ARDP Construction Permit Application: Chapter Content: Xe-100 Methodologies, Analysis, and Licensing Basis Events

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NRC White Flint

Rockville, MD

Department of Energy Acknowledgement and Disclaimer

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Agenda & Objectives

Agenda:
- Walk through expected PSAR Chapter 3 content for the Xe-100 reactor technology

Closed Portion:
- Discussion of preliminary analysis sequences and example results

Objectives:
- Increase NRC staff familiarity with PSAR Chapter 3 (structure, content, level of detail, level of completeness, scope, etc.)
- Support upcoming reviews of submitted material: Readiness Assessment, Construction Permit Application Acceptance Review
- Receive NRC staff feedback on PSAR Chapter 3, such as preliminary questions or identified gaps in necessary information
- Specifically interested in staff feedback on the approach to LBE selection for non-core sources and non-full-power plant operating states

NEI 21-07 Implementation | PSAR Chapter 3 Structure

- 3.1 Methodologies and Analysis
  - 3.1.1 Probabilistic Risk Assessment
  - 3.1.2 Mechanistic Source Term Methodology
  - 3.1.3 DBA Analytical Methods
  - 3.1.4 Other Methodologies and Analyses
  - 3.1.5 Testing Results
- 3.2 Licensing Basis Event Selection Methodology
- 3.3 Analysis of Anticipated Operational Occurrences
- 3.4 Analysis of Design Basis Events
- 3.5 Analysis of Beyond Design Basis Events
- 3.6 Analysis of Design Basis Accidents
- 3.7 Civil and Structural Analyses
- 3.8 Stress Analyses
- 3.9 Criticality Analyses
- 3.10 Non-Core Related Source Radiological Analyses
- 3.11 Non-full-power Mode Event Selection and Analyses
- 3.12 Aircraft Impact Assessment
- 3.13 Mitigation of Beyond Design Basis Events

3.1 Methodologies and Analysis

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3.1.1 Probabilistic Risk Assessment

- X-energy submitted a white paper titled “Xe-100 Licensing White Paper - Probabilistic Risk Assessment Technical Adequacy Approach” (ML22318A236)
  - NRC provided feedback (ML23097A127)
- Consistent with NRC expectations, PRA self-assessment in-line with the PRA standard as endorsed in RG 1.247 (with deviations documented in the WP) and NEI 20-09 will be summarized along with a commitment for a full scope peer review for the Operating License application
- The expected scope of the Xe-100 PRA for the CPA is shown below, juxtaposed with a table presented by the NRC on PRA for CPAs implementing the Licensing Modernization Project approach (ML23101A123):

		NRC Presentation 4/18/23		X-energy Plan	
		Reactor	Non-reactor	Reactor	Non-reactor
Internal Events	At-power	PRA	PRA/SE[2]	PRA	SE
	LPSD[3]	PRA/SE	PRA/SE	SE	N/A
Other Hazards[1]	At-power	PRA/SE/DBHL	PRA/SE/DBHL	DBHL	DBHL
	LPSD	PRA/SE/DBHL	PRA/SE/DBHL	DBHL+SE	N/A

[1] *Other hazards* means hazards other than internal events (e.g., internal fires, seismic)

[2] Risk-informed supplemental evaluation (SE)

[3] Low-power shutdown (LPSD)

3.1.1 Probabilistic Risk Assessment | Scope of Radiological Sources

- Sources of radionuclides within the helium pressure boundary are expected to have the necessary design detail to meet the technical requirements of the non-LWR PRA Standard
- LBEs for sources that are yet to be incorporated in the PRA are addressed in PSAR Section 3.10
- The Xe-100 PRA will include all radiological sources for inclusion of such plant risk insights for the FSAR—X-energy expects to include this commitment in the PSAR

3.1.1 Probabilistic Risk Assessment | Scope of plant Operating States

- Only at-power events are expected to have the necessary design detail to meet the technical requirements of the non-LWR PRA Standard
- LBEs for plant operating states that have yet to be incorporated in the PRA are addressed in PSAR Section 3.11
- The Xe-100 PRA scope will include all plant operating states for inclusion of risk insights in the FSAR—X-energy expects to include this commitment in the PSAR

