# 6.0 Engineered Safety Features

## 6.3 Emergency Core Cooling Systems

### 6.3.1 Regulatory Criteria

In the GE-Hitachi Nuclear Energy (GEH), U.S. Advanced Boiling-Water Reactor (ABWR) Design Control Document (DCD) Revision 6, the applicant had not changed the DCD regarding the loss of coolant accident (LOCA) analysis to incorporate error corrections and other changes to the emergency core cooling system (ECCS) evaluation model (EM) that have been identified by GEH since the original certification of the ABWR design in 1997. As discussed below, GEH has proposed changes to the DCD to account for these error corrections and other changes to the ABWR DCD ECCS EM. This evaluation documents the staff's review of GEH's proposed DCD changes.

In a July 21, 2016, letter to GEH (Agencywide Documents Access and Management System (ADAMS) Accession No. ML16174A175), the U.S. Nuclear Regulatory Commission (NRC) staff made GEH aware that reported ECCS EM changes and errors for the ABWR standard plant design had not been accounted for in Revision 6 of the ABWR DCD. Therefore, the staff requested that GEH provide DCD changes to meet the requirements of Title 10 *Code of Federal Regulations* (10 CFR) 52.57(a), which specifies that the renewal application must contain all information necessary to bring up to date the information and data contained in the previous application. GEH responded in a letter dated August 19, 2016 (ADAMS Accession No. ML19031C851) and committed to addressing the issue in Revision 7 of the DCD.

Because the applicant's proposed changes correct errors in the DCD and otherwise account for changes to the ABWR ECCS EM in accordance with 10 CFR 50.46(a)(3), they are "modifications," as this term is defined in Chapter 1 of this supplement. These modifications must comply with the Atomic Energy Act of 1954, as amended, (AEA) and the Commission's regulations applicable and in effect at the time the certification was originally issued. Therefore, the proposed changes are evaluated using the regulations in effect at the time the certification was originally issued. The following regulatory requirements provide the basis for the acceptance criteria for the staff's review:

> In 1997, 10 CFR 50.46, "Acceptance criteria for emergency core cooling systems for light-water nuclear power reactors," provided various requirements related to the design and analysis of ECCS for light water power reactors. In particular,
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> - 10 CFR 50.46(a)(1)(i) required that boiling or pressurized light-water reactors be provided with an ECCS, and that the ECCS design performance be analyzed to meet certain acceptance criteria using an acceptable EM.
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> - 10 CFR 50.46(a)(1)(ii) allowed ECCS EMs to be developed in conformance with the required and acceptable features of ECCS EMs described in 10 CFR Part 50, Appendix K (in lieu of providing a best estimate plus uncertainty EM as described in 10 CFR 50.46(a)(1)(i)).
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> - 10 CFR 50.46(b)(1) through (5) provided the ECCS acceptance criteria for peak cladding temperature, maximum cladding oxidation, maximum hydrogen generation (often expressed in terms of corewide oxidation), maintaining a coolable geometry, and providing for long term core cooling following a LOCA.

In 1997, Appendix A to 10 CFR Part 50, "General Design Criteria for Nuclear Power Plants," provided minimum requirements for the principal design criteria for a facility. Facility principal design criteria were required under both 10 CFR Part 50 and Part 52. The following general design criterion (GDC) is relevant to this particular ECCS review:

- GDC 35, "Emergency core cooling," which required an ECCS to be provided that, following any loss of reactor coolant, transfers heat away from the core at a sufficient rate to (1) prevent fuel and clad damage that could interfere with continued effective core cooling and (2) limit the clad metal-water reaction to negligible amounts. This GDC also provided single failure criteria and electric power system requirements for ECCSs.

The original DCD LOCA analysis was performed using SAFER/GESTR-LOCA, an EM approved by the NRC in 1984 (ADAMS Accession No. ML102230240) for performing ECCS evaluations in accordance with 10 CFR 50.46 and 10 CFR Part 50, Appendix K. The staff notes that by the time the DCD was approved in 1997, the ECCS rule had been updated to no longer require EMs be compliant with the required and acceptable features in Appendix K; however, GEH maintained the use of an Appendix K-compliant EM, as provided for in 10 CFR 50.46(a)(1)(ii).

