Enclosure 3

M170049

Technical Report NEDO-33875, Revision 3

Public

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NEDO-33875
Revision 3
February 2017

Non-Proprietary Information – Class I (Public)

ABWR US Certified Design

Aircraft Impact Assessment

Licensing Basis Information and Design Details for Key Design Features

INFORMATION NOTICE

This document is a public version of GE-Hitachi Nuclear Energy Americas LLC (GEH) NEDE-33875P, Revision 3. Proprietary information has been redacted as indicated by open and closed brackets as shown here [[ ]]. In addition, security-related information has been redacted as show here {{{ }}}. Where entire figures have been redacted for security-related reasons, the notation {{{Contains Security-Related Information – Withheld Under 10 CFR 2.390}}} is provided.

IMPORTANT NOTICE REGARDING CONTENTS OF THIS REPORT
Please Read Carefully

This document provides certain details of the aircraft impact assessment for the ABWR standard design. The information contained in the document is furnished to the NRC for the purpose of conducting its review for the renewal of the ABWR standard design certification. The use of this information by anyone for any other purpose than that for which it is intended is not authorized; and with respect to any unauthorized use, GEH makes no representation or warranty, and assumes no liability as to the completeness, accuracy, or usefulness of the information contained in this document.

Rev #	Preparer	Date	Revision Summary
0	Patricia Campbell	9/02/16	Initial Issue
1	Patricia Campbell	9/13/16	Revised Table 4-4 and Figures 4-1 and 4-2, as follows: • Changed 2nd Column heading from "Current Design Detail" to "Current FOAKE Detail." • Items in Table 4-4 are changed to address minor inconsistencies within the supporting document for Locations (A), (B), (C), (D), (E), (F), (G), (H), (I), (J), (K), (L), (M), (Q), and (R). • Added items in Table 4-4 for locations (T), (U), and (V) to address strengthening measures for additional walls at the stated elevations. • Figures 4-1 and 4-2 are revised to include new locations (T), (U), and (V). Revised Table 5-1 to remove floor elevations in Items (4) and (11).
2	Patricia Campbell	11/21/16	Revised to incorporate changes from NRC inspection 09/12 to 09/16 (2016) (Inspection Report 05200045/2016-201; 11/15/2016). Changed header for revision number. Page numbers also are changed. Minor editorial changes or corrections are made. Table of Contents, list of table, and list of figures are updated. Proprietary Information Notice: updated to indicate that a limited public version of this document is provided in NEDO-33875, Revision 0, which is created to support the future ABWR design certification renewal rulemaking. Section 3.3: added information on certain structural enhancements and other design changes; added reference to Table 3-1; added reference to Table 3-2; and added discussion for the inclusion of new Appendices B and C. Sections 3.4, 3.4.1, and 3.5: editorial change to space after bullet lists in these sections. Added new Tables 3-1 and 3-2.

Rev #	Preparer	Date	Revision Summary
2 (cont.)	Patricia Campbell	11/21/16	Section 4.3 is updated to correct title of Reference and to change the titles of Figures 4-1 and 4-2. Added references to Reference 4 and made minor edits to Section 4.4. Table 4-4 is updated for consistency with structural evaluation report revisions on strengthening measures. Certain changes are editorial only, such as changes to align information consistently. Figures 4-1 and 4-2 are replaced with updated figures for consistency with Table 4-4 changes. The figure titles are changed. Section 4.4: corrected spelling of "constructability." Changed wording for consistency with report on alternative reinforcement. Added a paragraph to describe conclusions of mesh sensitivity assessment. Table 5-1: changed "will be" to "are" for consistency with DCD changes; added intake and exhaust awnings for EDG HVAC in Items (6a) and (6b); and corrected T/B elevation for Item (10). Table 5-2: added statement to reflect credit as intervening structures for Items (1), (2), (3), (6), and (7); and added Item (11). Table 5-3 is updated for consistency. Section 6: updated References 3 and 4 to reflect revisions to the assessment report and the structural evaluation report. The affidavit for withholding was previously in Appendix B, but is now in Appendix D. References to the affidavit are changed to refer to Appendix D. Appendices B and C are added to provide the status of crediting walls on sketches and to identify interface boundary walls and floors on sketches. Appendix D is added and the affidavit is revised to reflect Revision 2 of this document.

Rev #	Preparer	Date	Revision Summary
3	Patricia Campbell	02/2017	General change: The document is modified to indicate which portions are proprietary and which portions are or contain security-related information so that a public version may be created to redact the information being withheld under 10 CFR 2.390. This includes the notice page and the header. The Table of Contents, List of Illustrations, and List of Tables are updated. Section 1.1 is updated to explain that this report is incorporated by reference in the ABWR DCD for revisions beyond Revision 6. Section 1.2 is updated to better clarify the purpose of this report. Section 1.4 is updated to add acronyms used for the Control Building Annex. Section 2.1 is changed to explain that this report is part of the DCD for DCD revisions beyond Revision 6. Section 3.3 is changed to add "and Figure 3-1" for showing the distances between the structures. Section 3.5 is updated to add information regarding why it is important to contact an AIA cognizant engineer if considering adding a penetration to the C/B roof to address a key design feature, or if routing cables or HVAC ducting or considering locating equipment in certain fire areas. Table 3-2 is updated and Figure 3-1 is added to provide the distances and locations of structures. The row on seismic gap is removed because it is addressed in a specific key design feature. Table 3-3 is added to identify fire areas and rooms with no AIA-credited equipment. Figure 3-1 is added to show distances and locations of structures in relation to each other for crediting intervening structures. Table 4-1 is updated to remove a row for input that is not a part of the scope of this document. Table 4-3 is changed to remove a material which is not a part of the scope of this document.

Rev #	Preparer	Date	Revision Summary
3 (cont.)	Patricia Campbell	02/2017	Table 4-4 is updated to clarify strengthening details for Location (L). Tables 5-1 and 5-2 are changed in the manner of referencing to NEDE-33875P. Table 5-1 is updated to renumber the items 6 through 12 to be consistent with DCD Section 3H.6. References to sections within this document are added in the "Reference" column for Items 4 and 12. Table 5-2 is updated to add information or references to sections within this document in the "Reference" column. A key design feature under 19G.4.2 is updated to be consistent with DCD Section 19G.4.2 and a key design feature under 19G.4.3 is updated to be consistent with DCD Section 19G.4.3. Appendices B and C are changed to add the elevations of the floors to the title of the figures. Appendix D is updated to reflect proprietary and security-related information markups and the basis for these to be redacted in the public version of the report.

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1.0 INTRODUCTION

1.1 Background

GE-Hitachi Nuclear Energy (GEH) submitted an application to renew the Advanced Boiling Water Reactor (ABWR) design certification on December 7, 2010 (MFN 10-343; NRC ADAMS Accession Number ML110040176). The application included a revised Design Control Document (DCD), Revision 5. The application review includes changes to the DCD to address Nuclear Regulatory Commission (NRC) Requests for Additional Information (RAI) and issues that GEH may identify as necessary. On February 19, 2016 (MFN 16-002), Revision 6 of the ABWR DCD was submitted. This report is incorporated by reference in the ABWR DCD for revisions beyond Revision 6.

Subsequent to the original design certification (1997), the NRC added to its regulations specific requirements to perform a design-specific assessment of the effects on the facility of the impact of a large, commercial aircraft, as set forth in 10 CFR 50.150 (see Appendix A of this report). As specified in 10 CFR 50.150(a)(3)(iii)(B), renewal of a standard design certification is to address the requirements by the time of application for renewal. An Aircraft Impact Assessment (AIA) was performed for the renewal application. In the DCD, Revision 5, Appendix 3H and Appendix 19G identified key design features for the aircraft impact assessment. As explained below, updates to the ABWR AIA have been made to address NRC RAIs and revised NRC regulatory guidance. The ABWR DCD is revised as necessary to conform to the AIA results.

1.2 Purpose

The purpose of this document is to provide licensing basis information regarding additional details of key design features credited for AIA. This document can also be used as a cross-reference tool for identifying and understanding certain information on the key design features and the basis for those being designated as key design features and its use is to preclude making design changes that might invalidate the AIA results.

Key Message:
When considering a change that relates in any manner to the aircraft impact key design features, consult with the AIA cognizant engineer.

This document also contains a high-level summary of the AIA, as well as detailed information and references for key design features. This document does not provide sufficient information for determining the effects of a change to the ABWR standard design on the ABWR AIA, and it is still necessary to involve the appropriate engineering personnel that are familiar with the AIA when considering a design change and in completing additional detailed design. This document does, however, provide a tool for the AIA engineers to review the supporting information for the key design features, as well as regulatory guidance. It is not the intent of this document to supersede information in either the ABWR DCD or the ABWR AIA reports, but it is intended to provide information for understanding certain details and references regarding the AIA results and conclusions. However, it is also important to note that the tables are not identical to the DCD or

the supporting reports, but may condense information or use acronyms, or remove information that might be too detailed. It is appropriate that this document may be revised periodically.

