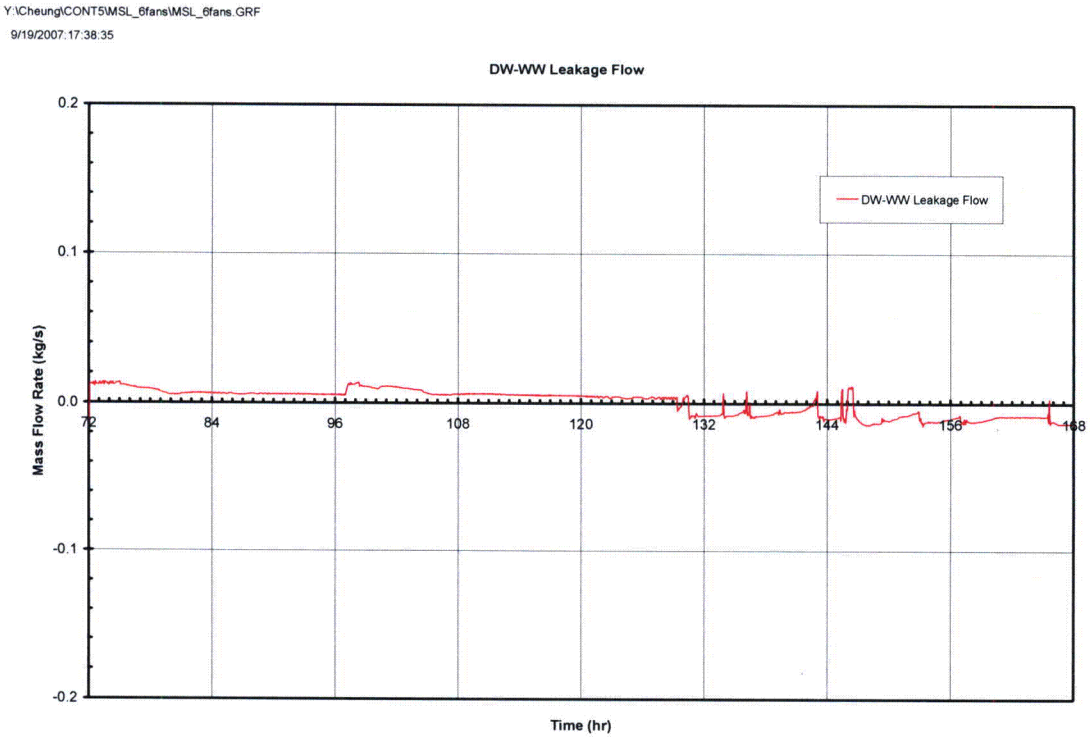

Figure 6.2-98S01R01-4. DW-WW Leakage Flow - Six PCC Vent Fans (Negative value corresponding to leakage flow from DW to WW)

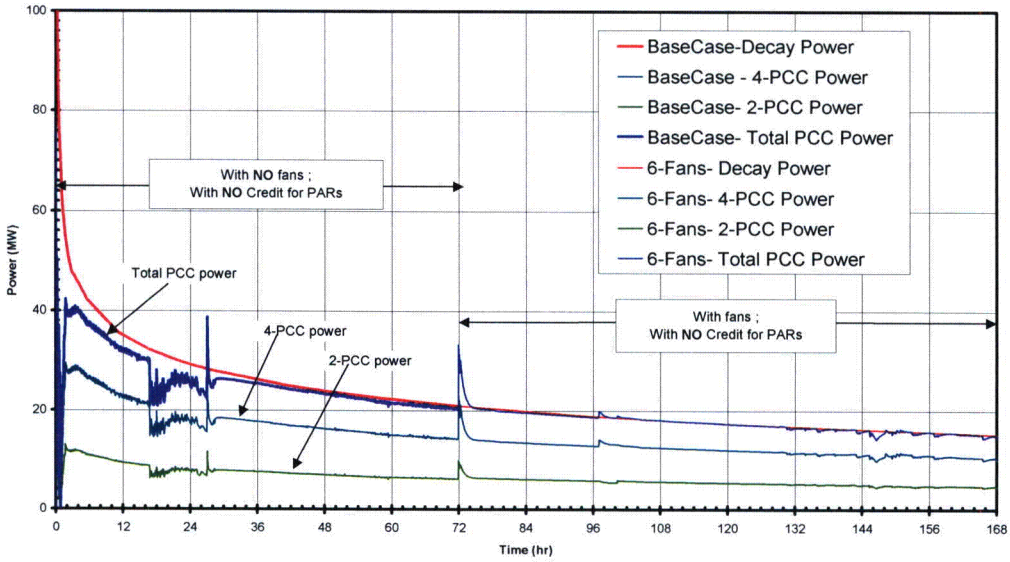

Figure 6.2-98S01R01-5. Decay Heat and PCC Condenser Heat Removal - Six PCC Vent Fans

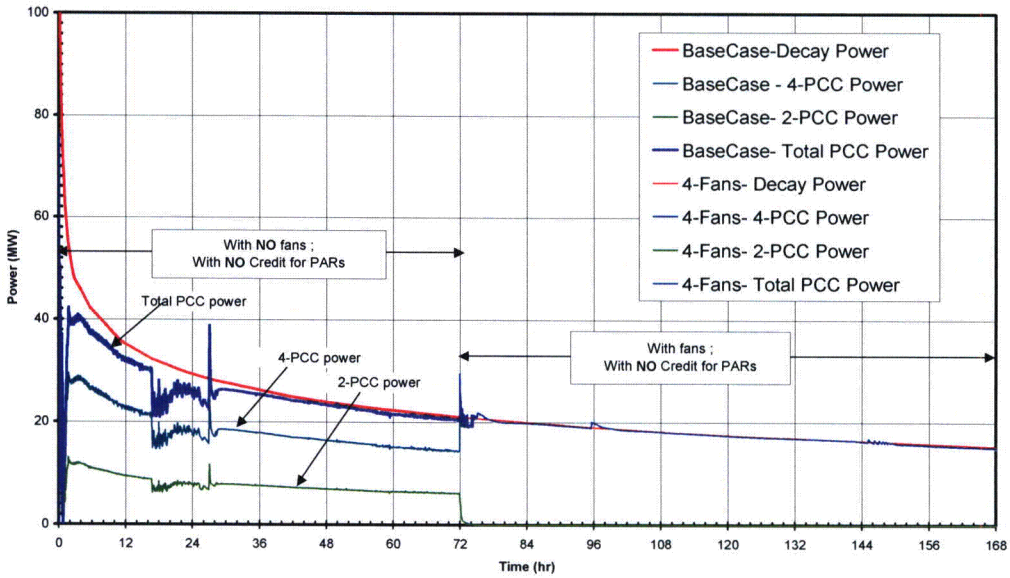

Figure 6.2-98S01R01-6. Decay Heat and PCC Condenser Heat Removal - Four PCC Vent Fans