3.1.1 Probabilistic Risk Assessment | Scope of Hazards

NRC feedback on the PRA white paper indicates:

> *"Regarding BDBEs, the NRC staff is interested in X-energy's approach, or additional engagement on low frequency and high-consequence external hazards (e.g., seismic) and internal plant hazards (e.g., internal fire) at the CP stage."*

X-energy's Clarification:

> *The Xe-100 CPA PRA will not include internal or external hazards for the purpose of developing AOOs, DBEs, and BDBEs. It will be limited to establishing and justifying the DBHLs.*
>
> *The Xe-100 PRA scope will include all hazards for the FSAR. X-energy plans to include this commitment in the PSAR.*

- The PRA will address all internal and external hazards in Appendix B of RG 1.247 to inform selection of Design Basis Hazard Levels (DBHLs)

DBHL Selection Method	Role of PRA	Hazard Examples
Screened as beyond design basis (less frequent than 1E-4/yr plus margin)	Implement RG 1.247 (PRA Standard) to define the hazard characteristics for the site. Hazard screening (HS) element.	• Aircraft impact • Volcanic hazard
External hazard DBHLs identified using traditional deterministic methods	Provide justification that the DBHL is a more severe challenge than the 1E-4 hazard event.	• Seismic • External Flooding • High winds (structural)
Hazard DBHLs informed by a probabilistic external hazard analysis using available methods, data, design, site information, and guides and standards	Implement RG 1.247 (PRA Standard) to define the hazard characteristics for the site. DBHL selected such that there is sufficient margin to the 1E-4 hazard event.	• High winds (duration)
Internal hazard DBHLs based on design requirements	Identify areas where further analysis is needed to define the hazard when design information is available.	• Internal fires • Internal floods

3.1.1 Probabilistic Risk Assessment | Analytical Tools

- Event sequence frequencies quantified using CAFTA (part of EPRI's Phoenix Architect software suite) and FTREX
  - Uncertainties quantified using UNCERT
- LBE mechanistic source term and radiological consequence evaluations (which provide PRA results for the F-C plot) performed using combination of tools

1. Flownex is used for thermal hydraulic modeling and mass and energy profiles for the transients
2. In the long term (30 days), GOTHIC is used for thermal hydraulic modeling and mass and energy profiles.
3. The resulting profiles are then used with multiple XSTERM modules to determine the source term
4. Add other source terms for steady state, liftoff, washoff (if applicable), and steam effects (if applicable)
5. XSTERM's XDIS module is used to determine the offsite dose consequences

- Cumulative dose and risk calculations performed using individual LBE doses as an input, conservative assumptions, and hand calculations (rather than software)
- The site characteristics intend to reflect a generic atmospheric dispersion factor (ground-level, non-location-specific, non-directional release) that's bounding for the Seadrift site

3.1.2 Mechanistic Source Term Methodology

- (Licensing Topical Report (LTR)) Xe-100 Mechanistic Source Term (MST) Methodology Rev. 2
- This report will describe the Xe-100 approach to functional containment, fuel performance criteria, how MSTs are computed, and the V&V plan for the MST models. Previously submitted and withdrawn as Revision 1, Revision 2 will include MST methods for Xe-100, XSTERM Evaluation Model development, and Licensing Basis Event (LBE)-specific methodologies.

3.1.3 DBA Analytical Methods

- (LTR) Transient and Safety Analysis Methodology
- Revision 1 of this topical report will include Safety Analysis Flownex & GOTHIC Evaluation Model structure and LBE-specific methodologies. It is the successor to X-energy's Transient and Safety Analysis Methodologies Framework LTR (2021-XE-NRC-013), for which the NRC issued a Safety Evaluation Report (ML21288A172).

