ENCLOSURE 2

M220080

Presentation Slides for Pre-Application Meeting for Planned Submittal of GE Hitachi Nuclear Energy BWRX-300 Safety Strategy Topical Report NEDC-33934P

Non-Proprietary Information

IMPORTANT NOTICE

This is a non-proprietary version of Enclosure 1, from which the proprietary information has been removed. Portions of the enclosure that have been removed are indicated by an open and closed bracket as shown here [[ ]].

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Pre-Submittal Meeting For GE Hitachi Licensing Topical Report

NEDC-33934P
BWRX-300 Safety Strategy

June 29, 2022

Agenda

Open Session

- BWRX-300 Introduction
- BWRX-300 Safety Strategy

Closed Session

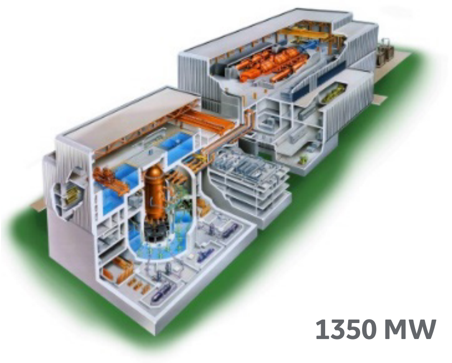
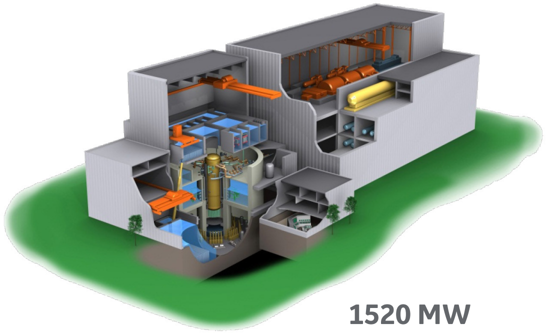
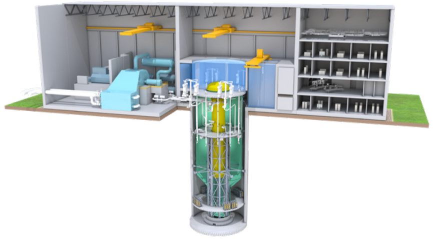
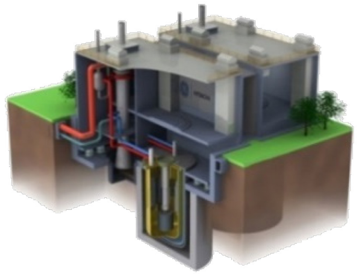
- Licensing Topical Report Purpose and Scope
- Description of the BWRX-300 Safety Strategy
- Conclusions
- Questions & Comments

BWRX-300 Introduction

Open Session

GE Hitachi Alliance … Continual Innovation

Gen III — Gen III+ — Gen IV

ABWR	ESBWR	BWRX-300	PRISM
			
1350 MW	1520 MW	300 MW	165 to 311 MW
Operational Boiling Water Reactor	**Evolutionary Boiling Water Reactor**	**Innovative Small Modular Reactor**	**Advanced Non-Light Water Reactor**

