6.0 Engineered Safety Features

6.2.1.3 Short-Term Pressure Response

6.2.1.3.1 Regulatory Criteria

The applicant proposed changes to the certified ABWR DCD as a result of its identification of an error in the containment peak pressure analysis as discussed in a letter dated June 8, 2009 (ADAMS Accession No. ML100640164). In Enclosure 1 of the letter dated December 7, 2010, transmitting its application to renew the ABWR DCR (ADAMS Accession No. ML110040176), the applicant stated, in part, that:

> the containment peak pressure reanalysis complies with NRC regulations that were in place at the time of certification, as required by 10 CFR 52.59(a), the amendment also complies with current applicable NRC regulations. GEH expects that the applicable regulations will remain the same during the NRC review of the application. However, if the NRC amends those regulations during the time period of its review, GEH will review such amendments to determine if any further changes are necessary.

The staff assessed the proposed changes associated with the containment peak pressure reanalysis and determined that some of the changes would meet the criteria for modifications while others would be identified as amendments, as these terms are defined in Chapter 1 of this supplement. However, due to the interrelationship of the proposed changes, the staff decided to treat all the proposed changes as “amendments” to the certified design and will correspondingly evaluate the changes using the regulations applicable and in effect at renewal. This decision is supported by GEH’s statement above regarding compliance with current regulations. In addition, the staff determined that the pertinent requirements in current regulations and associated staff guidance for the review of the proposed changes are not substantially different than the regulations and associated guidance in effect at the time of the original certification. Therefore, by conducting the review against current regulations, the staff’s evaluation also supports a finding of compliance with the applicable regulations in effect at initial certification.

The NRC staff’s requirements are specified in 10 CFR Part 50, Appendix A, General Design Criteria (GDCs) 16 and 50, as they relate to the containment and its associated systems being able to accommodate, without exceeding the design leakage rate and with sufficient margin, the calculated pressure and temperature conditions resulting from any loss-of-coolant accident. NUREG-0800, "Standard Review Plan" (SRP), Section 6.2.1.1.C, "Pressure-Suppression Type BWR Containments" (Revision 7), provides guidance on analytical models that are acceptable for calculating the containment peak pressure and temperature.

6.2.1.3.2 Summary of Technical Information

ABWR DCD, Revision 6, Tier 2, Section 6.2 includes the following changes from the original ABWR certification, incorporating proposed changes contained in GEH’s response to RAI 06.02.01.01.C-1, Revision 1 dated August 11, 2015 (ADAMS Accession No. ML14239A137):

- A change in decay heat curves assumed for the long-term containment analysis from nominal ANSI/ANS–5.1 (1979) to ANSI/ANS-5.1 (1994) with a two standard deviation uncertainty on decay heat

- Containment vent system modeling changes to include the drywell connecting vent (DCV) loss coefficients to correct the modeling of horizontal vents

- The feedwater line break (FWLB) flow changes to remove the initial 3.75-second inventory depletion period in the original DCD Figure 6.2-3

- A change in the suppression pool water level assumed for the long-term containment response analysis from 7 meters (equivalent to a volume of 3,580 cubic meters) to 6.9 meters (equivalent to a volume of 3,455 cubic meters)

- A change in the residual heat removal system (RHR) heat exchanger overall heat transfer coefficient assumed for the long-term containment response from 3.7x105 W/°C to 4.27x105 W/°C (an approximately 15% increase)

- Wetwell design temperature change from 104°C to 124°C

- Negative pressure design evaluation changes including (a) eliminating analyses for events with inadvertent initiation of containment (drywell/wetwell) spray during normal operation, (b) taking credit for heating of emergency core cooling system (ECCS) flow in the reactor pressure vessel before being discharged into the drywell, and (c) using the GEH SUPERHEX computer code instead of the previous analyses, which "used a series of end-point calculations to generate a set of conditions that produces a bounding prediction of the peak negative [wetwell to reactor building] differential pressure"

In Supplement 1 and 2 of the applicant's response to RAI 06.02.01.01.C-1, Revision 1 dated May 6 and June 22, 2016, respectively, the applicant proposed to make changes to DCD Tier 2, Revision 6, including the following (ADAMS Accession Nos. ML16127A032 and ML16174A179):

- An addition of text in Section 5.4.7.3.2, "Worst Case Transient," to state that "[t]he normal shutdown condition is used to establish the limiting heat exchanger capacity and is evaluated in Appendix 5B.3."