3.1.4 Other Methodologies and Analyses

- 3.1.4.1. Civil and Structural Analysis
- 3.1.4.2. Piping Analysis
- 3.1.4.3. Electrical Load Analysis
- 3.1.4.4. Stress Analysis
- 3.1.4.5. Criticality Analysis
- 3.1.4.6. Thermal-Hydraulic Analysis
- 3.1.4.7. Environmental Qualification Analysis
- 3.1.4.8. Dispersion Modeling
- 3.1.4.9 Core Design and Analysis
- 3.1.4.10 Analysis Uncertainties
- 3.1.4.11 Spent Fuel Management
- 3.1.4.12 Code Qualification

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- SAR will describe the analytical methodology and the key inputs and assumptions used
- SAR will address the applicability of the analytical methodology to the specific analysis, including a discussion of supporting data

3.1.4 Other Methodologies and Analyses

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- 3.1.4.12 Code Qualification

(*Technical* Report) Xe-100 Ex-core Criticality Analysis Methodology

This report will present the Ex-core and Criticality Analysis Methods for the Xe-100. It will be included with the CPA for review/approval.

3.1.4 Other Methodologies and Analyses

- 3.1.4.1. Civil and Structural Analysis
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(LTR) Xe-100 Atmospheric Dispersion & Dose Consequence Methods

This report provides a discussion of the atmospheric dispersion and dose consequences methods for LBEs.

3.1.4 Other Methodologies and Analyses

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- 3.1.4.2. Piping Analysis
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(LTR) Xe-100 Core Design and Analysis Methods

The purpose of this report is to introduce Core Design Steady-state and Transient Evaluation Model specific methods.

3.1.4 Other Methodologies and Analyses

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- 3.1.4.12 Code Qualification

This section provides a high-level summary of the uncertainty methods for LBE analyses contained in several LTRs. This section will reference the associated reports.

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3.1.4 Other Methodologies and Analyses

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- 3.1.4.2. Piping Analysis
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(WP) Spent Fuel Management

The purpose of this white paper is to outline the regulatory approach to licensing the spent fuel handling building and equipment of the Xe-100 to satisfy a 60-year reactor operating life and 80-year spent fuel storage facility life. This white paper will discuss DOE engagement to take possession of the spent fuel under standard contract, as well as the facility's reliance on automation for transporting the spent fuel onsite.

(Tech. Report) Spent Fuel Management

Expected to be submitted with the CPA and contains similar information as the WP. X-energy may transition all development effort to the Technical Report to support the CPA submission schedule

3.1.4 Other Methodologies and Analyses

- 3.1.4.1. Civil and Structural Analysis
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- 3.1.4.12 Code Qualification

Will identify Licensing Topical Reports that have been submitted describing code qualification plans and completed qualification.

3.1.5 Testing Results

- Provides overview of X-energy's testing programs, objectives, and results that support various analyses and methods.
- Will be supported by descriptions of the remaining research/development activities to be completed to support Operating License issuance in accordance with 10 CFR 50.34(a)(8) and 50.43(e)