Continuous Experience

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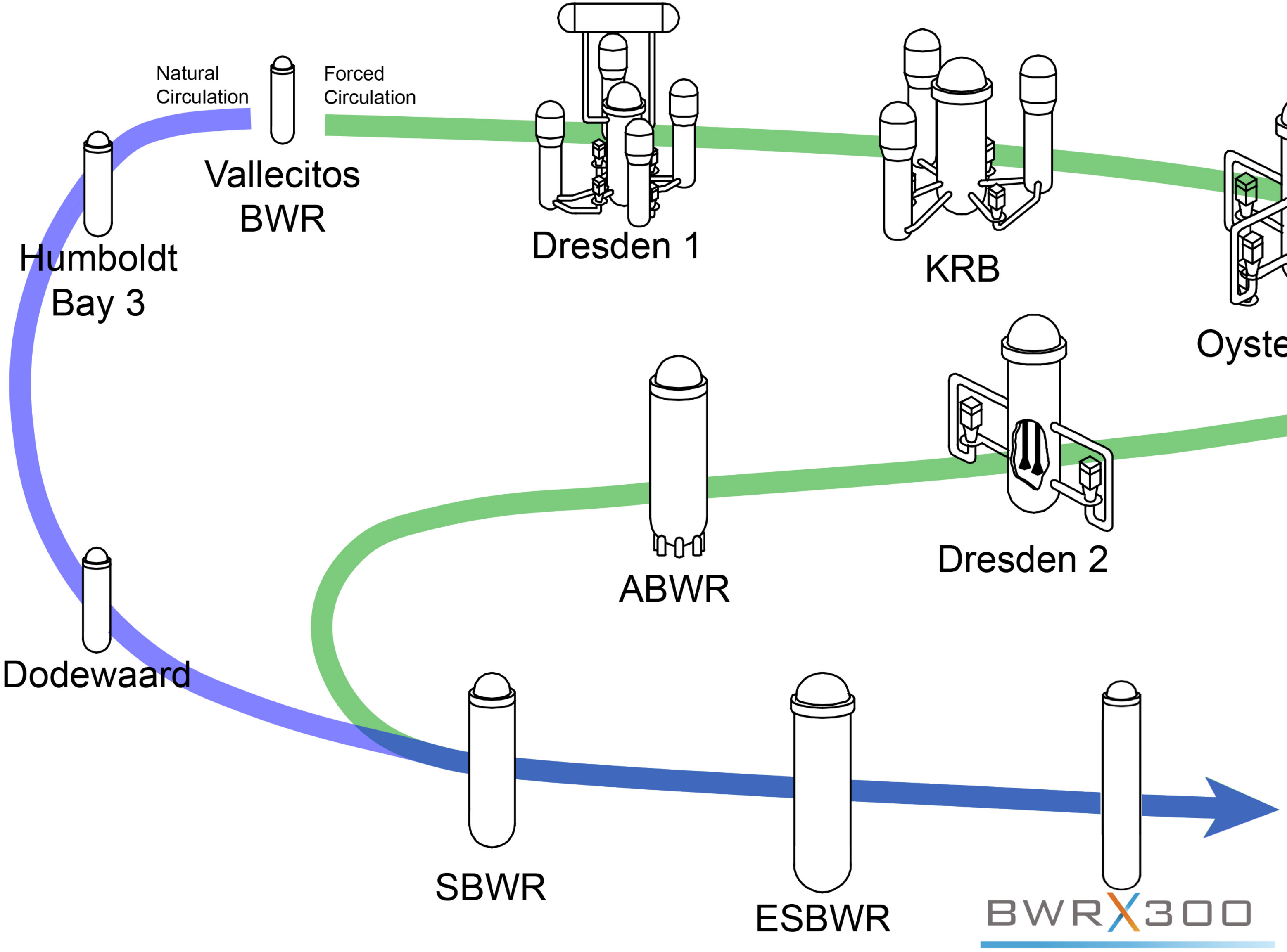
Boiling Water Reactor Evolution