- A replacement of text in Section 5.4.7.3.2, where rather than stating that RHR heat exchanger size was established to limit the suppression pool peak temperature to 97°C, the text will instead state that the heat exchanger size will also support the safety function of limiting suppression pool peak temperature to 97°C.

- Two changes to Table 6.2-2, "Containment Design Parameters": the vent loss coefficient (VLC) is changed from 2.5 – 5.0 to 4.2 – 6.7 and a footnote is added to the table to state that the overall vent system loss coefficient includes a contribution from flow loss coefficient of 1.7 for DCV.

6.2.1.3.3 Technical Evaluation

The staff reviewed the proposed changes in GEH ABWR DCD Tier 2, Revision 5 and Revision 6, Sections 6.2.1 and 6.2.2 to determine compliance with GDCs 16 and 50 in 10 CFR Part 50, Appendix A, using the guidance in SRP Section 6.2.1.1.C, Revision 7. The staff determined that additional information was needed to complete its review and issued RAI 06.02.01.01.C-1. GEH responded in a letter dated August 27, 2014 (ADAMS Accession No. ML14239A137), which was revised and replaced by a letter dated August 11, 2015 (ADAMS Accession No. ML15223B146). GEH supplemented its response in a letter dated June 22, 2016 (ADAMS Accession No. ML16174A179). The RAIs, GEH responses, and staff's evaluation are described below.

Enclosure 1 of the December 7, 2010 DC renewal application (ADAMS Accession No. ML110040176) proposed DCD changes to correct the containment peak pressure analysis to reflect a more limiting line break that GEH identified and discussed in a GEH letter dated June 8, 2009 (ADAMS Accession No. ML100640164). The limiting line breaks for the short-term accident response did not change from the certified design to the revised design. However, for the long-term accident response, revisions to FWLB analysis resulted in a change to the drywell peak pressure and revisions to the main steam line break (MSLB) analysis resulted in changes to the drywell peak temperature. The June 8, 2009, letter, refers to the report NEDO-33372, "Advanced Boiling Water Reactor (ABWR) Containment Analysis," which was later withdrawn from NRC topical report review by letter dated March 30, 2010 (ADAMS Accession No. ML100890313). As such, the staff was not clear about the documentation supporting the ABWR design certification renewal application changes to Sections 6.2.1 and 6.2.2. Therefore, in RAI 06.02.01.01.C-1 Part (1), the staff requested GEH to provide documentation supporting containment reanalysis DCD changes.

In its response dated August 11, 2015, GEH stated the following:

> There are no new documents that have been issued or new references cited that were required to support the changes for the DCD revision. Although NEDO-33372 is no longer directly applicable to the ABWR for the reasons discussed above, there is certain information that remains applicable to the ABWR renewal application. Therefore, rather than revise NEDO-33372, the information is proposed to be included in the ABWR DCD.

GEH's response identified two major and four minor changes associated with containment analysis. Major changes were associated with the decay heat used for the long-term containment analyses and modeling of the containment vent system. Minor changes were associated with FWLB flow, suppression pool volume margin, the overall heat transfer coefficient for the RHR heat exchanger, and wetwell design temperature.

The original certified ABWR DCD long-term containment analysis was based on nominal ANSI/ANS-5.1 (1979) decay heat curves. GEH determined that additional actinides and activation products not accounted for in the ANSI/ANS-5.1 (1979) standard affect the decay heat curves. Therefore, in the revised Section 6.2 long-term containment analysis, GEH used ANSI/ANS-5.1 (1994), which includes contributions from additional actinides and activation products. In addition, GEH conservatively used two standard deviation uncertainty on decay heat when performing the revised Section 6.2 long-term containment analysis. The staff finds that using the ANSI/ANS-5.1 (1994) decay heat model with a two standard deviation uncertainty for the long-term containment analysis is acceptable since the addition of decay heat from actinide decay and activation products is conservative for containment pressure and temperature analysis.