While the renewal application was under NRC review, the NRC issued Regulatory Guide (RG) 1.217, "Guidance for the Assessment of Beyond-Design-Basis Aircraft Impacts" (August 2011; ADAMS Accession Number ML092900004, Reference 1). RG 1.217 endorses the methodologies described in the industry guidance document NEI 07-13, "Methodology for Performing Aircraft Impact Assessments for New Plant Designs," Revision 8 (April 2011, Reference 2). The public version of NEI 07-13, Revision 8P, is available in NRC ADAMS, Accession Number ML111440006. [[

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This document is considered to contain GEH proprietary and security-related information, but this document does not contain SGI. Rather, it references information that is part of the ABWR DCD or that supports the more detailed design information (e.g., design specifications, procurement specifications, detailed design drawings) that is used in the ABWR AIA assessments, which are documented in reports that contain SGI (note that SGI material is accessible only to individuals cleared for SGI and who have a "need to know" before accessing the SGI material). As noted above, the tables presented in this report may not be direct quotes from the DCD or the reports.

1.3 Conduct of Assessment

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1.4 Acronyms

Acronym	Explanation
ABWR	Advanced Boiling Water Reactor
ACIWA	Alternating Current Independent Water Addition System
ADS	Automatic Depressurization System
AIA	Aircraft Impact Assessment
C/B	Control Building
C/B Annex or CB Annex	Control Building Annex
CDI	Conceptual Design Information
COLA/COL	Combined Operating License Application/Combined Operating License
COPS	Containment Overpressure Protection System
DCD	Design Control Document
ECCS	Emergency Core Cooling System
EDG	Emergency Diesel Generator
EF	Each Face
EPRI	Electric Power Research Institute
EW	Each Way
FCS	Flammability Control System
FHA	Fire Hazards Analysis
FOAKE	First-of-a-Kind Engineering
FPC	Fuel Pool Cooling and Cleanup
FSER	Final Safety Evaluation Report
GEH	GE-Hitachi Nuclear Americas LLC
HCU	Hydraulic Control Units
HPCF	High Pressure Core Flooder
HVAC	Heating, Ventilation, and Air Conditioning
ITAAC	Inspections, Tests, Analyses, and Acceptance Criteria
NRC	Nuclear Regulatory Commission
RAI	Requests for Additional Information
R/B	Reactor Building
RCCV	Reinforced Concrete Containment Vessel
RCIC	Reactor Core Isolation Cooling
RCW	Reactor Building Cooling Water
RG	Regulatory Guide
RHR	Residual Heat Removal
RPV	Reactor Pressure Vessel
RSS	Remote Shutdown System

Acronym	Explanation
RSW	Reactor Service Water
SB	Service Building
SFP	Spent Fuel Pool
SGI	Safeguards Information
SGTS	Standby Gas Treatment System
SLC	Standby Liquid Control
SSC	Systems, Structures, and Components
TB	Turbine Building
TS	Technical Specifications
UHS	Ultimate Heat Sink
URD	Utilities Requirement Document

1.5 Definitions

To understand certain key design features or supporting information, definitions are provided below with a reference to the section of the industry guidance for aircraft impact assessments.

Term	Definition
Adjacent Structure/Building	The presence of one building adjacent to another can provide protection to all or a portion of one of the buildings, as described in NEI 07-13, Section 3.2.
Interface Boundary	The interface boundary is the line between the end of the physical damage footprint and the beginning of the extension of the fire damage footprint. The interface boundary is usually a physical boundary (e.g., wall, ceiling, floor) between fire areas. See NEI 07-13, Section 3.3.2 for the rule sets that apply to an interface boundary.
Intervening Structure	An intervening structure is one that meets the criteria in NEI 07-13, Section 3.2, Selection of Elevations for Evaluation for preventing damage by an aircraft.

2.0 ANALYSIS INPUTS

The DCD represents the ABWR standard design at a level of design detail that meets NRC regulations for the content of a design certification application (10 CFR 52.47). In performing the AIA, certain information must be used as inputs to the assessment. As described below, the ABWR DCD provides much of the information necessary to perform the AIA.

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2.1 ABWR Design Certification Document

The ABWR design was the first standard design certification issued by the NRC, in May 12, 1997 (10 CFR Part 52, Appendix A). The certified design references ABWR DCD, Revision 4.

Prior to the certification, the NRC first issued a Final Design Approval (FDA) July 13, 1994, and revised it on November 23, 1994, to provide a 15-year duration. The FDA was based on the NRC Final Safety Evaluation Report (FSER), NUREG-1503, in July 1994. Changes to the design were submitted and the NRC staff evaluated these design changes in a supplement to the FSER, which was issued May 1997 to support the design certification.

The ABWR DCD is used as input for the AIA. DCD, Revision 6 is the basis for the AIA, with changes that are to be included in Revision 7. Thus, DCD Revision 6 and updates for changes in Revision 7 are used as AIA inputs. This report is also part of the DCD for DCD revisions beyond Revision 6.

Chapters 3, 9, and 19 contain the structural design descriptions, support system descriptions, fire protection, and risk insights. Chapter 9, Appendix 9A, provides the Fire Hazards Analysis (FHA), which identifies the fire barriers that provide divisional separation and resistance to impact, fire propagation, shock propagation, and fire or pressure dissipation. The key design features for the AIA are listed in Section 3H.6 (structural) and Section 19G (overall). [[

]] In addition, Tier 1 includes certain inspections, tests, analyses,

and acceptance criteria (ITAAC) and interface requirements that are related to AIA key design features.

2.2 ABWR First-of-a-Kind Engineering

During the time period when the ABWR standard plant design was undergoing NRC review, Congress enacted statutes for commercialization of advanced light water reactor technology.[1] GEH participated in this program to develop FOAKE for the ABWR, under a Department of Energy (DOE) program, with sponsors through the Advanced Reactor Corporation.[2] The program included developing and using the Electric Power Research Institute (EPRI) Utilities Requirement Document (URD) for the design features considered appropriate for the more advanced designs. The ABWR FOAKE project began in June 1993 and was completed in September 1996. Although most of the information from the FOAKE project was not added to the DCD, certain information was used to modify the ABWR DCD (shown as a dotted line on Figure 2-1).[3] The NRC issued a supplement to the FSER (NUREG-1503) to evaluate those changes. Certain other information was considered more detailed than the information in the DCD, but is consistent with the design basis information in the DCD and no changes were made to the DCD.

The ABWR design was used in Japan for licensing two ABWRs in the 1990s, which were constructed and are operational (known informally as K6/K7[4]). [[

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Certain information developed through the ABWR FOAKE program and certain information from the additional design details developed for an ABWR project were used as input in the ABWR AIA (largely where necessary details were not presented in the DCD). A listing of the FOAKE drawings used for the initial details of the design features for inputs to the AIA structural evaluations of the R/B is provided below.

Certain FOAKE details are used as inputs for AIA, as described below. Where it is shown that these detailed design inputs need to be enhanced for AIA, those enhancements are identified as key design features for the AIA. The key design features are described in the DCD in Section 3H.6 and Section 19G.

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[1] 42 U.S. Code § 13493 (Pub. L. 102-486) Oct. 14, 1992, 106 Stat. 3083.

[2] The Advanced Reactor Corporation as set up as a non-profit membership corporation in 1992. Its members included 16 utilities, DOE, and EPRI. The purpose of the corporation was to implement the FOAKE development process for advanced reactors. The ABWR FOAKE design team consisted of a number of design and engineering firms, with GE having the overall responsibility for the project.

[3] MFN 050-96, GE (J. Quirk) to NRC (D. Crutchfield), April 16, 1996, which identified 10 FOAKE design changes: four changes related to HVAC; corrections of certain inconsistencies between Tier 1 and Tier 2; CR Habitability HVAC dampers power supply to meet single failure criteria; removal of RCIC turbine exhaust rupture disks and upgrading of piping; upgrade Fire Motion Control Rod Drive (FMCRD) piping design pressure; material change for cladding on lower drywell access tunnels and Reactor Pressure Vessel (RPV) pedestal; and changes in Technical Specifications (TS) to address inconsistencies.

[4] Kashiwazaki-Kariwa Nuclear Power Station, Units 6 and 7.