### 6.3.1 Summary of Technical Information

In December 2010, GEH submitted an application to renew the ABWR design certification (DC). Subsequently, GEH submitted several letters[1] providing annual reports of ECCS EM changes and errors for the ABWR standard plant design, pursuant to the requirements of 10 CFR 50.46. Some of these ABWR annual reports referenced information in earlier annual reports that had been submitted to the NRC but had not been specifically associated with the ABWR design.

Revision 6 of the ABWR DCD was also submitted by letter dated February 19, 2016 (ADAMS Accession No. ML16081A268). However, the NRC staff pointed out in the July 21, 2016, letter to GEH that the reported changes and error corrections had not been adequately accounted for in the revised DCD, and therefore the renewal failed to meet the requirements of 10 CFR 52.57(a), which specifies that the renewal application must contain all information necessary to bring up to date the information and data contained in the previous application. In the letter dated August 19, 2016, GEH committed to addressing the issue in Revision 7 of the DCD.

By letters dated October 12, 2016, and October 10, 2017 (ADAMS Accession No. ML16291A490 and ADAMS Accession No. ML17283A307, respectively), GEH provided additional annual reports of ECCS EM changes or errors that resulted in an increased peak cladding temperature (PCT) for the standard ABWR design, pursuant to 10 CFR 50.46. The 2016 annual report included with it additional supplemental information describing each of the errors and changes in more detail than the previous reports, as well as proposed changes to the ABWR DCD. The proposed changes included the addition of a reference to the October 12, 2016, 10 CFR 50.46 annual report, and a note on the limiting PCT result in Table 6.3-4, "Summary of Results of LOCA Analysis," that reported the impact of the changes and errors on the PCT. In a March 20, 2017, letter (ADAMS Accession No. ML17079A353, with enclosures in ADAMS Accession No. ML17079A356 (Enclosure 1) and ADAMS Accession No. ML17079A357 (Enclosure 2)), GEH supplemented the information in the 2016 annual report with additional discussion and further changes to the ABWR DCD.

[1] The annual reports of ECCS EM changes/errors for the ABWR standard plant design were submitted on February 13, 2012 (ADAMS Accession No. ML12046A048); December 19, 2012 (ADAMS Accession No. ML12355A207); December 13, 2013 (ADAMS Accession No. ML13350A583); December 19, 2014 (ADAMS Accession No. ML14363A096); and December 3, 2015 (ADAMS Accession No. ML15337A119).

Beginning in August 2018, the NRC staff audited GEH information related to the PCT error and change estimates, first through an electronic portal and subsequently in an on-site audit (see audit plan in ADAMS Accession No. ML18199A273 and audit report in ADAMS Accession No. ML19136A281). On October 29, 2018, the applicant provided a 2018 annual report of ECCS EM changes and errors for the ABWR pursuant to 10 CFR 50.46 (ADAMS Accession No. ML18302A023). This report removed the effect of several changes and errors that had previously been reported. On December 19, 2018, the NRC staff held a public meeting with GEH (ADAMS Accession No. ML19009A413) to discuss how the increase in PCT associated with the reported errors would be incorporated into the ABWR DCD. Subsequently, GEH submitted a letter on January 21, 2019 (ADAMS Accession No. ML19021A015), that justified the removal of several entries provided in the 2016 10 CFR 50.46 annual report, revised some of the information provided along with the 2016 annual report, and provided proposed revised ABWR DCD markups.

The January 21, 2019, letter removed several ECCS EM changes and errors from the table of cumulative PCT changes and errors that had originally been included in the 2016 10 CFR 50.46 report. After further review, the applicant found that a variety of changes and errors, including both input and modeling errors, were not applicable to the ABWR design. The sum of the remaining errors deemed applicable to the ABWR had a combined impact on the PCT of 42 degrees Celsius (°C) (approximately 75 degrees Fahrenheit (°F)).