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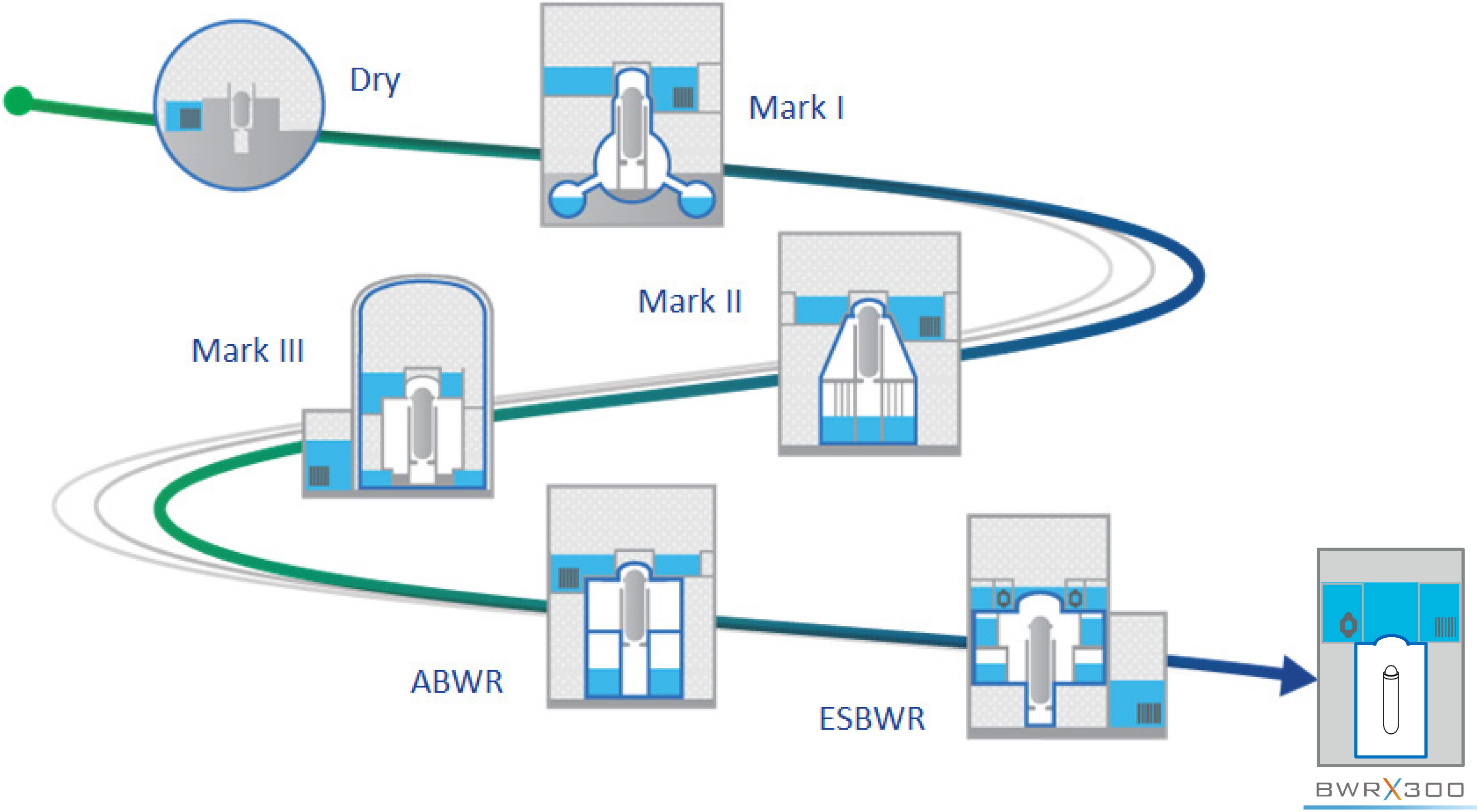
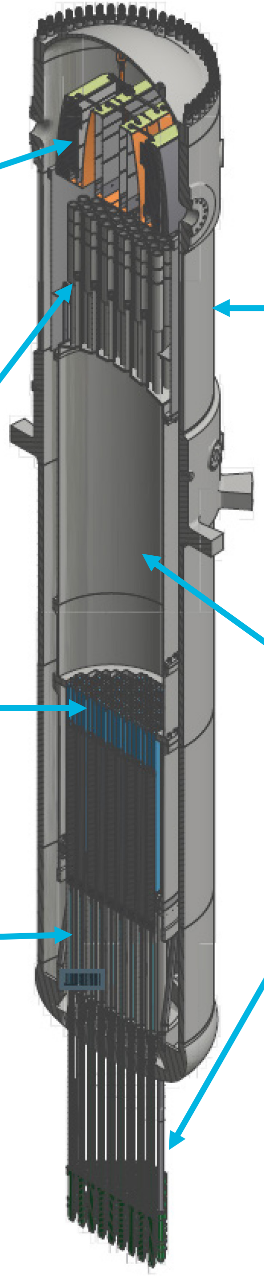
BWR Evolution



Proven Reactor Technology

BWRX300



Dryer:
Same features as ABWR* & ESBWR ...
Same as upgrades for existing fleet ...
Size nearly identical to KKM**

Steam Separators:
Same as ABWR* & ESBWR ...
Similar to others in the BWR fleet

GNF2 Fuel:
18,500+ bundles delivered ...
Utilized by ~70% of BWR fleet

Control Rod Blades:
Same as ABWR* ...
Longer than ESBWR ...
Almost identical to latest design for BWR fleet

Reactor Pressure Vessel:
Same material and fabrication processes as ABWR*, ESBWR and many of the BWR fleet ...
Diameter almost identical to KKM**