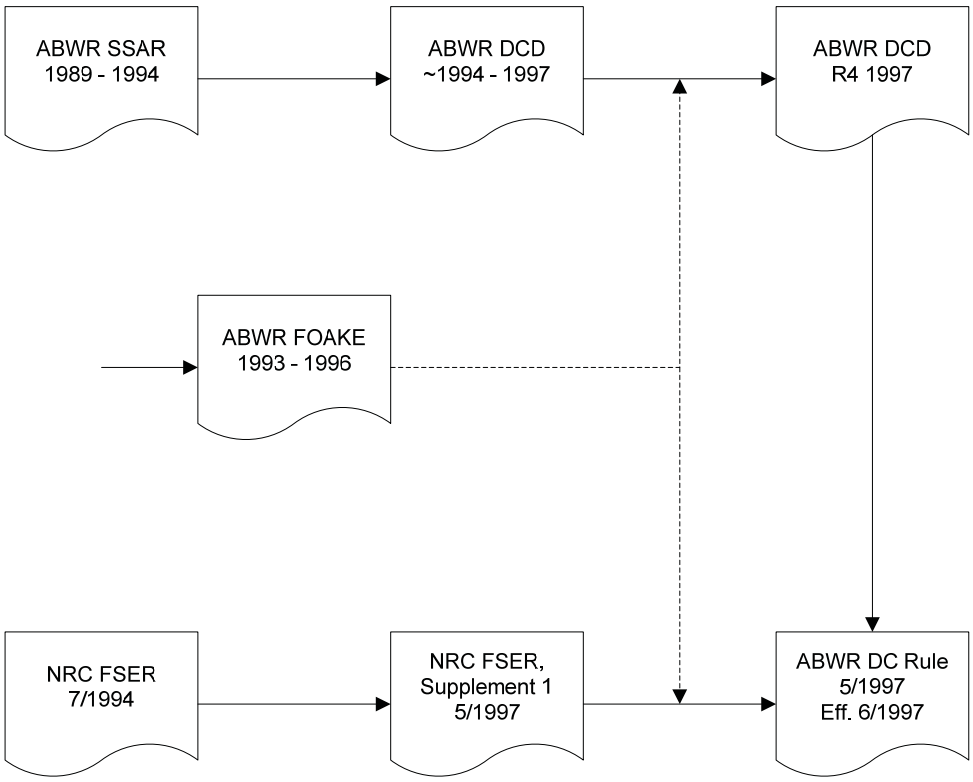

Figure 2-1 ABWR Documents

Key Message:
The level of detail in the ABWR DCD is supplemented by detailed design information for the AIA. When considering a design change or in performing further detailed design, consult with the AIA cognizant engineer.

3.0 ASSESSMENT

The assessment is documented in Reference 3. The report references the structural response analyses report prepared for GEH (Reference 4). These reports are considered SGI and are maintained in the GEH SGI storage facilities.

Portions of the information in the assessment report are not SGI and are discussed herein.

3.1 Acceptance Criteria

The AIA is performed using realistic analyses and incorporates into the DCD those design features and functional capabilities to show that, with reduced use of operator actions:

- The reactor core remains cooled or the containment remains intact; and
- Spent fuel cooling or Spent Fuel Pool (SFP) integrity is maintained.

Note: These criteria need to be maintained for 24-hours, as a minimum, in a stable hot standby condition after which it is assumed that additional offsite support can be obtained. The assessment also considers shutdown conditions.

The acceptance criteria selected by GEH for this heat removal assessment are:

- The reactor core remains cooled
- SFP integrity is maintained

NOTE: SFP cooling need not be maintained as long as SFP integrity can be maintained; however, SFP cooling must be assessed in accordance with 10 CFR 50.150.

3.2 Approach

The ABWR AIA approach follows the detailed guidance provided in NEI 07-13, Revision 8, which involves the following four steps:

1. Identify the buildings or structures that contain fuel cooling equipment to be credited in the assessment (i.e., buildings of concern).
2. Identify the strike locations for each elevation of the buildings of concern that can be impacted by an aircraft.
3. Develop physical, fire, and shock damage footprints for each strike on each accessible elevation. Overlay the damage footprints to determine what fuel cooling equipment is lost. Determine if surviving equipment assures adequate fuel cooling.
4. If the initial assessment shows that core cooling cannot be maintained, explore potential design changes to maintain fuel cooling.

Although NEI 07-13, Revision 8, allows credit for off-site power and non-safety related equipment to achieve core and/or SFP cooling, the ABWR AIA does not credit either.

3.3 Limitations and Key Assumptions

Certain specific limitations and key assumptions are associated with the ABWR AIA beyond those provided in NEI 07-13, Revision 8, and those are delineated in the assessment report (Reference 3). Where appropriate, certain of these limitations and key assumptions are identified as key design features in the DCD, Section 3H.6 or Appendix 19G.

The following design reference materials were used in the AIA.

- Site Plot Plan: DCD, Revision 6, Figure 1.2-1.
- General Arrangement Drawings for the Reactor Building, Control Building, Control Building Annex, Service Building, and Turbine Building: DCD Revision 6 and markup for including in DCD Revision 7, Figures 1.2-2 through 1.2-31.
- Structural Drawings: ABWR [[ ]] and ABWR DCD, Revision 6, and Appendix 3H.6, "Summary of Key Structural Design Features" (as informed by the Structural Integrity report for changes that will be included in DCD Revision 7).
- Fire Protection Drawings: ABWR DCD, Revision 6 with markups to be included in Revision 7, Chapter 9A.4, Figures 9A.4-1 thru 9A.4-32 Located in Chapter 21.
- Equipment in Fire Rooms: ABWR DCD, Revision 6, Chapter 9A.6, Table 9A.6-2.
- Primary Containment Penetration List: ABWR DCD, Revision 6. Table 6.2-8.
- Piping and Instrumentation Drawings: ABWR DCD, Revision 6, Tier 2, Chapter 21.
- Probabilistic Risk Assessment Criteria: ABWR DCD, Revision 6, Chapter 19.3.
- Spent Fuel Pool Safety Analysis: ABWR DCD, Revision 6, Chapter 9.1.3.3.

Certain structural enhancements and other design changes, which have been incorporated in the DCD, are also used as input for the structural analyses and the assessment. These are listed below in Table 3-1, "Structural and Design Enhancements Included in DCD." In addition, Table 3-2, "Intervening Structures Credited in ABWR Aircraft Impact Assessment," provides the building distance to the shielded structure credited for intervening structures, as shown on Figure 3-1, which also shows the location of the structures in relation to each other. When a construction plan is developed for a project, the layout must be checked by an AIA cognizant engineer to ensure that the AIA remains valid (see Table 3-2).

Key Message:
When developing a construction site plan for a project, consult with an AIA cognizant engineer.

Appendix B of this document shows the R/B layout drawings and identifies the status of crediting walls. In addition to these assumptions, enhancements, and design changes, there are certain interface boundary walls and floors which are assumed to contain no penetrations. See

Appendix C of this document for the identification of these interface boundaries for the portions of walls and floors that are assumed to have no penetrations.

Key Message:
When considering penetrations through walls and floors, it is essential to consult with the AIA cognizant engineer.

3.4 ABWR Design

The ABWR design is based on three divisions of safety systems, with a fourth division for instrumentation and controls. There are exceptions to the three divisions, in that certain systems are two divisional (but the HPCF is two-train supplemented by RCIC). Generally, these two-divisional safety systems are not credited in the ABWR AIA (except for HPCF/RCIC). {{{

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The safety systems that are two divisional and which are not credited in the ABWR AIA for core cooling or safe shutdown are as follows:

- Standby Gas Treatment System (SGTS)
- Standby Liquid Control (SLC)
- Flammability Control System (FCS) (Hydrogen Recombiners)
- Containment Overpressure Protection System (COPS)
- Automatic Depressurization System (ADS)
- RHR Wetwell and Drywell Spray
- Remote Shutdown System (RSS)

It is recognized that, as for other beyond-design-bases events, operators will be implementing symptom-based emergency procedures, which may not specifically preclude the use of systems that may be undamaged. However, such actions would be part of an overall coping strategy to account for actual conditions that may exist.

3.4.1 Core Cooling Capability

The ABWR DCD design is a boiling water reactor with three 100 percent independent safety trains. The ABWR design is a 3 x 100% for core cooling, but not for decay heat removal, under design basis assumptions. Each safety train consists of:

- Onsite electrical AC power from an Emergency Diesel Generator (EDG)
- Onsite electrical DC power from batteries

  NOTE: Electrical Division 4 only provides additional instrumentation and control logic in support of the other three divisions which contain all of the safety-related depressurization,

core cooling and containment heat removal capacity. Therefore, the assessment did not credit Division 4.