In the ABWR DCD, markups provided as Enclosure 2 to the January 21, 2019, letter, a new column was added to Table 6.3-4, which provided the summary of LOCA analysis results. This new column represents a new set of licensing basis PCTs for the ABWR DC renewal and is based on adding the 42°C (75°F) value to the prior licensing basis PCT values in the table. The limiting PCT, following incorporation of estimated effects of the ECCS EM changes and errors since the original ABWR DC, is now 663°C (1225°F). The same adder of 42°C (75°F) was also applied to the LOCA evaluation results included in the internal event analysis section of the probabilistic risk assessment reported in Section 19.3.1.3.1, “Success Criteria,” of the DCD, since the analyses were carried out using the same EM.

**Reported ECCS EM Changes and Errors**

As discussed above, the applicant’s original licensing basis LOCA analysis for the ABWR standard plant design was performed using the SAFER/GESTR-LOCA EM and the limiting LOCA was found to be a steam line break outside of containment. These basic concepts remain unchanged in the updated DCD.

Enclosure 1 to the applicant’s 2016 annual report of ECCS EM changes and errors included a table of the changes and errors in the SAFER/GESTR EM that were identified since the original ABWR licensing basis analysis was performed, including those that were found to have negligible impact. These errors were identified through continued use of the EM for operating BWR analyses. For each error, the impact on the PCT was assessed for the ABWR. In total, the absolute value of the sum of the errors reported in the 2016 annual report was +220°F. The estimated effect on the PCT for each error depended on the nature of the individual error and how it related to the ABWR design. Of the reported errors, only the error in one of the 50.46 annual reporting (AR) letters (AR Letter 2006-01) reached the 50°F criterion used in 10 CFR 50.46(a)(3)(i) to establish that an error is significant with respect to the reporting requirements. However, several of the reported errors had an effect on the PCT that the NRC staff considers to be non-trivial (more than a few degrees). Others, mostly software platform ports and other minor changes, had an estimated effect of 0°F.

Enclosure 1 to the applicant's January 21, 2019, letter proposed that it was appropriate to remove several entries from the table. The removed entries included AR Letters 1996-01, 2002-02, 2002-04, 2006-01, 2012-01, and 2014-03. AR Letters 1996-01 and 2002-02 reported input errors related to fuel bundle modeling and inclusion of the steam dryer pressure drop in the initial core water level input. These were eliminated in the January 2019, letter because further review found that the input was correct for the ABWR LOCA analysis. AR Letters 2002-04 and 2014-03 were related to software platform changes and were removed since the analysis had not actually been performed on the new platform, and thus, any associated changes in the PCT were not applicable to the ABWR DCD analysis.

AR Letter 2006-01 addressed the issue that it is potentially non-conservative to apply a cosine axial power shape in small break LOCA analyses and that a more top-peaked shape would have a greater impact on the PCT. This was originally assessed as applicable to the ABWR analysis because one of the ABWR LOCA sensitivity studies included with the licensing analysis was found to include what appeared to be a brief core uncover within the first few seconds. However, on further inspection, the applicant found that the apparent uncovery was actually a departure from nucleate boiling (DNB) event caused by the depressurization and reactor internal pump trip after the initiating LOCA. During this portion of the transient, the peak cladding temperature of 1,149°F is reached. Liquid droplet entrainment from the depressurization subsequently cools the fuel back to saturation conditions. GEH assessed that these phenomena differed from the event that caused the reported non-conservatism in the operating fleet, and that the DNB and subsequent cooldown would occur during the ABWR LOCA transient regardless of the axial peak power location. Therefore, the applicant determined after more detailed review that the error was not applicable to the ABWR.

AR Letter 2012-01 addressed fuel thermal conductivity degradation (TCD), the process by which fuel thermal conductivity degrades with increasing irradiation. As discussed in NRC Information Notice 2009-23 (ADAMS Accession No. ML091550527), "Nuclear Fuel Thermal Conductivity Degradation," fuel performance codes approved by the NRC before 1999 did not include a reduction in fuel thermal conductivity with increasing irradiation because earlier test data were inconclusive as to the significance of the effect. This is the case for the ABWR licensing analysis, which was performed using the SAFER/GESTR-LOCA methodology, approved in 1984. The applicant thus initially determined TCD was not accounted for in the ABWR licensing analysis. Resolution of the TCD issue in the operating fleet was achieved by switching from the GESTR-LOCA fuel thermal-mechanical code to a newer fuel thermal-mechanical code, PRIME. The overall effect on the PCT of implementing PRIME was initially assessed for the ABWR as 45°F. On further review, the applicant determined that TCD would not impact the LOCA analysis for the ABWR because the bounding fuel state with respect to LOCA analysis is early in core life, as discussed more fully below. The applicant thus determined that the implementation of PRIME and the associated 45°F effect on PCT was unnecessary for ABWR.