3.2 Licensing Basis Event Selection Methodology

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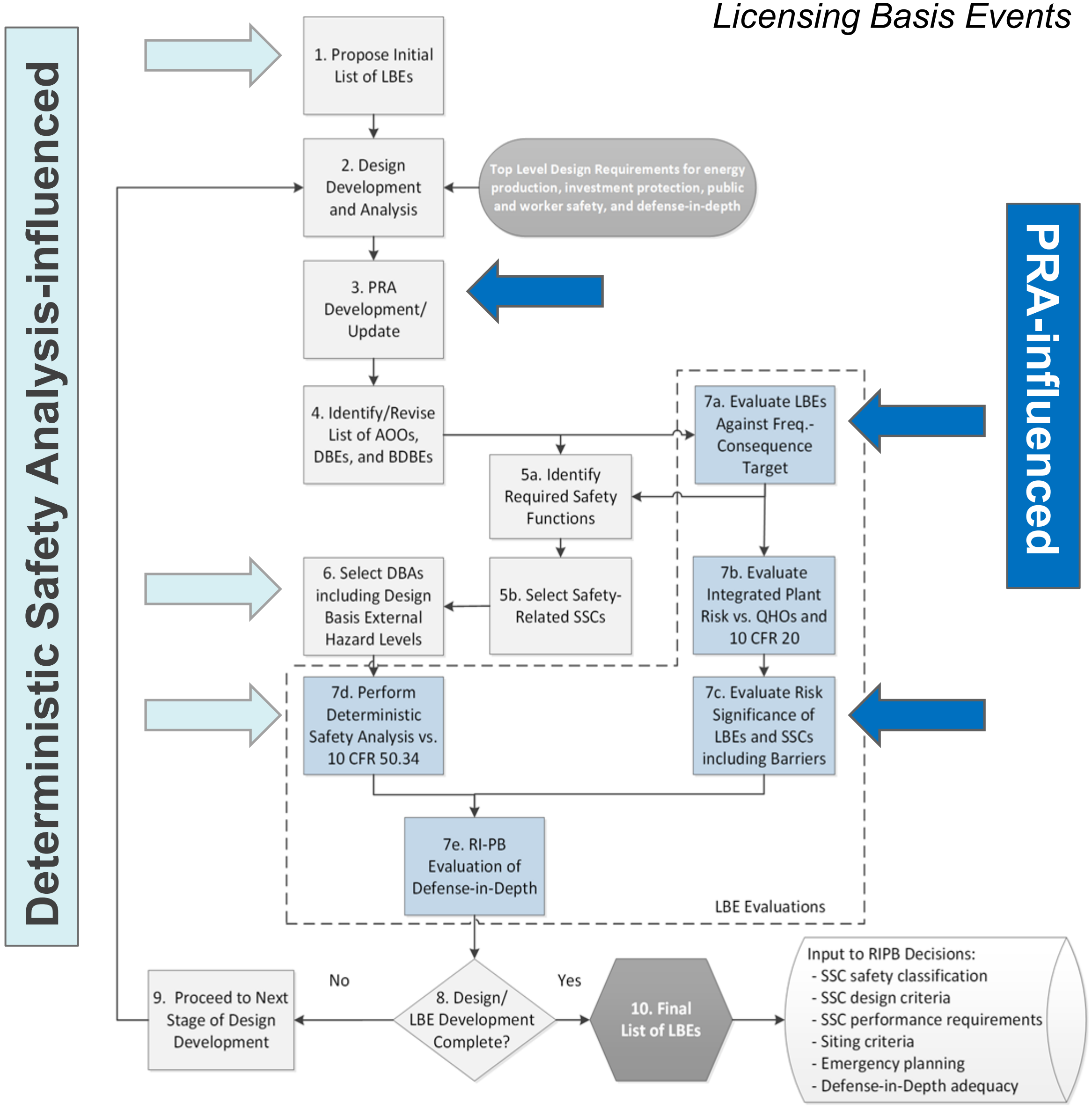
Licensing Basis Event Selection

Derived from NEI 18-04, Figure 3-2. Process for Selecting and Evaluating Licensing Basis Events

Approach that incorporates deterministic and probabilistic methods that is:

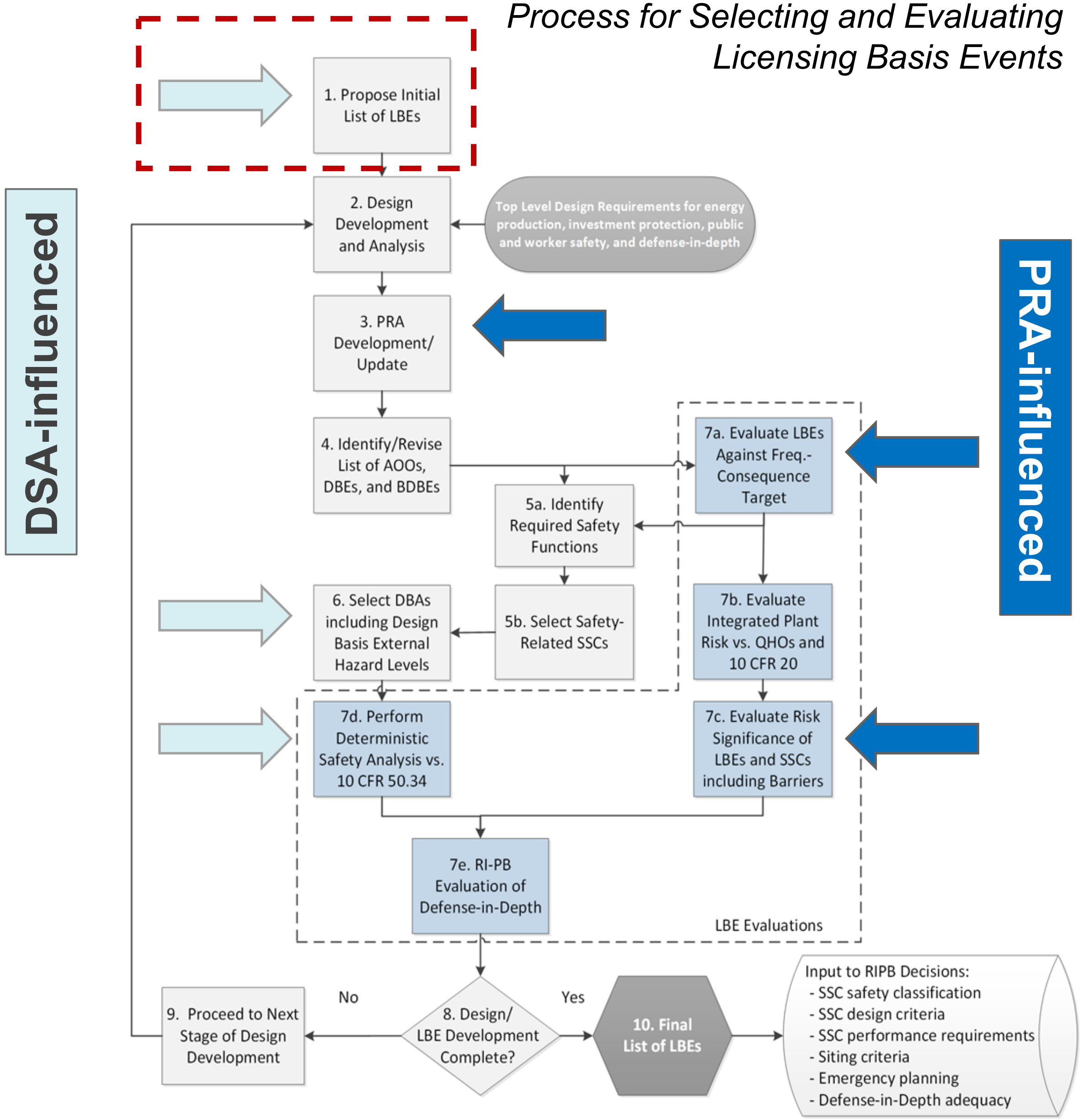
- Systematic and reproducible
- Sufficiently complete
- Available for timely input to design decisions
- Risk-informed and performance-based
- Reactor technology-inclusive
- Consistent with applicable regulatory requirements



Licensing Basis Event Selection

Derived from NEI 18-04, Figure 3-2. Process for Selecting and Evaluating Licensing Basis Events

- For the PSAR, LBEs for non-core sources and non-full-power modes are deterministically selected by implementing Step 1
  - Initial set of LBEs will not have frequency values, since they are deterministic
  - Step 1 precedes implementation of the PRA Standard technical requirements
- For the FSAR, these LBEs will be selected using the PRA and will fully implement the NEI 18-04 approach
- Information for non-PRA LBEs will be covered in PSAR Sections 3.10 and 3.11