- Mechanical/Fluid Systems including:
  - Residual Heat Removal (RHR)
  - RHR System Containment Cooling
  - High Pressure Core Flooder (HPCF) which is applicable to divisions 2 and 3
  - Reactor Core Isolation Cooling (RCIC) which is applicable to division 1
- Electrical support systems such as switchgear, and instrumentation and control (I&C)
- Mechanical/fluid support systems such as heating, ventilation and air conditioning (HVAC), Reactor Service Water (RSW) system and the suppression pool

  NOTE: Cooling for the Reactor Building Cooling Water (RCW) system is provided by the Reactor Service Water (RSW) system. The design and location of the Intake Structure and RSW pump house(s) are not described in the DCD.

Two safety trains are necessary to bring the reactor to cold shutdown conditions from 100 percent power; however, each 100 percent train is capable of maintaining the reactor in a hot standby condition.

3.4.2 Spent Fuel Pool Cooling Capability

Cooling of fuel in the SFP is accomplished through the Fuel Pool Cooling and Cleanup (FPC) system. There are two separate trains of FPC powered by non-safety busses, and both trains of FPC are needed to achieve SFP cooling under high heat load conditions that occur during outages and with freshly discharged spent fuel. {{{

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Any one RHR train can provide a safety related backup for the FPC system when the reactor is shut down. The RHR discharge connections to the FPC system contain motor operated valves in both the RHR and FPC systems. The power, control and indication to the RHR cross connect valves are in the three respective safety divisions. {{{

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The suction to the RHR system from the FPC system is connected by locked closed manual valves which would need to be manually aligned. Such manual action was not credited in this assessment.

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3.5 Functional Success Criteria

The following core cooling functional success criterion was used in this assessment.

- Core cooling is maintained in hot standby condition for 24-hours. One safety train of Reactor Pressure Vessel (RPV) high pressure injection is needed to maintain hot standby conditions. Credited systems, including their mechanical and electrical support systems for RPV injection include RCIC, HPCF, RHR, and the suppression pool.

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Key Message:
When considering penetrations through the C/B roof, it is essential to consult with the AIA cognizant engineer.

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Key Message:
For divisional equipment that may be used for core cooling, when routing cables or HVAC ducting, or considering locating equipment in the listed fire areas and associated rooms in Section 9A.5.5.10 or Table 3-3 below, it is essential to consult with the AIA cognizant engineer.

Table 3-1 Structural and Design Enhancements Included in DCD

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Table 3-1 Structural and Design Enhancements Included in DCD

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Table 3-1 Structural and Design Enhancements Included in DCD

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Table 3-2 Intervening Structures Credited in ABWR Aircraft Impact Assessment

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Table 3-3 Fire Areas and Rooms with No Equipment Necessary for Core Cooling

Fire Area	Room No.	Comment
F1510	195	Northeast Stairwell
F1520	192	Northeast Elevator
F1530	193	Southwest Stairwell
F1540	194	Southwest Elevator
F3101	341	RSS not required as MCR is available for all strikes
F3210	329	West Stairwell
F3211	328	West Elevator
F3300	315, 331, 336, 413, 517, 638, 654	FMCRD Equipment and non-1E power supplies
F3310	316	East Stairwell
F3311	317	East Elevator
F3400	345, 380, 444, 543	Division 4
F4203	611, 685	HVAC for Main Steam Tunnel
F4301	430, 433, 435, 438, 530, 531, 615, 616, 617, 639, 657, 658, 674, 711, 716, 720, 721, 722, 723, 733, 734, 741, 742	Instrumentation penetrations and instrument lines associated with reactor water level and pressure and drywell pressure are required to be wrapped with secure, 3-hour fire barrier material and, if necessary, 5-psid rated.
F4303	434, 537	Fire buffer zone created between divisions 1 and 3 at elevation 1F and 2F
F4304	437	Fire buffer zone created between divisions 2 and 3 at elevation 1F
F4305	535, 631	Fire buffer zone created in crossover corridor between divisions 2 and 3 at elevation 2F and 3F
F4306	635	Fire buffer zone created in crossover corridor between divisions 2 and 3 at elevation 3F and 3.5F
F4307	637	Fire buffer zone created in crossover corridor between divisions 2 and 3 at elevation 3F and 3.5F
F6100	659	Containment Atmospheric Monitoring System Rack A
F6102	614, 644	Fire buffer zone created in crossover corridor between divisions 1 and 2 at elevation 3F
F6200	640, 680	Non-1E power supplies for FMCRD
F7202	744	Fire buffer zone created in crossover corridor between divisions 1 and 2 at elevation 4F
F7203	743	Fire Buffer zone created in crossover corridor between divisions 1 and 2 at elevation 4F
F7300	715	RIP and ASD equipment

Source: DCD Section 9A.5.5.10 and Appendix A of Reference 3.

Figure 3-1 ABWR Site Plan – Location of Structures

{{{Security-Related Information – Withheld Under 10 CFR 2.390}}}

4.0 STRUCTURAL ANALYSES

Structural analyses were performed as part of the AIA, as described below.

4.1 Structural Analyses Process

The structural performance of the GEH-ABWR plant design, as part of the requirements in meeting the AIA regulations in 10 CFR 50.150, is documented in the SI/Anatech report (Reference 4).

The scope of the evaluation is to perform the necessary structural performance analyses per NEI 07-13 (Reference 2) guidelines to demonstrate that the plant design with the identified design enhancements meet the regulatory requirements for AIA.

4.2 Input Data Specifications and Material Properties

The sources for the input data used in the structural modeling are summarized in Table 4-1, "Summary of Input Specifications." Table 4-2, "Summary of Material Specifications" provides a summary of the design specifications for the materials that serves as the basis for developing the material properties for use in the analyses per the NEI 07-13 (Reference 2) methodology.

Table 4-3, "Summary of Material Properties" summarizes the material properties used in these analyses.

Table 4-1 Summary of Input Specifications

Component	Drawing/Reference	Source/Comments
DCD Chapter 3	25A5675AE Rev 6	25A5675AE_ABWR_DCD_Rev_6_Tier_2 _Chapter_3_Vol_1.pdf _Chapter_3_Vol_2_Sensitive.pdf
DCD Chapter 9	25A5675AL Rev 6	25A5675AL_ABWR_DCD_Rev_6_Tier_2 _Chapter_9.pdf
DCD Chapter 19	25A5675AX Rev 6	25A5675AX_ABWR_DCD_Rev_6_Tier_2 _Chapter_19_Sensitive.pdf
DCD Chapter 21	25A5675BB Rev 6	25A5675BB_ABWR_DCD_Rev_6_Tier_2 _Chapter_21_Vol_1_Sensitive.pdf
DCD Chapter 21	25A5675BH Rev 6	25A5675BH_ABWR_DCD_Rev_6_Tier_2 _Chapter_21_Vol_7_Sensitive.pdf
R/B Concrete Outline	[[ ]]	[[ ]]
R/B Concrete Reinforcing Steel	[[ ]]	[[ ]]
R/B Structural Steel	[[ ]]	[[ ]]
Diaphragm Floor Reinforcement	[[ ]]	[[ ]]
RCCV Concrete Reinforcing Steel	[[ ]]	[[ ]]

Table 4-2 Summary of Material Specifications

Component	Specification	Reference
RCCV and R/B Concrete	Compressive strength (f'c) 27.6 MPa (4,000 psi)	25A5675AE Rev 6 & 7 Section 3H.1.4.4.1
Concrete Reinforcing Steel	ASTM A-615 Grade 60	25A5675AE Rev 6 & 7 Section 3H.1.4.4.2
SFP Liner	ASTM A-240 Type 304L 6.4mm thick	25A5675AE Rev 7 Section 3H.6 [[ ]]
Structural Steel	ASTM A-36 Grade 36	25A5675AE Rev 6 & 7 Section 3H.1.4.4.4
High Strength Structural Steel	ASTM A-572 Grade 50	25A5675AE Rev 6 & 7 Section 3H.1.4.4.4 [[ ]]