After removing the table entries discussed above, the revised cumulative sum of the PCT effects from the remaining changes and errors was reported by the applicant in the January 21, 2019, letter to be 75°F.

**Effect of ECCS EM Changes and Errors on Non-LOCA Analyses**

Enclosure 1 to the applicant's March 20, 2017, letter provided a list of analyses that had the potential to be affected by the reported ECCS EM changes and dispositioned whether each analysis was affected or not. The list and associated disposition was updated in the January 21, 2019, letter.

The applicant stated that the errors discovered in, and changes made to, the ECCS EM had no potential impact on the station blackout analysis, decay heat analysis, containment analysis, or radiological analysis. Since the ECCS EM was directly affected by the changes and errors, the probabilistic risk assessment (PRA) success criteria for events reported in Chapter 19 of the DCD that relied on the ECCS EM were also affected. Several of the originally-reported ECCS EM changes and errors had potential effects on the non-LOCA analyses, including AR Letter 1996-01, which was the error involving the incorrect number of active fuel rods in the SAFER input file, AR Letter 2003-03, which was the error involving the steam separator pressure drop, and AR Letter 2012-01, which was the change that implemented the PRIME fuel thermal-mechanical performance code to resolve the TCD issue.

The applicant stated in the January 21, 2019, letter that the AR Letter 1996-01 error was only a potential issue for the SAFER input file, which was only used in the LOCA analysis. Because the error was not present in the SAFER input file for ABWR, the applicant determined that the error was not applicable to any ABWR analysis.

The AR Letter 2003-03 error could theoretically have had an impact on the transient and anticipated transient without scram (ATWS) analyses. However, the applicant determined that the transient and ATWS analysis base decks for the ABWR DCD were developed separately from the LOCA analysis base deck and confirmed that they used the correct steam separator pressure drop. Thus, the error affects only the LOCA analysis.

As discussed above, the licensee determined that the AR Letter 2012-01 change, which included the effects of fuel TCD, was not applicable to the ABWR LOCA analysis. However, the effects of TCD were not included in the transient or ATWS analyses, and GEH therefore addressed the potential impacts of TCD on these analyses. In its evaluation, the applicant referenced an NRC document (ADAMS Accession No. ML120750001), which evaluated various GEH codes and methods for operating reactors to ascertain the consequences of TCD. The codes and methods assessed included those used for the ABWR DCD transient and ATWS analyses, and the applicant therefore determined that the conclusions could be extended to the ABWR DCD analyses. The applicant also determined that the sensitivity to TCD for the ABWR DCD would be lower than that for the BWR/4 because the DCD analysis assumes an initial core with low exposure, making the effects of TCD less pronounced. The applicant therefore concluded that it is not necessary to include the effects of fuel TCD in the transient and ATWS analyses.

**DCD Changes**

Changes to the ABWR DCD related to the ECCS EM changes and errors were originally made in Enclosure 2 to the applicant's March 20, 2017, letter. A revised set of changes to the DCD were included in the applicant's January 21, 2019, letter, consistent with the changes to the applicant's evaluation included in the same letter.

The applicant added the 2018 annual report of ECCS EM changes and errors pursuant to 10 CFR 50.46 as a reference in Section 6.3.7 "Reference," of the DCD.

The applicant added a new column titled "Renewal PCT /w ΔPCT adjustment (°C)", and two new footnotes to Table 6.3-4. Footnote 2 explained that the new column was added to account for errors in and changes to the ECCS EM since the DCD was originally approved, and that the values in the column were determined by adding the cumulative change in PCT from the 10 CFR 50.46 reports of 42°C (approximately 75°F) to the original DCD values for each LOCA case considered in the table. Footnote 3, which is the same as the general note for the table

that was included in the approved version of the DCD, clarified the method used to calculate the core-wide metal-water reaction for the analysis.