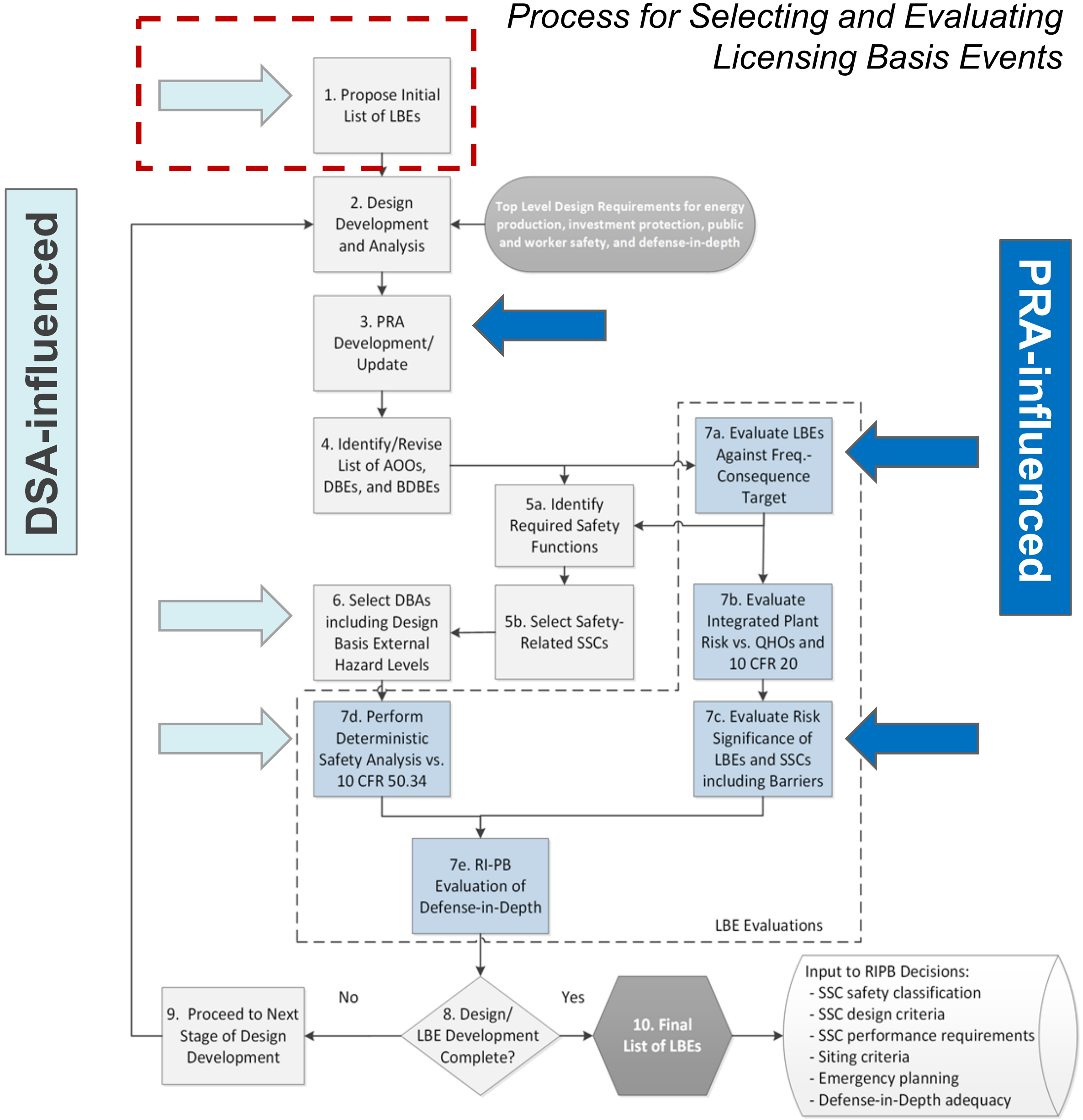


Licensing Basis Event Selection

Derived from NEI 18-04, Figure 3-2. Process for Selecting and Evaluating Licensing Basis Events