Table 4-3 Summary of Material Properties

Concrete < 3' Thick		
Compressive Strength (Design Minimum)	4000	psi
Nominal with 1.2 Aging Effect	5520	psi
Elastic Modulus (based on factored strength)	4.235E6	psi
Poisson's Ratio	0.20	
Tensile Strength (not explicitly used)	531.0	psi
Fracture Strain (based on factored strength)	125.4E-6	
Weight Density	150	lbs/ft^3
Concrete ≥ 3' Thick		
Compressive Strength (Design Minimum)	4000	psi
Nominal with 1.4 Aging Effect	6440	psi
Elastic Modulus (based on factored strength)	4.574E6	psi
Poisson's Ratio	0.20	
Tensile Strength (not explicitly used)	588.4	psi
Fracture Strain (based on factored strength)	128.6E-6	
Weight Density	150	lbs/ft^3
A-615 Grade 60 Rebar		
Elastic Modulus	29.0E6	psi
Poisson's Ratio	0.30	
Yield Stress (Nominal)	67.5	ksi
Yield Stress with 1.1 Rate Effect	74.25	ksi
Ultimate Strength (nominal*1.05 Rate Effect)	111.6	ksi
Elongation (typical)	12-15	%
Failure Strain (analysis)	5.0	%
A-572 Grade 50		
Elastic Modulus	29.5E6	psi
Poisson's Ratio	0.29	
Yield Stress (Nominal)	57.6	ksi
Yield Stress with 1.1 Rate Effect	63.36	ksi
Ultimate Strength (Nominal)	75.6	ksi
Ultimate Strength with 1.05 Rate Effect	79.38	ksi
Elongation (typical)	19	%
Failure Strain	7.8	%
Weight Density	0.284	lbs/in^3

Table 4-3 Summary of Material Properties

A-240 Type 304L		
Elastic Modulus	29.0E6	psi
Poisson's Ratio	0.30	
0.2% Yield Stress (Nominal)	29.0	ksi
Yield Stress with 1.18 Rate Effect	34.22	ksi
Ultimate Strength (Minimum)	70.0	ksi
Elongation (typical)	40	%
Failure Strain	13.8	%
Weight Density	0.284	lbs/in^3
A-36 Structural Steel		
Elastic Modulus	29.5E6	psi
Poisson's Ratio	0.30	
Yield Stress (Minimum)	36.0	ksi
Yield Stress (Nominal)	49.282	ksi
Ultimate Strength (Minimum)	60.0	ksi
Ultimate Strength (Nominal with 1.1 Rate)	75.4	ksi
Elongation (typical)	18-20	%
Failure Strain	8.3	%
Weight Density	0.284	lbs/in^3

4.3 Structural Assessment

The SI/Anatech structural response analysis report (Reference 4) describes the modeling and analyses performed to evaluate the structural performance {{{

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Table 4-4, "Summary of Strengthening Measures," provides a summary of the strengthening measures configured as part of the design enhancements for aircraft impact. [[

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Table 4-4 Summary of Strengthening Measures		
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Figure 4-1 Schematic for Design Enhancements, El 4800 through 19600

{{{Security-Related Information – Withheld Under 10 CFR 2.390}}}

Figure 4-2 Schematic for Design Enhancements, El 19600 through 31700

{{{Security-Related Information – Withheld Under 10 CFR 2.390}}}

4.4 Conclusions of Structural Analyses

The structural integrity of the SFP is maintained, considering the design enhancements described above. Interior and exterior walls are strengthened above the original design basis, as described above. Representative configurations for the shield blocks above the drywell head were analyzed to demonstrate adequate protection to the drywell head. Two representative configurations are provided for a barrier door for the Truck Bay opening on the south wall of the R/B. Key design features for structural analyses are captured in DCD Section 3H.6, as appropriate (e.g., roof, fire protection features, or awnings). [[

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In addition, the SI/Anatech Report (Reference 4) describes a review of the analysis results [[

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5.0 RESULTS

A design-specific assessment of the effects on the GEH-ABWR DCD, Revision 6, design (with updates that will be included in Revision 7) of the impact of a large, commercial aircraft on the ability to maintain cooling of fuel in the reactor and SFP was performed as described in Section 3 of this report. The assessment was based on the Commission's specified aircraft characteristics used to define the beyond-design-basis impact of a large, commercial aircraft. The associated structural analyses are described in Section 4, Structural Analyses of this report.

The assessment concludes that cooling of the core is maintained for all postulated strikes by at least one division of core cooling equipment, with limited reliance on operator actions. SFP integrity is maintained for all postulated strike locations. Thus the GEH ABWR DCD, Revision 6, design (with updates to be included in DCD Revision 7) satisfies the acceptance criteria of 10 CFR 50.150 with reduced use of operator actions.

5.1 Key Design features

The structural key design features are described in DCD Section 3H.6 and on Table 5-1, "Key Structural Design Features in DCD Appendix 3H.6." The overall key design features are described in DCD Appendix 19G and on Table 5-2, "Key Design Features in DCD Appendix 19G," below. The tables below are consistent with the DCD and provide reference information.

Key Message:
When considering a change that relates in any manner to the aircraft impact key design features, consult with the AIA cognizant engineer.

Table 5-1 Key Structural Design Features in DCD Appendix 3H.6[5]

Number in DCD	Key Structural Design Features 450mm = 18"; 600mm = 24"; 900mm = 36"	Reference
3H.6, Summary of Key Structural Design Features	(1) Structural configuration of Spent Fuel Pool (SFP) within the Reactor Building precludes a direct strike on the SFP.	DCD Sections 3.8.4 and 3H.1. "Evaluation of Aircraft Impact on GEH-ABWR Plant Design, Structural Response Analyses" (Reference 4).
	The spent-fuel pool is a reinforced concrete structure with a 6.4mm (minimum) thick ASTM A-240 Type 304L stainless steel liner (see DCD Section 9.1.2.1.3).	DCD Section 9.1.2.1.3 and 3H.6. ABWR Project L, R/B and C/B Civil Construction Specification, 31113.71.0410 Rev. 8, Section 5C.2.2.
	The SFP walls are strengthened as described in this document [NEDE-33875P, Reference 19G-3] to ensure the integrity of the SFP is maintained.	"Evaluation of Aircraft Impact on GEH-ABWR Plant Design, Structural Response Analyses" (Reference 4). See Table 4-4 above.
	(2) Structural configuration of primary containment (RCCV) within Reactor Building precludes direct strike on containment, and structural design of RCCV ensures that RCCV is not perforated.	DCD Sections 3.8.1, 3.8.2, and 3H.1 describe the structural design of the RCCV.
	(3) Shield blocks over drywell head are configured to fully resist secondary impacts from concrete debris, aircraft wreckage, and falling crane components to protect integrity of drywell head. The reactor cavity shield blocks are shown in Figure 3H.1-23.	DCD Figure 3H.1-23. "Evaluation of Aircraft Impact on GEH-ABWR Plant Design, Structural Response Analyses" (Reference 4).
	(4) Interior partition walls are thickened and strengthened as shown in this document [NEDE-33875P, Reference 19G-3] to limit physical damage to interior partition walls.	DCD Figures 1.2-8 and 1.2-9. See Section 4 above. "Evaluation of Aircraft Impact on GEH-ABWR Plant Design, Structural Response Analyses" (Reference 4).
	(5) Reinforced Concrete Sliding Barriers with structural capacity equivalent to the surrounding wall are provided for the 6 large openings on 1F (Figure 1.2-8) to limit physical damage to exterior wall.	DCD Figure 1.2-8. "Evaluation of Aircraft Impact on GEH-ABWR Plant Design, Structural Response Analyses" (Reference 4).

[5] The text is consistent with the DCD, but may not be exact quotes due to the use of acronyms.

Table 5-1 Key Structural Design Features in DCD Appendix 3H.6[5]

Number in DCD	Key Structural Design Features 450mm = 18"; 600mm = 24"; 900mm = 36"	Reference
	(6) Protective awnings for the HVAC exhaust openings on 2F (Figure 1.2-9) are sized to provide structural capacity equivalent to the corresponding exterior wall to prevent unabated wreckage through these openings.	DCD Figure 1.2-9. DCD Section 9.4.5.5.3.
	(7) Protective awnings for the HVAC intake openings on 3F (Figure 1.2-10) are sized to provide structural capacity equivalent to that provided in Table 3-2 of NEI 07-13 for exterior walls (Reference 19G-1).	DCD Figure 1.2-10. DCD Section 9.4.5.5.3.
	(8) Deleted.	
	(9) Control Building Annex exterior walls are made of reinforced concrete and are at least 450mm thick.	The rules for intervening structures are given in NEI 07-13 Rev 8 (page 44).
	(10) The Service Building exterior wall running in the North-South direction immediately adjacent to the Control Building is a reinforced concrete wall of 900mm minimum thickness.	This is an input assumption to allow credit of the SB wall as an intervening structure.
	(11) TB reinforced concrete exterior wall adjacent to the C/B (south wall) from column line T6 to T9 up to elevation 22750mm is at least 900mm thick.	This is an input assumption to allow credit of the TB south wall as an intervening structure to elevation 22750mm.
	(12) R/B exterior walls on the East, West, and South sides are strengthened with enhanced reinforcement as described in this document [NEDE-33875P, Reference 19G-3].	See Section 4 above. "Evaluation of Aircraft Impact on GEH-ABWR Plant Design, Structural Response Analyses" (Reference 4).