Additionally, the applicant revised the PCTs reported in Section 19.3.1.3.1, regarding the success criteria for the internal events probabilistic risk assessment. The PCTs in the section were all updated, consistent with those in Section 6.3, by increasing each reported PCT by 42°C (approximately 75°F).

### 6.3.3 Technical Evaluation

The NRC staff focused on three aspects of the applicant's evaluation: the assessment of the reported ECCS EM errors and changes for the LOCA analysis, the disposition of the same EM changes and errors for the non-LOCA analyses, and the implementation of the EM changes and errors in the DCD.

**Effect of ECCS EM Changes and Errors on LOCA Analysis**

At the audit, the NRC staff reviewed the list of all errors reported in the SAFER/GESTR-LOCA EM since the ABWR LOCA analysis was originally performed in 1994. The NRC staff confirmed that the applicant's 2016 annual reporting of changes and errors pursuant to 10 CFR 50.46 contained all items potentially applicable to the ABWR. The staff also confirmed that the applicant assigned a conservative value to the estimated effect on peak cladding temperature for each change or error, based on assessments from the operating BWR fleet.

The NRC staff subsequently reviewed the rationale provided in the applicant's January 21, 2019, letter for removing several changes and errors from consideration for ABWR, as discussed in Section 0 of this SE. Since the issues reported in AR Letters 1996-01 and 2002-02 were found to not be present in the ABWR analysis, the NRC staff concluded that it was reasonable to remove them from the list of changes and errors affecting the PCT for ABWR. Additionally, because the platform changes associated with AR Letters 2002-04 and 2014-03 were not applied in the analysis, the NRC staff determined that it is reasonable to remove those changes and errors from consideration as well.

For AR Letter 2006-01, which assessed the potential impact of using a top-peaked axial power shape in small break LOCA analyses in the operating fleet, the applicant initially concluded that the effect on PCT would be approximately 50°F, but then revised the estimate to conclude that the effect would be negligible in the January 21, 2019, letter. The applicant's rationale for neglecting the effect of this error is that there is no impact on the PCT because there is no core uncovery in the LOCA analysis. The applicant stated in the DCD that there are no design basis events that result in core uncovery, and the one case that the applicant observed to have potential uncovery was a sensitivity study, not a licensing basis analysis. The applicant further found that this single case represented a localized DNB event. Under these conditions, the NRC staff assessed that, while a change to the axial peak power location would potentially change the location of the DNB event, there is no phenomenological reason to believe that the duration of the heat up, and thus the peak cladding temperature reached, would be extended. Therefore, the NRC staff agreed with the applicant's assessment that the error addressed in AR Letter 2006-01 would have a negligible effect on the PCT.

AR Letter 2012-01 assessed the effect on PCT of resolving fuel TCD by implementing the PRIME fuel thermal-mechanical code. As discussed above, the applicant initially found that implementation of PRIME would change the PCT by 45°F. However, the applicant concluded in the January 21, 2019, letter that the implementation of PRIME was not necessary to solve the issue of TCD for the ABWR LOCA analysis, and therefore concluded that the change was not

applicable to the ABWR standard design. The applicant's rationale is that the bounding fuel state with respect to LOCA analysis is early in core life, because of gap conductance and stored energy, and that since TCD is an irradiation effect that does not have a significant impact on fuel until later in life, it has no appreciable impact on the LOCA PCT. The NRC staff disagrees in part with this conclusion: experience with the issue over the last several years has shown that TCD may make fuel bundles in their second cycle of operation more limiting than those in their first, depending on the arrangement of the core and other plant- and cycle-specific parameters. However, since the core remains covered in the ABWR design for all break locations, the NRC staff judged that the stored energy increase resulting from TCD will be removed by increased boiling and will therefore not appreciably impact the PCT. This is consistent with the conclusion regarding small break LOCAs from the NRC staff's 2012 letter to GEH evaluating the impacts TCD for existing approved methods for operating plants (ADAMS Accession No. ML120750001). Additionally, the fuel rod design criteria specified in DCD Appendix 4B, "Fuel License Acceptance Criteria," must be satisfied for initial core and reload applications. Any change to these criteria must have prior NRC review and approval, as specified in Appendix 4B, because the information is Tier 2*.