GEH's RAI response dated August 11, 2015, stated the following on containment vents model changes:

> In the containment analysis for the certified ABWR DCD, the main vent system model did not capture some of the key features that impact the short-term containment response and thus the pool swell loads. The model for DCD Revision 4 did not properly simulate the horizontal vent portion of the vent system and consequently incorrectly modeled the vent clearing time. These deficiencies are the major contributor to the difference between the previous certified ABWR and the ABWR revised containment analysis results.
>
> The revised ABWR containment analysis correctly models the horizontal vents, and was performed with DCV loss coefficients included. The total DCV loss coefficient is based on a summation of losses. The entrance loss coefficient accounts for the presence of the biological shield wall that is next to the upper drywell entrance to the DCV. The flow loss coefficient accounts for trash racks at the entrance to the vents to block insulation from entering the vents and flowing into the suppression pool. The friction loss through the DCV is the maximum pressure loss coefficient due to piping, cabling and supports routed in the DCV. The exit loss coefficient can be neglected since each DCV is directly above a Drywell-Wetwell (DW-WW) vertical vent. These flow losses are then summed and included in the containment analysis model for the DCV.
>
> The dimensions of the horizontal vents were included in the revised analysis and confirmation of the vent clearing was performed to ensure the revised model was correct. These modifications were the major contributors to the revised analysis results for the wetwell pressure and drywell-to-wetwell differential pressures.

GEH's containment vents model changes were needed to correct self-identified errors in containment analysis. The staff finds that the above features, which were missing in the containment analysis for the certified ABWR DCD by error, were needed to correctly model the GEH ABWR design, and therefore, determines that these modeling changes are acceptable.

DCD Revision 4 Table 6.2-2 lists the VLC range between 2.5 to 3.5. In DCD Revision 5 the VLC range was changed to between 2.5 to 5.0. GEH cited NEDO-33372 and indicated that the applicable information was extracted from this NEDO document and put into the DCD. The staff noted that NEDO-33372 lists the VLC as between 2.5 to 3.5, which is different from the range of values provided in DCD Revision 5, specifically the upper limit. Therefore, in a public teleconference on April 6, 2016, the NRC staff requested GEH to clarify.

In RAI 06.02.01.01.C-1, Revision 1, Supplement 2 dated June 22, 2016, GEH reiterated that it does not intend for NEDO-33372 to be part of the licensing basis for ABWR Certification Renewal and all pertinent content will be included in the ABWR DCD and that the range of VLC values shown in the markup for DCD Table 6.2-2 that was included in NEDO-33372 does show a VLC range of 2.5 – 5.0. The original upper end value of 3.5 is shown crossed out in the markup.

The original range of 2.5 - 3.5 was first developed for use with the GEH M3CPT code for analyses of the Mark III short-term containment response. It was then applied in the ABWR M3CPT analyses due to the similarity in the Mark III and ABWR horizontal vent system geometry. A subsequent evaluation updated the range of VLCs for Mark III M3CPT analysis to 2.5 - 5.0. The revised values were then also applied to the ABWR M3CPT containment analysis. The values shown in Table 6.2-2 for DCD Revision 5 (2.5 - 5.0) only included the losses associated with the ABWR vent system. It did not include or identify a 1.7 loss coefficient adder to the values shown in Table 6.2-2 that was applied to account for flow losses associated with the ABWR DCV that connects the upper drywell to the vent system. The applicant provided a markup for DCD Revision 6 Table 6.2-2 identifying the range of overall VLCs used for the analyses for DCD Revision 6 that includes the 1.7 adder (4.2 - 6.7).

The staff review finds that the proposed range of VLC as 4.2 - 6.7 as conservative and therefore acceptable. This is a confirmatory item pending the applicant incorporating the proposed changes to DCD Revision 6 and is being tracked as **Confirmatory Item 6.2.3.1-1**.