Table 5-2 Key Design Features in DCD Appendix 19G[6]

Number in DCD	Key Design Features	Reference
19G.4.1, Primary Containment	The RCCV, as described in Sections 3.8 and 3H.1, is a key design feature that would protect the safety systems located inside primary containment from the impact of a large commercial aircraft. The assessment concludes that a strike upon the primary containment would not result in the perforation of the primary containment, and would not cause direct damage to the systems within the primary containment or expose them to jet fuel. The assessment also finds that safety-related components inside primary containment, including the reactor pressure vessel and associated Emergency Core Cooling System (ECCS) piping are unaffected by shock-induced vibrations resulting from the impact of a large commercial aircraft.	DCD Sections 3.8 and 3H.1.
19G.4.2, Site Arrangement and Plant Structural Design	The design and arrangement of major structures associated with the ABWR design as described in Section 1.2 and Figure 1.2-1 are key design features.	DCD Section 1.2 and Figure 1.2-1. See Table 3-2 and Figure 3-1 above.
19G.4.2, Site Arrangement and Plant Structural Design	Key structural design features for aircraft impact are listed in Section 3H.6.	DCD Section 3H.6. See Table 5-1 above.
19G.4.2, Site Arrangement and Plant Structural Design	Specifically, the assessment credited the arrangement and design of the following building features to limit the location and effects of potential aircraft strikes on the R/B, RCCV and C/B in the following locations:	DCD Section 1.2.2.1.3 lists the figures that show arrangements of the buildings on the site: "The containment and building arrangements, including equipment locations, are shown in Figures 1.2-2 through 1.2-31. The arrangement of these structures on the plant site is shown in Figure 1.2-1." Figure 1.2-1 shows the location of the buildings in relation to each other. Also, see Table 3-2 and Figure 3-1 above.

[6] The text is consistent with the DCD, but may not be exact quotes due to the use of acronyms.

Table 5-2 Key Design Features in DCD Appendix 19G[6]

Number in DCD	Key Design Features	Reference
	(1) The location and design of the C/B structure as described in Sections 3.8.4 and 3H.2 are key design features that protect portions of the north wall of the R/B below Elevation 22000 from the impact of a large commercial aircraft. The C/B location on site is reflected on Figure 1.2-1, Site Plan. The C/B location, fixed with respect to other major structures, is defined in this document [NEDE-33875P, Reference 19G-3] to ensure that credit of the C/B as an intervening structured is maintained.	DCD Sections 3.8.4 and 3H.2. Also, see Table 3-2 and Figure 3-1 above.
	(2) The location and design of the TB structure and layout as described in Tier 1 Section 2.15.11 and Tier 2 Figures 1.2-24 through 1.2-31 are key design features that protect the entire north wall of the C/B and portions of the north wall of the R/B from the impact of a large commercial aircraft. The TB location on site is reflected on Figure 1.2-1, Site Plan. The TB location, fixed with respect to other major structures, is defined in this document [NEDE-33875P, Reference 19G-3] to ensure that credit of the TB as an intervening structure is maintained.	DCD Tier 1, Section 2.15.11; DCD Figures 1.2-24 through 1.2-31. DCD Section 3H.6(10). DCD Figure 1.2-1 shows the site arrangement of the TB and C/B. Also, see Table 3-2 and Figure 3-1 above.
	(3) The location and design of the R/B structure as described in Sections 3.8.4 and 3H.1 are key design features that protect portions of the primary containment and the entire south wall of the C/B from the impact of a large commercial aircraft. This includes the protection provided by exterior walls, interior walls, intervening structures and barriers on the large openings in the R/B exterior walls. A detailed structural analysis using the NEI 07-13 Revision 8 methodology was utilized to determine the design of selected internal walls as shown in Figures 1.2-10 thru 1.2-12 and external barriers as shown in Figures 1.2-8 and 1.2-9 that, in combination with the external wall, protects the critical penetrations. That analysis was also used to determine the key design features for the reactor cavity shield blocks for protecting the drywell head from secondary impacts as identified in Section 3H.1.3 and Figure 3H.1-23. The R/B location on site is reflected on Figure 1.2-1, Site Plan. The R/B location, fixed with respect to other major structures, is defined in this document [NEDE-33875P, Reference 19G-3] to ensure that credit of the R/B as an intervening structure is maintained.	DCD Sections 3.8.4, 3H.1, and 3H.1.3; DCD Figures 1.2-10 through 1.2-12, and 3H.1-23. Also, see Table 3-2 and Figure 3-1 above.

Table 5-2 Key Design Features in DCD Appendix 19G[6]

Number in DCD	Key Design Features	Reference
	(4) The location and design of the SFP and its supporting structure as described in Section 9.1 and Figure 1.2-12 are key design features in protecting the SFP from the impact of a large commercial aircraft.	DCD Section 9.1 and Figure 1.2-12.
	(5) The physical separation of the Class 1E EDG is a key design feature that prevents the loss of all electrical power to core cooling systems by protecting them from physical damage, fire damage and smoke effects.	DCD Section 8.3 discusses the divisional separation of the onsite power systems, including the three diesel generators. DCD Figure 9A.4-4 shows the separation of the three diesel generators and the fire barriers for the rooms (412, 423, and 432). DCD Appendix 9A discusses the various fire areas.
	(6) The location and design of the Service Building structure as described in Section 3H.6 and Figures 1.2-20 through 1.2-22 are key design features that protect the east wall of the C/B from the impact of a large commercial aircraft. The SB location on site is reflected on Figure 1.2-1, Site Plan. The SB location, fixed with respect to other major structures, is defined in this document [NEDE-33875P, Reference 19G-3] to ensure that credit of the SB as an intervening structure is maintained.	DCD Section 3H.6 and Figures 1.2-20 through 1.2-22. Also, see Table 3-2 and Figure 3-1 above.
	(7) The location and design of the C/B Annex structure as described in Section 3H.6 and Figures 1.2-20 through 1.2-22 are key design features that protect the west wall of the C/B from the impact of a large commercial aircraft. The C/B Annex location on site is reflected on Figure 1.2-1, Site Plan. The C/B Annex location, fixed with respect to other major structures, is defined in this document [NEDE-33875P, Reference 19G-3] to ensure that credit of the C/B Annex as an intervening structure is maintained.	DCD Section 3H.6 and Figures 1.2-20 through 1.2-22. Also, see Table 3-2 and Figure 3-1 above.
	(8) The seismic gap between the R/B and C/B described in DCD Section 3.8.5.1 is a key design feature in protecting the C/B from shock effects from strikes on the R/B.	DCD Section 3.8.5.1.
	(9) The R/B HVAC ducting locations ensure routing maintains separation divisionally through protection or physical separation so that AIA strikes do not result in a loss of all divisions of core cooling.	Appendix 9A (however, HVAC detailed design is not yet complete).

Table 5-2 Key Design Features in DCD Appendix 19G[6]

Number in DCD	Key Design Features	Reference
	(10) During normal operating conditions, the R/B crane will be parked at the R/B North wall when not in use.	DCD Section 9.1.5.2.1.
	(11) Any permanent structure that penetrates the C/B roof is sized to preclude a strike from the east and west directions.	DCD Figure 1.2-22. Also, see Section 3.5 above.
19G.4.3, Fire Barriers and Fire Protection Features	The design and location of 3-hour fire barriers and 3-hour, 5-psid fire barriers are key design features for the protection of core cooling equipment within these buildings from the impact of a large commercial aircraft.	DCD Appendix 9A.
	The assessment credited the design and location of fire barriers (including doors, dampers and other penetrations) as shown on R/B Fire Protection drawings 9A.4-1 through 9A.4-8 and described in Sections 9.5.1 and 9A.4 for the R/B to limit the effects of internal fires created by the impact of a large commercial aircraft.	DCD Appendix 9A and R/B fire protection drawings Figures 9A.4-1 through 9A.4-8 and described in Sections 9.5.1 and 9A.4.
	All credited watertight doors have a 5-psid, 3-hour fire rating.	DCD Appendix 9A and R/B fire protection drawings Figures 9A.4-1 through 9A.4-8 and described in Sections 9.5.1 and 9A.4.
	All doors, dampers and other penetrations at the perimeter of a fire area will be designed to meet the rating of the designated fire barrier (3-hour or 3-hour, 5-psid).	See response to RAI 19-5. MFN 14-063, and its supplements 1 through 3.
	Additionally, all credited penetration seals in 3-hour fire barriers will also be rated for 3-hour, 5-psid and fire dampers with a 3-hour 5-psid rating will be quick actuating (Blast) type.	See GEH response to RAI 19-5. MFN 14-063, Supplement 2.
	Section 9A.5.5.10 establishes fire hazards requirements that are key design features for aircraft impact assessment. Locating divisional core cooling equipment in certain fire areas and their associated rooms must be assessed under 10 CFR 50.150, as described in Section 9A.5.5.10. Divisional power, instrumentation or control cabling or HVAC ducting routed through certain fire areas must be assessed under 10 CFR 50.150 as described in Section 9A.5.5.10.	DCD Section 9A.5.5.10. Also, see Section 3.5 and Table 3-3 above.