Chimney:
Uses ESBWR and Dodewaard*** technology ...
Simplified

Fine Motion Control Rod Drives:
Same as ABWR* & ESBWR

* Advanced Boiling Water Reactor (ABWR) fleet has combined 22+ years of operating experience
** Kernkraftwerk Mühleberg (KKM): 355 MWe BWR/4 in operation since 1972
*** Dodewaard: 58MWe natural circulation BWR, 1969 ~ 1997

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BWRX-300 Safety Strategy

Safety Strategy

- IAEA SSR 2/1, Safety of Nuclear Power Plants: Design, is used to develop the BWRX-300 Safety Strategy
- BWRX-300 Safety Objective is to achieve a reactor facility design with a very high level of safety and operated in a manner that will protect individuals, society, and the environment from harm by establishing and maintaining effective defenses against radiological hazards due to ionizing radiation
- Safety is enhanced by defense-in-depth design decisions using quantitative and qualitative deterministic and probabilistic safety analyses, and an iterative framework wherein the design is implemented to meet defined safety objectives

Defense-in-Depth (DiD)

- Consistent with the IAEA Levels of Defense approach – 5 Defense Lines (DLs)
- 1st and 5th DLs do not include performance of standby plant functions to control or initiate response to Postulated Initiating Events (PIEs)
  - 1st DL minimizes potential for accidents to occur in the first place and minimizes potential for failures to occur in subsequent defense lines by applying high quality and conservatism in design, construction, and operation
  - 5th DL involves off site emergency preparedness to protect the public in case a Severe Accident radioactive release occurs
- 2nd, 3rd, & 4th DLs comprise operating and standby plant functions which act to prevent PIEs from leading to significant radioactive releases
- DLs provide a systematic approach to classifying safety functions and Structures, Systems, and Components (SSCs)

Break

Licensing Topical Report Purpose and Scope

Closed Session

Licensing Topical Report Purpose

- Request NRC review and approval of the BWRX-300 Small Modular Reactor (SMR) Safety Strategy
- BWRX-300 Safety Strategy is an innovative approach to develop and ensure the design meets high levels of safety through the establishment of design rules based on defense-in-depth concepts consistent with International Atomic Energy Agency (IAEA) Specific Safety Requirements SSR-2/1, “Safety of Nuclear Power Plants: Design,” Revision 1
- Approach complies with the requirements of 10 CFR 50 Appendix A General Design Criteria (GDC) 1 and 10 CFR 50 Appendix B
- Meets the applicable requirements of other GDCs for determining required safety functions, identifying design and analysis requirements, and classification of SSCs

Licensing Topical Report Scope

- Prescribed generic safety methodology based on the requirements of IAEA SSR-2/1
- Methodology for the establishment of Defense Lines (DLs) and the physical barriers in the design
- Basic rules for identification of the plant states, based on probabilistic and deterministic determined event frequencies, including design extension conditions (DECs)
- Methodology for deterministic safety analysis and probabilistic safety assessment used to establish and confirm the design bases
- Practical application of the concept of defense-in-depth with inclusion of design extension conditions and practically eliminated conditions in the design
- How the defense-in-depth design approach minimizes offsite doses and the probability of early or large releases of radioactivity
- Qualitative and quantitative acceptance criteria for radiological consequences of plant operational states or accident conditions
- Regulatory review of the BWRX 300 Safety Strategy to describe compliance with regulatory requirements and to describe the bases for any exemptions to regulatory requirements or approaches to regulatory guidance that may be referenced during future licensing applications.

Description of BWRX-300 Safety Strategy

Safety Strategy

- IAEA SSR 2/1, Safety of Nuclear Power Plants: Design, is used to develop the BWRX-300 Safety Strategy
- BWRX-300 Safety Objective is to achieve a reactor facility design with a very high level of safety and operated in a manner that will protect individuals, society, and the environment from harm by establishing and maintaining effective defenses against radiological hazards due to ionizing radiation
- Safety is enhanced by defense-in-depth design decisions using quantitative and qualitative deterministic and probabilistic safety analyses, and an [[ ]] wherein the design is implemented to meet defined safety objectives
  - [[ ]]

Fundamental Safety Functions

- Fundamental safety functions:
  - Control of reactivity
  - Fuel cooling
  - Long-term heat removal
  - Confinement of radioactive materials
- The first three fundamental safety functions support the fuel cladding and reactor coolant pressure boundary physical barriers
- The third and fourth fundamental safety functions also support the containment physical barrier
- If the fundamental safety functions are performed successfully, then the corresponding physical barriers will remain effective