The FWLB flow change was to increase the 116 percent nuclear boiler rated (NBR) flow from the balance of plant side during the initial 3.75-second feed water inventory depletion period to 164 percent NBR flow, as assumed for the inventory depletion period after the 3.75-second period and shown in certified design DCD Figure 6.2-3. The specific enthalpy of feed water flow as shown in DCD Figure 6.2-4 was unchanged. This increase in mass flow is conservative because it produces a higher energy flow into the containment than that used in the certified ABWR design during FWLB, resulting in higher short-term containment peak pressures. Therefore, the staff finds that the FWLB flow change is acceptable.

On suppression pool volume margin change, GEH's response dated August 11, 2015, stated the following:

> The water volume in the suppression pool including the vents is required to be equal to or greater than 3,580 cubic meters, as stated in the Tier 1 Section 2.14.1. The ABWR revised [long-term] containment analyses of scenarios with low initial suppression pool water level were performed with a smaller water volume (3,455 cubic meters) to ensure analysis/operational margin. This smaller volume is based on a suppression pool water level of 6.9 meters. The volume of 3,580 cubic meters is equivalent to a 7-meter water level. The technical specification for suppression pool water level (LCO 3.6.2.2) is greater than or equal to 7 meters and less than or equal to 7.1 meters. This is a very tight band to control the suppression pool water level; so additional margin (0.1 meters) has been built-in to the safety analysis. It is conservative to base the safety analysis for scenarios with a lower initial suppression pool

water level based on a smaller water volume as this results in higher pool temperatures.

The staff determines that the suppression pool volume margin change in the safety analysis is conservative for the reason given by the applicant, and therefore, is acceptable.

As part of the response to RAI 06.02.01.01.C-1 dated August 11, 2015, and supplemented with a response dated May 6, 2016, GEH increased the residual heat removal heat exchanger's heat transfer coefficient. The staff reviewed the increase in heat transfer coefficient as it effects DCD Tier 2, Section 5.4.7. The staff determined that the design change was made in the conservative direction (i.e., more conservative than the original design) because an increase in the heat exchanger's heat transfer coefficient allows for more heat to be removed in any given time period. Thus, the staff concluded that this design change has no adverse effects on the safety analyses. The staff also considered the possibility that a larger cooldown rate could be experienced given the increase in the heat transfer coefficient. However, cooldown rates for the ABWR are administratively controlled and are governed by technical specifications; therefore, the staff concluded that the increase in the heat transfer coefficient does not negatively affect the safety of the reactor. The staff reviewed all markups associated with the applicant's change to the RHR system in DCD Tier 2, Section 5.4.7 and finds that the applicant's change is acceptable. The staff confirmed that the applicant has made these changes presented in the August 11, 2015, response in DCD Revision 6. The changes associated with the May 6, 2016, supplemental response were not made prior to DCD Revision 6 being issued. Therefore, this is being tracked as **Confirmatory Item 6.2.3.1-1** pending the applicant incorporating the proposed changes as presented in the May 6, 2016 supplemental response to the next revision of the DCD.

On the wetwell design temperature change, GEH's response dated August 11, 2015, stated the following:

> The certified ABWR wetwell gas space design temperature was 104°C. The containment structural analysis design value is 124°C; therefore the Tier 2 DCD wetwell chamber design temperature was revised to 124°C." The staff finds this change acceptable because it is more protective from a safety standpoint and makes the containment structural analysis and wetwell chamber design temperatures consistent.

As described above, the staff finds that GEH's response to RAI 06.02.01.01.C-1 Part (1) acceptable.

ABWR DCD Tier 2, Revision 5, Chapter 6, Change List Item 18 (which is related to DCD Section 6.2.1.1.3.3.1.2) stated that lower drywell flooding is not modeled. The staff was not clear why lower drywell flooding was not modeled. Therefore, in RAI 06.02.01.01.C-1 Part (2), the staff requested GEH to justify not modeling lower drywell flooding.

In its response dated August 11, 2015, GEH described two mechanisms causing lower drywell flooding. The first was spilling of break flow water from the upper drywell to the lower drywell through the DCV connection. GEH has assumed that water that can spill into the lower drywell would flow into the suppression pool instead. This assumption is conservative because water that flows out from the break during suppression pool drawdown during ECCS injection will be hotter than the water in the suppression pool and adding it back to the suppression pool would heat the suppression pool water.

