GE Hitachi Nuclear Energy

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BWRX-300 UK Generic Design Assessment (GDA) Chapter 15 – Safety Analysis (Including Fault Studies, PSA and Hazard Assessment)

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EXECUTIVE SUMMARY

This document is a cover document for Chapter 15 Safety Analysis, of the Preliminary Safety Report of the GEH BWRX-300 for the purposes of UK Generic Design Assessment. It presents the content list of Chapter 15.

ACRONYMS AND ABBREVIATIONS

Acronym	Explanation
ALARP	As Low As Reasonably Practicable
BWR	Boiling Water Reactor
D-in-D	Defence-in-Depth
DEC	Design Extension Conditions
DL	Defence Line
DSA	Deterministic Safety Analysis
GDA	Generic Design Assessment
GEH	GE Hitachi
IAEA	International Atomic Energy Agency
PIE	Postulated Initiating Event
PSA	Probabilistic Safety Assessment
PSR	Preliminary Safety Report
SSC	Structures, Systems and Components

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LIST OF TABLES

None.

LIST OF FIGURES

None.

REVISION SUMMARY

Revision #	Section Modified	Revision Summary
A	All	Initial Issuance
B	All	Update for end of GDA Step 2 Consolidation

STRUCTURE OF CHAPTER 15

Chapter Route Map

Chapter 15 presents the BWRX-300 Safety Analysis and comprises of the following subchapters:

- 15.1 – General Considerations, NEDO-34179, “BWRX-300 UK GDA Ch. 15.1 - Safety Analysis - General Considerations,” (Reference 15-1)
- 15.2 – Identification, Categorisation, and Grouping of Postulated Initiating Events and Accident Scenarios, NEDO-34180, “BWRX-300 UK GDA Ch. 15.2 - Safety Analysis - Identification, Categorization, and Grouping of Postulated Initiating Events and Accident Scenarios,” (Reference 15-2)
- 15.3 – Safety Objectives and Acceptance Criteria, NEDO-34181, “BWRX-300 UK GDA Ch. 5.3 – Safety Analysis - Safety Objectives and Acceptance Criteria,” (Reference 15-3)
- 15.4 – Human Actions, NEDO-34182, “BWRX-300 UK GDA Ch. 15.4 - Safety Analysis - Human Actions,” (Reference 15-4)
- 15.5 – Deterministic Safety Analysis, NEDO-34183, “BWRX-300 UK GDA Ch.15.5 Deterministic Safety Analyses,” (Reference 15-5)
- 15.6 – Probabilistic Safety Assessment, NEDO-34184, “BWRX-300 UK GDA Ch. 15.6: Probabilistic Safety Assessment,” (Reference 15-6)
- 15.7 – Analysis of Internal Hazards, NEDO-34186, “BWRX-300 UK GDA Ch. 15.7: Deterministic Safety Analyses – Analysis of Internal Hazards,” (Reference 15-7)
- 15.8 – Analysis of External Hazards, NEDO-34187, “BWRX-300 UK Ch.15.8: Safety Analysis - External Hazards,” GE-Hitachi Nuclear Energy, (Reference 15-8)
- 15.9 – Summary of Results of the Safety Analysis, NEDO-34187, “BWRX-300 UK GDA Ch. 15.9: Summary of Results of the Safety Analyses (including Fault Schedule),” (Reference 15-9)

This layout mainly follows the structure set out in the International Atomic Energy Agency (IAEA) specific safety guide SSG-61 “Format and Content of the Safety Analysis Report for Nuclear Power Plants,” (Reference 15-10) with the exception that internal and external Hazards are discussed in two separate subchapters, NEDO-34186 (Reference 15-7), NEDO-34187 (Reference 15-8).

Chapter 15’s safety analysis, covers Deterministic Safety Analysis (DSA), Probabilistic Safety Assessment (PSA), human factor considerations and hazard analysis. It includes the strategy and approach for each plant state, ranging from normal operation to Design Extension Conditions (DECs) with core melting. This chapter evaluates the Defence Lines (DL) that are an integral part of the safety strategy, founded on the Defence-in-Depth (D-in-D) concept.

The BWRX-300 uses a layered analysis approach that covers multiple DSA evaluations to address DL function failures in a systematic and structured manner. The DSA presented in PSR Subchapter 15.5 , NEDO-34183 (Reference 15-5) is compared against applicable state acceptance criteria and dose limits as discussed in PSR Subchapter 15.3, NEDO-34181 (Reference 15-3). The PSA is performed to supplement the DSA and is presented in Chapter 15.6, NEDO-34184 (Reference 15-6). The results of the safety analysis are presented in PSR Subchapter 15.9, NEDO-34187 (Reference 15-9).

Chapter Overview

Chapter 15 has been split into the following subchapters:

15.1 – Safety Analysis – General Considerations (Reference 15-1) - This chapter provides an introduction to the safety analysis chapter, covering both DSA and PSA. This subchapter includes a description of the scope of the safety analysis and the approach adopted (i.e. conservative or realistic, as appropriate) for each plant state, for normal operations to design extension conditions with core melting. This subchapter also explains the approach to the fault analysis and hazards evaluation to identify hazards that could lead to PIEs.

15.2 – Safety Analysis – Identification, Categorization, and Grouping of PIEs and Accident Scenarios (Reference 15-2) - This subchapter provides the approach used to identify Postulated Initiating Events and accident scenarios for both the DSA and the PSA. It also details the method of categorisation and grouping of PIEs as a fundamental element of fault evaluation and event sequence selection.