Table 5-2 Key Design Features in DCD Appendix 19G[6]

Number in DCD	Key Design Features	Reference
	Steel Roof Trusses supporting the R/B roof (el. 49700mm) are fireproofed and encased with a 3-hr, 5-psid fire retardant material/system that will not be dislodged by the postulated aircraft Impact overpressure (see Section 9A.2.4).	DCD Section 9A.2.4. See DCD Tier 1 Table 2.15.10 for ITAAC.
19G.4.4 Core Cooling Features	The design and physical separation of the emergency core cooling systems described in Section 6.3 are key design features for assuring core cooling.	DCD Section 6.3.
	The following support systems are also designated as key design features for ensuring ECCS is available. All support systems were assessed for physical, fire and shock damage.	See numbered items below.
	(1) The Class 1E Onsite AC power system described in DCD Section 8.3.1 is a key design feature. The Class 1E Onsite DC power system described in DCD Section 8.3.2 is a key design feature.	DCD Sections 8.3.1 and 8.3.2.
	(2) The instrumentation system described in DCD Sections 7.2, 7.3.2.1, 7.3.2.4, 7.3.2.6, 7.3.2.7, and 7.3.2.8 is a key design feature.	DCD Sections 7.2, 7.3.2.1, 7.3.2.4, 7.3.2.6, 7.3.2.7, and 7.3.2.8.
	(3) The Makeup Water Condensate System described in DCD Section 9.2.9, the Fire Water Storage System described in DCD Section 9.5.1 and the Suppression Pool described in DCD Section 6.2.1 are key design features for providing adequate cooling water to maintain fuel cooling.	DCD Section 6.2.1, 9.2.9, and 9.5.1.
	(4) The Reactor Service Water System described in DCD Section 9.2.15 and the R/B Cooling Water System described in DCD Section 9.2.11 are key design features for providing the necessary cooling water for ECCS system operation.	DCD Sections 9.2.11 and 9.2.15. DCD Tier 1 Section 2.11.9 provides the site interface requirements for the RSWS.
	(5) The Ultimate Heat Sink described conceptually in DCD Section 9.2.5 is a key design feature for cooling the Reactor Service Water System. The AC Independent Water System (ACIWA) described in DCD Section 5.4.7 is a key design feature for maintaining cooling of the fuel in the event the Ultimate Heat Sink (UHS) is lost.	DCD Sections 5.4.7 and 9.2.5. See DCD Tier 1 Section 4.1 for UHS interface requirements.
	(6) The Reactor Safety Relief Valves described in DCD Section 6.2 are a key design feature.	DCD Section 6.2.
	(7) The Containment Overpressure Protection System (COPS) described in DCD Section 6.2.5 is a key design feature.	DCD Section 6.2.5.

Table 5-2 Key Design Features in DCD Appendix 19G[6]

Number in DCD	Key Design Features	Reference
	(8) The design and physical location of the CRD Hydraulic Control Units (HCU) and the CRD System mechanisms described in DCD Section 4.6.1 are key design features for ensuring that a reactor scram is available.	DCD Section 4.6.1. Added to the DCD in response to NRC RAI 19-4. See MFN 14-063 (09/24/2014).
	(9) Cabling and ventilation routing is designed divisionally.	Detailed design features. See DCD Chapters 7 and 8 (cabling) and Section 9.4 (HVAC). Note that this item relates to safety-related cabling and ventilation.
	(10) The Main Control Room (MCR) HVAC mechanical and electrical cross connects described in DCD Section 9.4.1.1.4 are key design features.	DCD Section 9.4.1.1.4. DCD Section 13.5.3.4 addresses development of procedures for combating emergencies and other significant events. Aircraft impact is listed as one of the events to be considered in developing these procedures. See DCD Tier 1, Sections 2.11.6 and 2.15.5.
	The ABWR design for aircraft impact is in full compliance with the guidance of NEI 07-13 Rev 8, "Methodology for Performing Aircraft Assessments for New Plant Designs." In the event of a threatened aircraft impact while the reactor is critical and operating normally at power, the guidelines in NEI 07-13 Rev 8 allow the assumption that the operators will have advance warning to take manual action to shutdown the reactor prior to impact unless the Hydraulic Control Units (HCUs) are in the physical damage footprint. For the ABWR design, the HCUs are located below grade, outside of the physical and shock damage footprints. As a result, such advance warning to shutdown the reactor can be credited.	NEI 07-13, Revision 8. Table 3-4, “Approach to Key Issues in Scenario Development,” Item 3, addresses reactor scram prior to strike. DCD Section 13.5.3.4 addresses development of procedures for combating emergencies and other significant events. Aircraft impact is listed as one of the events to be considered in developing these procedures.

Table 5-2 Key Design Features in DCD Appendix 19G[6]

Number in DCD	Key Design Features	Reference
	During shutdown conditions, core cooling is maintained by injecting water into the Reactor Vessel using the available RHR or HPCF train. For some strike locations only one division of RHR/HPCF equipment is available. If this train were to be out of service for maintenance, shutdown cooling would be lost. Administrative controls will be established by the COL applicant to ensure that RHR Train A and either RHR or HPCF for Trains B and C are not out of service for maintenance until the cavity is flooded and the SFP gates are opened. This will ensure an adequate water reservoir to provide cooling of the fuel in the vessel for at least 24-hours. Subsequent installation of the SFP gates may be performed with less than the previously described ECC system injection capability as long as the amount of water in the reactor / reactor cavity is sufficient to provide 24-hours of cooling for the fuel remaining in the reactor. The minimum system availability requirements are covered by Technical Specifications.	DCD Section 13.5.3.4 addresses development of procedures for combating emergencies and other significant events. Aircraft impact is listed as one of the events to be considered in developing these procedures.

5.2 Operator Actions

The provisions of 10 CFR 50.150 are to identify and incorporate into the design those design features and functional capabilities, with reduced use of operator actions, that will meet the objective of the rule. In issuing the final rule, the NRC explained its expectations for reliance on operator actions. In addition, NEI 07-13 (Reference 2), Table 3-4, "Approach to Key Issues in Scenario Development," addresses certain actions that can be expected to occur after a warning and prior to damage (e.g., a reactor scram prior to a strike).

Key Message:
When considering a change that may involve the balancing of adding design features versus relying on operator actions (including mitigative strategies), to the extent practical, reduced reliance on operator actions is a key AIA goal. Consult with the AIA cognizant engineer.

Design features are added to reduce reliance on operator actions. In limited scope, operator actions may be involved (as described in Table 5-3, Programmatic/Operational Credits/Assumptions below) for actions in the C/B, which is not damaged by an aircraft impact. For those instances, the design features that are added reduce reliance on immediate operator action, consistent with the rule.[7]

[7] For example, the NRC discussed operator actions in the Statements of Consideration for the aircraft impact assessment final rule, indicating that the decision to rely on design features, as opposed to operator action or mitigative strategies, is complex and often involves a set of trade-offs between competing considerations. 74 Fed.Reg. 28112 (June 12, 2009), at 28118-28119.