A second mechanism is the potential for reverse vent flow from the suppression pool to the lower drywell through the lower drywell overflow orifice connection to the vertical vent. GEH showed that extended periods of large negative DW-WW pressure gradients would not exist because of opening of wetwell-to-drywell vacuum breakers. Further ABWR DCD Tier 2 Section 6.2.1.1.10.3 states the following: “The interconnection between the lower drywell and the wetwell is at elevation -4.55 m, [which is] 8.6 m above the floor of the suppression pool. Thus, approximately 7.2E5 kg of water must be added from outside the containment for the suppression pool to overflow into the lower drywell.” As such, reverse vent flow from the suppression pool to the lower drywell would be unlikely to occur. Therefore, the staff finds that GEH’s justification for not modeling the lower drywell flooding as provided in the response to RAI 06.02.01.01.C-1 Part (2) is acceptable.

ABWR DCD Tier 2, Revision 5, Chapter 6, Change List Item 19 (which is related to DCD Section 6.2.1.1.3.3.1.2, “Assumptions for Long-Term Cooling Analysis”) stated that the applicant deleted previous assumption No. 7 and inserted an assumption stating that the structural heat sinks are credited. The previous assumption, which was deleted, stated that at 70 seconds, the feedwater specific enthalpy becomes 418.7 J/g (i.e., saturation fluid enthalpy at 100 °C). The staff finds that removing previous assumption No. 7 is acceptable because the applicant used DCD, Revision 4, Figure 6.2-22 instead, which provides a more limiting value for feedwater specific enthalpy. Figure 6.2-22 shows that the feedwater specific enthalpy drops below 418.7 J/g only after 86 seconds.

However, the application did not provide the details for its modeling of the heat sinks. Therefore, in RAI 06.02.01.01.C-1 Part (3), the staff requested GEH to provide this information. In its response dated August 11, 2015, GEH provided details for its modeling of the structural heat sinks in the drywell airspace, wetwell airspace, and suppression pool. The applicant has modeled heat transfer in the drywell and wetwell air space by natural convection and condensation. The applicant modeled heat transfer from the suppression pool water to the suppression pool heat sinks. The applicant’s response included tables of heat sink parameters for the modeled heat sinks in the drywell airspace, wetwell airspace, and suppression pool. The applicant stated that the crediting of the heat sinks remains valid for as-built plants unless there is a change in plant dimensions. However, the applicant will include inputs for heat sinks in the standard form that the applicant uses to confirm inputs to the containment analysis and confirm the validity of the DCD analysis for the as-built plant. Design Commitment 4 in ABWR DCD Tier 1, Revision 6, and Table 2.14.1 states that “[t]he maximum calculated pressures and temperatures for the design basis accident are less than design conditions.” Inspections, Tests, Analyses for this commitment states that “[a]nalyses of the design basis accident will be performed using as-built [primary containment system] data.” The applicant provided tables with properties of heat sinks in response to RAI 06.02.01.01.C-1 Part (3). The staff reviewed these properties to confirm that the applicant has used correct thermal properties and correctly calculated the mass and internal thermal resistance for the heat sinks. Based on its review, the staff finds that the applicant’s response to RAI 06.02.01.01.C-1 Part (3) is acceptable.

ABWR DCD Tier 2, Revision 5, Chapter 6, Change List Item 23 (which is related to the main steamline break discussion in DCD Section 6.2.1.1.3.3.2) changes assumption (5). Assumption (5) in ABWR DCD Revision 4 stated that "MSIVs are completely closed at a conservative closing time of 5.5 seconds (0.5 seconds greater than the maximum closing time plus instrument delay), in order to maximize the break flow." ABWR DCD Revision 5 changed the closing time to 5 seconds and eliminated the reference to 0.5 seconds delay. The staff was not clear whether the 0.5-seconds delay was included in the MSIV closing time. Therefore, in RAI 06.02.01.01.C-1 Part (4), the staff requested GEH to clarify.