Safety Acceptance Criteria

- The Safety Strategy establishes a general approach to ensure that, in all plant states, radiation doses due to any radioactivity are kept below regulatory limits and as low as reasonably achievable
- Acceptance Criteria:
  - High-level (regulatory) criteria relate to radiological consequences of plant operational states or accident conditions
  - Detailed (derived) technical Qualitative Acceptance Criteria related to the integrity of radiological barriers developed for each operational state (Normal Operation, AOO, DBA and DEC) are defined by the Safety Strategy. Qualitative and quantitative components

Practical Elimination

- BWRX-300 Safety Strategy incorporates the concept of practical elimination consistent with IAEA SSR-2/1
- Practical elimination is achieved by prevention of the conditions that could lead to an early radioactive release, a large radioactive release, or a high radiation dose
- Fault sequences with an early or large release are considered to have been practically eliminated if either of the following apply:
  - It is physically impossible for the accident sequence to occur
  - The accident sequence can be considered, with a high degree of confidence, to be extremely unlikely to arise
  - Practical Elimination is considered to refer only to those fault sequences leading to, or involving, core damage

Design Principles

- Maintain Independence, diversity, redundancy and separation to an extent that is practicable to prevent common cause failures
- Assure Acceptable Safety Margin
- Minimize probability of failure to SSCs
- Single failure criterion
- Other approaches aimed at ensuring safety (e.g., Simplicity in design, demonstration of resilience of design of external hazards, and principle of inventory conservation)
- Safety Margin and Avoidance of Cliff Edge Effects
- Design Considerations for Ageing Management

Defense-in-Depth Design

- BWRX-300 applies a defense-in-depth IAEA approach
  - Level 1: Prevention of abnormal operation and failures
  - Level 2: Control of abnormal operation and detection of failures
  - Level 3: Control of Accidents within the design basis
  - Level 4: Control of severe plant conditions, including prevention of accident progression and mitigation of the consequences of severe accidents
  - Level 5: Mitigation of radiological consequences of significant releases of radioactive material
- Address Fundamental Safety Functions to ensure overall plant safety
- Assigns BWRX-300 functions to DLs associated with Fundamental Safety Functions

Plant Defense Lines (DLs)

- General approach to defining the design basis is to categorize safety functions based on their significance regarding safety
- Multiple DLs provide layered protection against unacceptable releases of radiation.
- DLs include engineering and operational practices, plant features, and plant functions.

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Plant Operational States

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- Normal Operation
- Anticipated Operational Occurrences: [[ ]]

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Plant is required to operate safely in Normal Operation and to reach safe operation or shutdown states following Anticipated Operational Occurrences (AOOs) without progressing into accidents

Or said another way, without the necessity of invoking provisions beyond Defense Line 1, or at the most Defense Line 2

Plant Accident Conditions [[

- Design Basis Accidents: [[

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- Design Extension Conditions:

[[

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Postulated Accidents derived from the listing of Postulating Initiating Events (PIE) in the Fault Evaluation for the purpose of setting the boundary conditions according to which the SSC are designed

Certain very low probability plant states that are **beyond design basis accident** conditions and which may arise owing to multiple failures of safety systems leading to situation that may jeopardize the integrity of the barriers to the release of radioactive material or core damage

Plant Design Extension Conditions (DEC)

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- Design Extension Conditions: [[

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Design Extension Conditions (DEC) are a set of conditions based on deterministic and probabilistic methods, operational experience, engineering judgment and the results of research and analysis

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DECs are used to further **improve** the safety of the reactor facility by enhancing the plant's **capabilities to withstand**, **without significant radiological releases**, **accidents** that are either more severe than DBA or that involve additional failures

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Safety Strategy Implementation

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- Primary process elements in for implementing the Safety Strategy are:
  - Hazard Evaluation
  - Fault Evaluation
  - Probabilistic Safety Analyses
  - Deterministic Safety Analyses
- Hazard Evaluation identifies postulated initiating events using a systematic methodology
- Fault Evaluation is developed [[

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Hazards Identification & Evaluation

- Identify hazards with the potential to challenge the fundamental safety functions
- Postulated initiating events are then identified using engineering judgment and deterministic and probabilistic assessments
- Scope and implementation of deterministic and probabilistic safety analyses are documented in the Fault Evaluation
- Postulated initiating event identification considers both direct and indirect events
- Four types of event evaluations:
  - [[