Therefore, based on the assessments detailed above, the NRC staff determined that the applicant adequately estimated the PCT effect of the changes and errors discovered in the SAFER/GESTR-LOCA EM since the original analysis of record was approved by the NRC. The total estimated effect of 75°F is conservative and appropriate to include in the DCD to account for these changes and errors.

The NRC staff notes that, in addition to PCT, 10 CFR 50.46(b) also contains criteria for maximum local cladding oxidation, maximum hydrogen generation, maintaining a coolable geometry, and providing for long-term core cooling following a LOCA. The NRC staff determined that none of the reported ECCS EM changes or errors would affect the ability of the ABWR to maintain a coolable geometry or to provide long term core cooling. While some of the reported changes and errors could potentially impact maximum local cladding oxidation or maximum hydrogen generation, the NRC staff judged that, because the core remains covered in the ABWR LOCA analysis, any effect would be essentially negligible and below the number of significant figures reported in the DCD.

**Effect of ECCS EM Changes and Errors on non-LOCA Analyses**

Enclosure 1 to the applicant's January 21, 2019, letter identifies the non-LOCA analyses included in the ABWR DCD that have the potential to be affected by the ECCS EM changes and errors and provides an evaluation as to the effect on each analysis. The non-LOCA analyses identified by the applicant as potentially affected by the ECCS EM changes and errors included the station blackout analysis, the RPV fluence analysis, the decay heat analysis, the containment analysis, the combustible gas analysis, the radiological analysis, the transient analysis, the ATWS analysis, and the analysis supporting the PRA success criteria. The NRC staff concurs with the applicant's assessment of the scope of analyses potentially affected by the ECCS EM changes and errors, since these represent the set of DCD analyses that are the most sensitive to core and fuel parameters.

The applicant reviewed the analyses listed above and found that the models used in the LOCA analysis were also used in the PRA success criteria evaluation and the break flow and mass release calculations associated with the radiological analysis. The NRC staff confirmed this during the audit. Additionally, the applicant noted that the base input decks for the transient and ATWS analyses were developed separately from the LOCA analysis. Thus, input file errors and modeling errors specific to the LOCA EM, which represent the majority of the reported errors, would not be expected to apply to the other analyses.

Of the reported errors, only the error related to the omission of fuel thermal conductivity degradation is potentially applicable beyond the direct application of the ECCS EM. The NRC staff reviewed the applicant's justification for removing this error, which relied heavily on the NRC Staff's 2012 evaluation of the methods in use at the time. This evaluation concluded that the effect of TCD on transient and ATWS analyses would be minimal, though the GESTRM fuel rod thermal performance code could have some non-conservatism in the calculation of fuel temperatures for higher burnup fuel. The staff reviewed the transient analysis included in Chapter 15 of the ABWR DCD and found that there is sufficient margin to the fuel centerline melt limit that no events would be substantially impacted by TCD. For the rod withdrawal error during startup, analyzed in Section 15.4.1.2 of the DCD, the fuel enthalpy calculations would be potentially affected by TCD, but the analysis would be expected to retain very substantial margin to the values at which fuel rod damage is anticipated. Thus, the NRC staff concludes that it is reasonable to neglect this error in the ABWR non-LOCA DCD analysis.

The radiological analysis would be potentially affected by changes to or errors in the ECCS EM that affect the break flow and mass and energy release. The applicant stated in the January 21, 2019, letter that no such errors were identified. The NRC staff disagrees since AR Letters 1999-02, 2001-02, 2001-04, and 2003-03 all identified errors that have a potential impact on the mass and energy release. AR Letters 1999-02, 2001-04, and 2003-03, which identified errors in the application of counter-current flooding limitation at the top of the core, in the steam flow from the core exit, and in the steam separator pressure drop, would all be expected to impact the pressure in the vessel during the transient and thus the transient mass and energy release. AR Letter 2001-02 identified a convergence error related to the time step size; without additional details, the effect on the transient break flow and mass and energy release is difficult to estimate, but the NRC staff expects that it is non-negligible. However, the NRC staff has determined that the integrated, rather than instantaneous, break flow and mass and energy release is what is important to the radiological analysis, and these errors would not be expected to significantly influence the total amount of mass and energy ejected through the break. Thus, the NRC staff concluded that any change in the radiological analysis from the errors reported for the ECCS EM would be negligible.