In its response dated August 11, 2015, GEH stated that the instrument delay of 0.5 seconds to begin closing the MSIVs is included in the total 5.0 second duration for MSIV closure from the start of the event. This clarifies how the instrument delay of 0.5 seconds is accounted for. The staff finds that closing the MSIVs sooner (i.e., in 5 seconds versus 5.5 seconds used in the certified ABWR DCD) is conservative because it reduces radioactive releases through MSIVs during a design basis accident. Based on its review, the staff finds that GEH's response to RAI 06.02.01.01.C-1 Part (4) acceptable.

ABWR DCD Tier 2, Revision 5, Chapter 6, Change List Item 24 relates to changing assumptions used in short-term containment analysis in DCD Section 6.2.1.1.3.3.2.1. GEH has deleted the following assumptions:

- Assumption 1. The vessel depressurization flow rates are calculated using the Moody's [homogeneous equilibrium model (HEM)] for the critical break flow.

- Assumption 2. The turbine stop valve closes at 0.2 second. This determines how much steam flows out of the RPV, but does not affect the inventory depletion time on the piping side.

- Assumption 4. The feedwater mass flow rate for a [main steam line] break was assumed to be 130 percent of NBR for 120 seconds. This is a standard [MSLB] containment analysis assumption based on a conservative estimate of the total available feedwater inventory and the maximum flow available from the feedwater pumps with discharge pressure equal to the [reactor pressure vessel] pressure. The feedwater enthalpy was calculated as described for the [FWLB] (Subsection 6.2.1.1.3.3.1.1) for 130 percent of NBR flow, and is shown in Figure 6.2-11.

The reason for these deletions was not clear to the staff. Therefore, in RAI 06.02.01.01.C-1 Part (5), the staff requested GEH to explain. In its response dated August 11, 2015, GEH noted that Assumption 1 was listed as an exception to the assumptions identified for the FWLB analysis in Section 6.2.1.1.3.3.1.1. GEH has deleted this assumption in Section 6.2.1.1.3.3.2.1 because the same assumption is listed under Section 6.2.1.1.3.3.1.1. The staff finds that deletion of Assumption 1 acceptable because the deletion was to remove a repetition.

Concerning deletion of Assumption 2, GEH noted that the use of the turbine stop valve closure time is not applied for the revised MSLB analysis to establish the vessel isolation time, and Assumption 5 in Section 6.2.1.1.3.3.2 states that "MSIVs are completely closed at a conservative closing time of 5 seconds in order to maximize the break flow." The staff finds GEH's deletion of Assumption 2 acceptable because it is not used for the revised analysis.

Concerning deletion of Assumption 4, GEH stated that Assumption 4 describes feedwater injection to the vessel for the MSLB, which is not modeled in the current short-term MSLB analysis. Injecting relatively colder feedwater into the reactor pressure vessel will tend to reduce the short-term vessel pressure due to reduced steaming that in turn reduces the break flow into the containment, thereby lowering the predicted short-term MSLB containment pressure and temperature. Therefore, to produce a more conservative short-term MSLB pressure and temperature response, the applicant has not included feedwater injection in the MSLB short-term analysis. The staff finds that applicant's deletion of Assumption 4 conservative and acceptable.

As described above, the staff finds GEH's response to RAI 06.02.01.01.C-1 Part (5) acceptable.

ABWR DCD Tier 2, Revision 5, Chapter 6, Change List Item 26 (which is related to the discussion of short-term accident response in Section 6.2.1.1.3.3.2.3) indicates that the short-term MSLB has a more severe drywell temperature response than before as it increased from 169.7 °C in Revision 4 to 177.2 °C in Revision 5. The reason for this change was not clear to the staff. Therefore, in RAI 06.02.01.01.C-1 Part (6), the staff requested GEH to explain.

In its response dated August 11, 2015, GEH stated the following:

> The revised analysis included corrections to the vent system modeling that had a significant impact on both the peak drywell pressure and peak drywell temperature. The length of the horizontal vent was not correctly accounted for in the original calculation. In addition, the overall flow loss coefficient for the ABWR vent system did not account for the flow losses associated with the drywell connecting vents (DCV). The corrections that were implemented in the revised calculations produced a delay in clearing of the horizontal vents and an increase in the vent flow resistance after vent clearing. These changes produced the higher values for predicted peak MSLB drywell pressure and temperature.
>
> The peak calculated MSLB drywell temperature of 177.2 °C is higher than the design limit of 171.1 °C. However, this value represents the peak predicted MSLB drywell atmosphere temperature. A review of the analysis shows that predicted drywell atmosphere temperatures are above 171.1 °C for approximately only 1 second during the early, steam break flow only phase of the MSLB. The MSLB analysis assumes level swell of the vessel liquid due to voiding, which produces a two-phase break flow mixture after two seconds into the event. Thereafter, drywell temperatures fall rapidly (see DCD Figure 6.2-13). The very short predicted duration of atmosphere temperature above 171.1 °C will not result in drywell structural temperatures that are above the drywell structure design limit.