15.3 – Safety Analysis – Objectives and Acceptance Criteria (Reference 15-3) - This chapter provides the safety objectives of the PSR for the GDA of the BWRX-300. It presents the acceptance criteria (quantitative and qualitative) for DSA and PSA that will be used in PSR subchapter 15.5, NEDO-34183 (Reference 15-5) and 15.6, NEDO-34184 (Reference 15-6).

15.4 – Safety Analysis – Human Actions (Reference 15-4) - The purpose of this chapter is to describe the approach to identify and model human actions in the BWRX-300 DSA and PSA. It also describes the approach to substantiation of human actions. The chapter will present a level of detail commensurate with a 2 step GDA (claims and arguments only) and will be structured in line with IAEA SSG-61, (Reference 15-10) (noting that SSG-61 does not differentiate between the level of detail required in preliminary safety report and later more detailed safety reports). PSR Chapter 18, NEDO-34190 “BWRX-300 UK GDA Preliminary Safety Report: PSR Chapter 18 – Human Factors Engineering,” (Reference 15-11) also incorporates material related to Human Factors.

15.5 – Deterministic Safety Analysis (Reference 15-5) - This chapter defines the initiating faults and hazards that are reasonably foreseeable, conservatively justifies accident sequences that follow those faults and hazards and assess the design against engineering principles. The purpose is to demonstrate the fault- tolerance of the design, the effectiveness of the safety measures, and to support the claim that all risks associated with the design and its operation have been reduced As Low As Reasonably Practicable (ALARP). The DSA does not quantify risk. instead, the adequacy of the design and the suitability and sufficiency of the safety measures are assessed against deterministic targets.

1**5.6 – Probabilistic Safety Assessment (Reference 15-6)** - This chapter provides a description of the PSA that has been undertaken for the BWRX-300, with an overview of the results and comparison with the safety goals and numerical targets. This chapter will present a discussion relating to the PSA has and will continue to support risk-informed design and decision making and support the claim that the BWRX-300 risk is ALARP.

15.7 – Deterministic Safety Analyses – Analysis of Internal Hazards (Reference 15-7) - This chapter will provide a description of the internal hazards to be considered within the BWRX-300 GDA PSR. This chapter will explain the identification process, assessment methodologies, and demonstrate the tolerance for the internal hazards of the BWRX-300 design.

15.8 – Safety Analysis – External Hazards (Reference 15-8) - This chapter will provide a description of the derivation of external hazards to be considered within the BWRX-300 GDA PSR. It will explain the process used to systematically identify and screen natural and man-made hazards. It will summarise the measures inherent in the design to ensure that the

fundamental safety functions and the SSCs that deliver them are protected against design basis external hazards and combinations thereof.

15.9 – Summary of Results of Safety Analysis (Reference 15-9) - This chapter provides a summary of the overall results of the safety analysis for each of the categories of events and covers DSA and PSA. This subchapter should also confirm that all relevant nuclear plant design expectations have been met, and a route for completion of any outstanding aspects should be defined.

PSR Subchapter 15.9, NEDO-34187 (Reference 15-9) contains three appendices to Chapter 15:

Appendix A – Reference Source Term for Conditions that are Practically Eliminated - This appendix discusses the accident scenarios considered for practical elimination.

Appendix B – Risk Reduction Included as Defence Line 4 Functions for Mitigating Design Extension Conditions - This appendix presents the risk reduction features included in DL 4 to mitigate DECs.

Appendix C – Approach to the Development of the Fault Schedule - This appendix presents the proposed approach to the development of the extant fault list into a fault schedule, along with details of how it will be used during design development.

REFERENCES

15-1 NEDO-34179, “BWRX-300 UK GDA Ch. 15.1: Safety Analysis - General Considerations,” Rev B, GE-Hitachi Nuclear Energy, Americas LLC.

15-2 NEDO-34180, “BWRX-300 UK GDA Ch. 15.2: Safety Analysis - Identification, Categorization, and Grouping of Postulated Initiating Events and Accident Scenarios,” Rev B, GE-Hitachi Nuclear Energy, Americas LLC.

15-3 NEDO-34181, “BWRX-300 UK GDA Ch. 15.3: Safety Analysis - Safety Objectives and Acceptance Criteria,” Rev B, GE-Hitachi Nuclear Energy, Americas LLC.

15-4 NEDO-34182, “BWRX-300 UK GDA Ch. 15.4: Safety Analysis - Human Actions,” Rev B, GE-Hitachi Nuclear Energy, Americas LLC.

15-5 NEDO-34183, “BWRX-300 UK GDA Ch. 15.5: Deterministic Safety Analyses,” Rev B, GE-Hitachi Nuclear Energy, Americas LLC.

15-6 NEDO-34184, “BWRX-300 UK GDA Ch. 15.6: Probabilistic Safety Assessment,” Rev B, GE-Hitachi Nuclear Energy, Americas LLC.

15-7 NEDO-34186, “BWRX-300 UK GDA Ch. 15.7: Deterministic Safety Analysis – Analysis of Internal Hazards,” Rev B, GE-Hitachi Nuclear Energy, Americas LLC.

15-8 NEDO-34187, “BWRX-300 UK GDA Ch. 15.8: Safety Analysis - External Hazards,” Rev B, GE-Hitachi Nuclear Energy, Americas LLC.

15-9 NEDO-34187, “BWRX-300 UK GDA Ch. 15.9: Safety Analysis - Summary of Results of the Safety Analyses,” Rev B, GE-Hitachi Nuclear Energy, Americas LLC.

15-10 Format and Content of the Safety Analysis Report for Nuclear Power Plants. Specific Safety Guide series, IAEA, SSG-61, September 2021.

15-11 NEDO-34190, “BWRX-300 UK GDA Ch. 18: Safety Analysis - Human Factors Engineering,” Rev B, GE-Hitachi Nuclear Energy, Americas LLC.