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- All four hazard evaluations address complete range of plant states (e.g., full power, low power, load following, shutdown, refueling)

Fault Evaluation

- Develops fault sequences and complex sequences to be demonstrated by deterministic safety analysis, and develops severe accident scenarios for severe accident analysis
- Includes complete range of operation
  - Ensures that defense line functions and resulting operational limits and conditions provide coverage to anticipated operational states
- [[ ]]
  - Establishes the fault sequences that have an initiating frequency lower than [[ ]] are considered beyond design basis accidents.
- Evaluation includes objectives to confirm analyzed scenarios have been properly categorized using probabilistic safety assessment inputs
  - Ensures that, while a qualitative relative approach can be used initially, the final deterministic analysis is consistent with postulated initiating event and fault sequence categories based on qualitative frequencies

Fault Sequence Selection

- Sequence Selection develops fault sequences from the PIEs and any additional failures that result in a challenge to the fundamental safety functions and demonstrates the independence of the defense lines
- Corresponds to PIEs identified as outputs of the four hazard evaluations
- Selection activities organize, group, screen, and combine PIEs to define a representative set of fault sequences in a Fault List
- Fault sequences are allocated to three different categories of deterministic safety analysis:
  - [[

    ]]
- Assumptions made during the deterministic fault selection produces Defense Line 1 design requirements

Deterministic Safety Analysis

- Deterministic safety analysis is used to demonstrate tolerance of the plant design to a fault sequence made up of the PIE and consequential failures
- Layered analysis approach is used to implement the deterministic safety analyses
- Approach designed to address initiation and mitigation failures in a systematic and structured manner and to explicitly align with the defense in depth approach that underpins the design

Probabilistic Safety Assessment

- Probabilistic Safety Assessments are performed to understand the overall risk presented by the facility to allow comparisons to be made against safety goals
- Provide essential understanding of the strengths and weaknesses of a design with complex systems and interdependencies
- Used for evaluating complementary design feature concepts or changes in operating conditions
- Two probabilistic safety assessments levels are applied where each level introduces a specific aspect of overall risk:
  - Level 1 estimates the first measure of risk (core damage frequency)
  - Level 2 estimates the second measure of risk (radioactive release)

Severe Accident Analysis

- General intention of severe accident analysis is to determine the likely outcome of fault sequences not included in the design basis
- Defense Lines 4a and 4b objectives are to provide additional features and procedures to prevent or mitigate fault progression and for accident management
- Goal is to incorporate design features to enhance resilience to accidents leading to significant inventory redistribution (e.g., core damage and relocation)
- Severe accident analyses involve determining the potential progression of the accidents, the magnitude and characteristics of the consequences, and any cliff edges

Design Rules for Classification of SSCs

BWRX-300 Safety Strategy SSCs based on Safety Class, Quality Group, Seismic Category, and Code Class

- Safety Class: Alternate approach based on international guidelines (IAEA SSG-30)
    - Based on deterministic methods and directly traceable to the safety functions performed by the SSC
- Quality Group: Follows USNRC Regulatory Guide 1.26
- Seismic Category: Alternate Approach based on international guidelines (IAEA SSR-2/1)
- Code Class for pressure-retaining systems: Follows USNRC Regulatory Guide 1.26

Conclusions

Conclusions

- Safety Strategy is an innovative approach to develop and ensure that the design meets high levels of safety through the establishment of design rules based on defense-in-depth concepts consistent with International Atomic Energy Agency (IAEA) Specific Safety Requirements SSR-2/1, “Safety of Nuclear Power Plants: Design,” Revision 1
- The approach complies with the requirements of 10 CFR 50 Appendix A General Design Criteria (GDC) 1, 10 CFR 50 Appendix B, and other GDCs for determining required safety functions, identifying design and analysis requirements, and classification of SSCs
- An alternative approach to RG. 1.26 is provided for the safety categorization of functions
- NUREG-0800 SRP application will be addressed with respect to the BWRX-300 Safety Strategy
- A regulatory review of the BWRX-300 Safety Strategy is included to describe compliance with regulatory requirements and to describe the bases for any exemptions to regulatory requirements or approaches to regulatory guidance that may be referenced during future licensing applications

Questions or Comments