The applicant has corrected a self-identified error in modeling the overall flow loss coefficient for the ABWR vent system. The staff reviewed these modeling changes under RAI 06.02.01.01.C-1 Part (1) and found them acceptable. The peak calculated MSLB drywell atmosphere temperature of 177.2 °C exceeds the drywell design limit of 171.1 °C for a 1 second duration. However, due to thermal inertia, components in the drywell structures (in particular, the upper head seals) will not have sufficient time to reach the design limit temperature during this 1 second period. Therefore, the staff finds that containment atmosphere temperature exceeding the structural design temperature in this case is acceptable. Based on its review, the staff finds GEH's response to RAI 06.02.01.01.C-1 Part (6) acceptable.

ABWR DCD Tier 2, Revision 5, Chapter 6, Change List Items 30 and 31 (which are related to DCD Sections 6.2.1.1.4.1 and 6.2.1.1.4.2 on the negative pressure design evaluation) states that the applicant replaced each section except the first two paragraphs. The applicant did not state the reasons for the changes. Therefore, in RAI 06.02.01.01.C-1 Part (7), the staff requested the applicant to provide details justifying the changes. In its response dated August 11, 2015, GEH stated that it performed the revised calculations to provide a more accurate and realistic simulation of negative pressurization events consistent with the ABWR plant system design, plant system operation and plant operating conditions. The main changes made in the revised analysis are as follows:

A. Elimination of analyses for events with inadvertent initiation of containment (drywell/wetwell) spray during normal operation. As described in DCD Section 6.2.1.1.4, the ABWR design has features that prevent the initiation of the RHR mode of the drywell spray(s) during normal plant operation.

B. The revised analyses start at time zero of the postulated LOCA event with normal operating conditions as the initial conditions. The analysis itself is used to predict the initial conditions prior to ECCS reflood or drywell (DW) spray initiation as opposed to using user defined conditions at the time of ECCS reflood or spray.

C. Drywell break flow rate and breakflow enthalpy during periods of ECCS injection are mechanistically calculated considering the effects of ECCS injection rates, ECCS source temperature, and heatup in the vessel before discharge to the drywell.

D. The revised analyses include modeling of DW spray with suction from the suppression pool. The DW spray temperature is established by the calculated exit temperature of the modeled RHR heat exchanger and accounts for the heat exchanger heat removal characteristics (heat exchanger coefficient), calculated suppression pool temperature, RHR service water temperature and containment spray flow rate.

E. The new analyses include a small steam line break with DW spray operation to provide the containment negative pressure response due to operation of drywell spray in a superheated steam drywell environment, that would occur during a small steam break, and which is potentially limiting for containment negative pressure.

The following is a staff evaluation of the above changes:

A. As stated in ABWR DCD Revision 6, Section 6.2.1.1.4, an interlock on the drywell spray injection valves that requires high drywell pressure to be present before the valves are allowed to be opened and a time delay in the logic will allow initiation of drywell spray 60 seconds after the drywell high pressure signal (2 psig) is received. In addition, the RHR system can only be manually initiated in the drywell spray mode from the main control room by two methods, both requiring two independent actions. Therefore, the staff finds that a likelihood of a spurious initiation of drywell spray during normal plant operation to be remote and the elimination of such activation from analysis to be acceptable.

B. The applicant used the analysis itself, rather than user defined conditions, to establish initiation of the negative design pressure evaluation. The staff finds that this approach is less subjective, and therefore, acceptable.