Table 5-3 Programmatic/Operational Credits/Assumptions

Programmatic/Operational Credits/Assumptions	Basis for the Credit
In the event of a threatened aircraft impact while the reactor is critical and operating normally at power, the guidelines in NEI 07-13 Rev 8 allow the assumption that the operators will have advance warning to take manual action to shut down the reactor prior to impact. The HCUs are not in the damage footprint for the ABWR.	NEI 07-13, Revision 8. Table 3-4, "Approach to Key Issues in Scenario Development," Item 3, addresses reactor scram prior to strike. DCD Section 13.5.3.4 addresses development of procedures for combating emergencies and other significant events. Aircraft impact is listed as one of the events to be considered in developing these procedures.
During shutdown conditions, core cooling is maintained by injecting water into the Reactor Vessel using the available RHR or HPCF train. For some strike locations only one division of RHR/HPCF equipment is available. If this train were to be out of service for maintenance, shutdown cooling would be lost. Administrative controls will be established by the COL applicant to ensure that RHR Train A and either RHR or HPCF for Trains B and C are not out of service for maintenance until the cavity is flooded and the SFP gates are opened. This will ensure an adequate water reservoir to provide cooling of the fuel in the vessel for at least 24-hours. Subsequent installation of the SFP gates may be performed with less than the previously described ECCS injection capability as long as the amount of water in the reactor / reactor cavity is sufficient to provide 24-hours of cooling for the fuel remaining in the reactor. The minimum system availability requirements are covered by Technical Specifications.	DCD Section 13.5.3.4 addresses development of procedures for combating emergencies and other significant events. Aircraft impact is listed as one of the events to be considered in developing these procedures.
The MCR HVAC mechanical and electrical cross connects described in DCD Section 9.4.1.1.4 are key design features. Note that these design features are added to facilitate operator actions prior to significant control room temperatures rise in the event that the two divisions that serve for cooling water and power for the MCR HVAC are affected by the strike.	DCD Section 9.4.1.1.4. DCD Section 13.5.3.4 addresses development of procedures for combating emergencies and other significant events. Aircraft impact is listed as one of the events to be considered in developing these procedures. See DCD Tier 1, Sections 2.11.6 and 2.15.5.

6.0 REFERENCES

1. Regulatory Guide 1.217, "Guidance for the Assessment of Beyond-Design-Basis Aircraft Impacts, Rev. 0 (August 2011).
2. NEI 07-13, "Methodology for Performing Aircraft Impact Assessments for New Plant Designs" (non-public), Rev. 8 (2011).
3. Jensen-Hughes, C0102080007-9536, "Aircraft Impact Assessment for Fuel Cooling, Report on the GEH-ABWR DCD, Revision 6 Design" (Rev. 5).
4. Structural Integrity Associates, Report Number 1600262.401.R3, "Evaluation of Aircraft Impact on GEH-ABWR Plant Design, Structural Response Analyses" (February 2017).

APPENDIX A

NRC Regulations for Aircraft Impact Assessment

§ 50.150 Aircraft impact assessment.

(a) *Assessment requirements*. (1) *Assessment*. Each applicant listed in paragraph (a)(3) shall perform a design-specific assessment of the effects on the facility of the impact of a large, commercial aircraft. Using realistic analyses, the applicant shall identify and incorporate into the design those design features and functional capabilities to show that, with reduced use of operator actions:

(i) The reactor core remains cooled, or the containment remains intact; and

(ii) Spent fuel cooling or spent fuel pool integrity is maintained.

(2) *Aircraft impact characteristics*.[1] The assessment must be based on the beyond-design-basis impact of a large, commercial aircraft used for long distance flights in the United States, with aviation fuel loading typically used in such flights, and an impact speed and angle of impact considering the ability of both experienced and inexperienced pilots to control large, commercial aircraft at the low altitude representative of a nuclear power plant's low profile.

(3) *Applicability*. The requirements of paragraphs (a)(1) and (a)(2) of this section apply to applicants for:

(i) Construction permits for nuclear power reactors issued under this part after July 13, 2009;

(ii) Operating licenses for nuclear power reactors issued under this part for which a construction permit was issued after July 13, 2009;

(iii)(A) Standard design certifications issued under part 52 of this chapter after July 13, 2009;

(B) Renewal of standard design certifications in effect on July 13, 2009 which have not been amended to comply with the requirements of this section by the time of application for renewal;

(iv) Standard design approvals issued under part 52 of this chapter after July 13, 2009;

(v) Combined licenses issued under part 52 of this chapter that:

(A) Do not reference a standard design certification, standard design approval, or manufactured reactor; or

(B) Reference a standard design certification issued before July 13, 2009 which has not been amended to address the requirements of this section; and

(vi) Manufacturing licenses issued under part 52 of this chapter that:

(A) Do not reference a standard design certification or standard design approval; or

(B) Reference a standard design certification issued before July 13, 2009 which has not been amended to address the requirements of this section.

(b) *Content of application*. For applicants identified in paragraph (a)(3) of this section, the preliminary or final safety analysis report, as applicable, must include a description of:

(1) The design features and functional capabilities identified in paragraph (a)(1) of this section; and

(2) How the design features and functional capabilities identified in paragraph (a)(1) of this section meet the assessment requirements in paragraph (a)(1) of this section.

(c) *Control of changes*. (1) For construction permits which are subject to paragraph (a) of this section, if the permit holder changes the information required by 10 CFR 50.34(a)(13) to be included in the preliminary safety analysis report, then the permit holder shall consider the effect of the changed feature or capability on the original assessment required by 10 CFR 50.150(a) and amend the information required by 10 CFR 50.34(a)(13) to be included in the preliminary safety analysis report to describe how the modified design features and functional capabilities continue to meet the assessment requirements in paragraph (a)(1) of this section.

(2) For operating licenses which are subject to paragraph (a) of this section, if the licensee changes the information required by 10 CFR 50.34(b)(12) to be included in the final safety analysis report, then the licensee shall consider the effect of the changed feature or capability on the original assessment required by 10 CFR 50.150(a) and amend the information required by 10 CFR 50.34(b)(12) to be included in the final safety analysis report to describe how the modified design features and functional capabilities continue to meet the assessment requirements in paragraph (a)(1) of this section.

(3) For standard design certifications which are subject to paragraph (a) of this section, generic changes to the information required by 10 CFR 52.47(a)(28) to be included in the final safety analysis report are governed by the applicable requirements of 10 CFR 52.63.

(4)(i) For combined licenses which are subject to paragraph (a) of this section, if the licensee changes the information required by 10 CFR 52.79(a)(47) to be included in the final safety analysis report, then the licensee shall consider the effect of the changed feature or capability on the original assessment required by 10 CFR 50.150(a) and amend the information required by 10 CFR 52.79(a)(47) to be included in the final safety analysis report to describe how the modified design features and functional capabilities continue to meet the assessment requirements in paragraph (a)(1) of this section.

(ii) For combined licenses which are not subject to paragraph (a) of this section but reference a standard design certification which is subject to paragraph (a) of this section, proposed departures from the information required by 10 CFR 52.47(a)(28) to be included in the final safety analysis report for the referenced standard design certification are governed by the change control requirements in the applicable design certification rule.

(iii) For combined licenses which are not subject to paragraph (a) of this section but reference a manufactured reactor which is subject to paragraph (a) of this section, proposed departures from the information required by 10 CFR 52.157(f)(32) to be included in the final safety analysis report for the manufacturing license are governed by the applicable requirements in 10 CFR 52.171(b)(2).

(5)(i) For manufacturing licenses which are subject to paragraph (a) of this section, generic changes to the information required by 10 CFR 52.157(f)(32) to be included in the final safety analysis report are governed by the applicable requirements of 10 CFR 52.171.

(ii) For manufacturing licenses which are not subject to paragraph (a) of this section but reference a standard design certification which is subject to paragraph (a) of this section, proposed departures from the information required by 10 CFR 52.47(a)(28) to be included in the final safety analysis report for the referenced standard design certification are governed by the change control requirements in the applicable design certification rule.

[74 FR 28146, Jun. 12, 2009]

[1] Changes to the detailed parameters on aircraft impact characteristics set forth in guidance shall be approved by the Commission.

APPENDIX B

Credited Walls

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Figure B-1, R/B 1st Floor (El 12300mm)

{{{Security-Related Information – Withheld Under 10 CFR 2.390}}}

Figure B-2, R/B 2nd Floor (El 18100mm)

{{{Security-Related Information – Withheld Under 10 CFR 2.390}}}

Figure B-3 R/B 3rd Floor (El 23500)

{{{Security-Related Information – Withheld Under 10 CFR 2.390}}}

Figure B-4 R/B 3.5 Floor (El 27200mm)

{{{Security-Related Information – Withheld Under 10 CFR 2.390}}}

Figure B-5 R/B 4th Floor (El 31700mm)

{{{Security-Related Information – Withheld Under 10 CFR 2.390}}}

APPENDIX C

Interface Boundary Walls and Floors

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Figure C-1 R/B 1st Floor (El 12300mm)

{{{Security-Related Information – Withheld Under 10 CFR 2.390}}}

Figure C-2 R/B 2nd Floor (El 18100mm)

{{{Security-Related Information – Withheld Under 10 CFR 2.390}}}

Figure C-3 R/B 3rd Floor (El 23500)

{{{Security-Related Information – Withheld Under 10 CFR 2.390}}}

Figure C-4 R/B 3.5 Floor (El 27200)

{{{Security-Related Information – Withheld Under 10 CFR 2.390}}}

Figure C-5 R/B 4th Floor (El 31700mm)

{{{Security-Related Information – Withheld Under 10 CFR 2.390}}}