For the PRA success criteria evaluation, which used the ECCS EM directly, the applicant decided to take the same approach as the LOCA analysis and apply the estimated effect of the changes and errors to the values reported in the DCD. The NRC staff finds this approach to be acceptable for addressing the issue, since the estimated effects are directly applicable to the analysis using the ECCS EM that are included in the PRA.

**DCD Changes**

The NRC staff reviewed the proposed ABWR DCD markups and found that they appropriately account for the changes and errors reported in the applicant's 2018 10 CFR 50.46 annual report and the justifications provided in the January 21, 2019, letter. In the revised DCD, the applicant took the approach of accounting for the ECCS EM changes and errors discovered since the original ABWR DCD approval by adding the estimated effect of the changes and errors to the original ABWR DCD cladding temperature values. As discussed above, the NRC staff reviewed the changes and errors to the ECCS EM and found that the applicant appropriately evaluated each change or error and conservatively assessed the associated effect on PCT.

The sum of the absolute magnitudes of the reported changes and errors is greater than 50°F, and thus exceeds the threshold of significance as defined in 10 CFR 50.46(a)(3)(i). Nonetheless, the NRC staff determined that the reported changes and errors are relatively minor and do not call the continued acceptability of the EM into question. Additionally, none of

the changes or errors impacts the features required by 10 CFR Part 50, Appendix K. By conservatively estimating the effects of the changes and errors and incorporating the estimated effects into the ABWR design basis by updating the PCT reported in the DCD, the applicant demonstrated continued compliance with the peak cladding temperature acceptance criterion in 10 CFR 50.46(b)(1). As discussed above, the effect of the changes and errors on the maximum local oxidation—also reported in the DCD—is negligible.

Because the changes are relatively minor, because the applicant incorporated the estimated effects into the design basis by updating the DCD, and because the ECCS EM, including the effects of the changes and errors identified since the original DCD, demonstrates significant margin to the 2200°F and 17% maximum local oxidation acceptance criteria of 10 CFR 50.46(b)(1) and (b)(2), the NRC staff concluded that the design as modified continues to meet the requirements of 10 CFR 50.46 and 10 CFR 50, Appendix K, and that the changes are therefore acceptable.

The PRA analysis in Chapter 19.3 of the DCD was also updated to incorporate the same change in peak cladding temperature as the ECCS evaluation in Chapter 6.3 of the DCD. Even with the addition of 42°C (75°F) to the PCTs reported in the PRA analysis, the results maintain significant margin to the acceptance criterion established in the original DCD of 1483°C (2700°F). The NRC staff therefore finds the changes to be acceptable.

The staff notes that GEH proposed to retain two COL information items related to the ECCS performance evaluation in the revised DCD. In accordance with DCD Sections 6.3.6.1, “ECCS Performance Results,” and 6.3.6.3, “Limiting Break Results,” a COL applicant referencing the ABWR DCD will provide various results for the limiting break for each bundle design.

### 6.3.4 Conclusion

Based on the above, the NRC staff finds that, with the changes proposed by GEH for incorporation into the ABWR DCD, the ECCS performance evaluation included in the DCD meets the requirements of 10 CFR 50.46 and 10 CFR Part 50, Appendix K. Because the changes only affected the peak cladding temperature and maximum local oxidation evaluations, compliance with the 10 CFR 50.46 acceptance criteria is sufficient to demonstrate that the design of the ECCS meets the requirements of GDC 35 from 10 CFR Part 50, Appendix A. The proposed ABWR DCD markups are treated as a **Confirmatory Item 6.3-1**, pending their incorporation into the next revision of the DCD.