C. The applicant stated in its RAI response dated August 11, 2015, that "[i]n the original DCD analysis it was assumed that 100 percent of ECCS flow (including [high pressure core flooder, low pressure core flooder and reactor core isolation cooling]) is taken from the [condensate storage tank] (at 60°F) and discharged directly into the drywell without heating of the ECCS injection fluid in the vessel." Using mechanistically calculated drywell break flow rate and break-flow enthalpy during periods of ECCS injection produces a less conservative result than that provided in the certified DCD. However, the staff finds the applicant's mechanistic calculation consistent with SRP Section 6.2.1.1.C, and therefore, acceptable

D. The analysis presented in the certified ABWR DCD did not assume the operation of drywell sprays. The staff finds that the operation of drywell sprays would lower the drywell temperature and pressure by condensing steam in the drywell, which conservatively increases the DW-WW negative pressure, and therefore, is acceptable.

E. As stated under Item D above, operation of drywell sprays in a steam environment would lower the drywell pressure, and thus, increases the DW-WW negative pressure. The small steam line break with DW spray operation is a new analysis which is potentially limiting for the negative containment pressure. The staff finds this change is acceptable because it was done to seek more conservative analysis for the containment negative pressure.

The results of the revised calculation shows a significantly smaller calculated peak DW-WW negative differential pressure relative to the value reported previously, -3.86 versus -9.8 kPaD. GEH attributes this change to a less conservative analysis approach as described above. Based on its review the staff finds that the applicant's negative pressure design evaluation is consistent with SRP Section 6.2.1.1.C guidance, and therefore, is acceptable.

The results of the revised calculation show a smaller calculated peak wetwell-to-reactor building (WW-RB) negative differential pressure relative to the value reported previously, -8.76 versus -9.8 kPaD. The applicant attributes this to the SHEX code used to generate transient responses; the previous analyses used a series of end-point calculations to generate a set of conditions that produces a bounding prediction of the peak negative WW-RB differential pressure. The GEH states the following on using the SHEX code for calculating the WW-RB negative differential pressure:

> The GEH SHEX computer code was used for the revised calculations of the ABWR negative containment pressure for ABWR DCD Revision 5. The SHEX code has models for all containment, safety and auxiliary systems needed for the

ABWR DCD negative pressure analysis. This is the code that corresponds to the Long-Term Cooling model identified in DCD Section 6.2.1.1.3.4.2. The GEH SHEX code has been verified and validated for general use in compliance with the GEH Nuclear Energy Quality Assurance Program.

The GEH calculations of the ABWR containment negative pressure response with the SHEX code and evidence of verification for the calculations are contained within the GEH electronic archives of the design records.

Although, the original ABWR DCD did not name the computer code used for analyzing the containment long-term cooling, as stated above GEH identified it as SHEX. Considering that the SHEX code has been verified and validated for general use, and used for analyzing the long-term containment response in the original ABWR DCD, the staff finds it acceptable to use the SHEX code for calculating the peak negative WW-RB differential pressure, which is another application of containment long-term response. As such, the staff finds GEH's response to RAI 06.02.01.01.C-1 Part (7) acceptable.

As discussed above the staff's review of the applicant's response to RAI 06.02.01.01.C-1 finds that it is acceptable. RAI 06.02.01.01.C-1 is being tracked as **Confirmatory Item 6.2.3.1-1** pending the applicant incorporating the proposed changes to DCD Revision 6 as discussed above. The staff finds the applicant's changes in GEH ABWR DCD Tier 2, Revision 6, Sections 6.2.1 and 6.2.2 related to short-term containment pressure response conform to SRP Section 6.2.1.1.C, Revision 7, and meet 10 CFR Part 50, Appendix A, GDCs 16 and 50.

6.2.1.3.4 Conclusion

Based on the evaluation provided in this SER section, the staff concludes that the proposed changes do not alter the safety findings made in NUREG-1503 and are consistent with SRP Section 6.2.1.1.C, Revision 7. Therefore, the staff finds that the proposed changes resulting from containment reanalysis are acceptable and meet the requirements in 10 CFR Part 50, Appendix A, GDCs 16 and 50. Inclusion of the proposed changes in the DCD is being tracked by the **Confirmatory Item 6.2.3.1-1** discussed above.