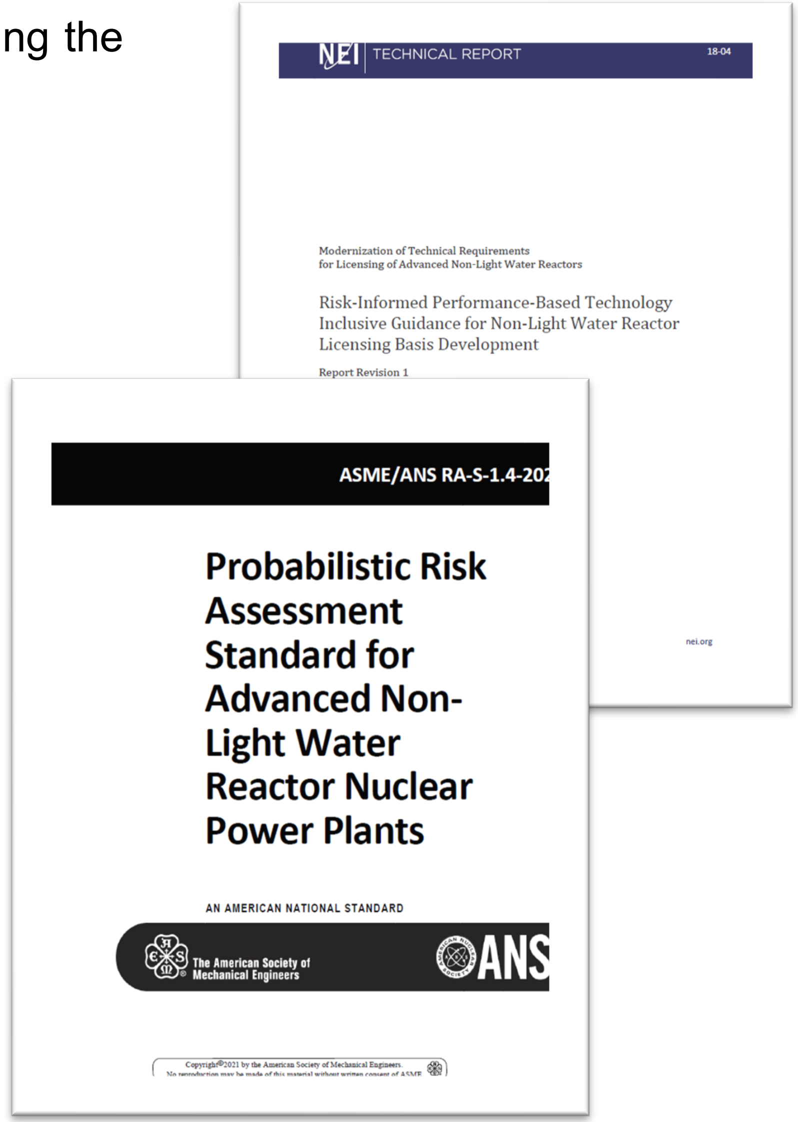
Task 1: Propose Initial List of LBEs

"During design development, it is necessary to select an initial set of LBEs which may not be complete but are necessary to develop the basic elements of the safety design. These events are to be selected deterministically and may be supported by qualitative risk insights based on all relevant and available experience, including prior experience from the design and licensing of reactors. The initial selection of events can also be supported by analysis techniques such as failure modes and effects analyses (FMEAs), hazard and operability studies (HAZOPs), and Master Logic Diagrams. In many cases, the designer may also have an initial assessment regarding which SSCs may be classified as Safety-Related (SR) to meet the safety design objectives for the reactor design. This classification would also be deterministically based and may be supported by qualitative risk insights using the same information utilized for the initial selection of LBEs."



Licensing Basis Event Selection

- Licensing Basis Events developed in accordance with NEI 18-04 process leveraging the Non-Light Water Reactor PRA Standard
- Overall strategy for PSAR
  - PRA covers LBEs for full-power internal events
  - Supplemental evaluations address (deterministic evaluations):
    - Non-full-power modes
    - Non-core sources of radioactivity
- Major Design Basis Accident assumptions
  - Only model safety related SSCs
  - No credit for reactor trip (shutdown on inherent reactivity only)
    - Facilitated by tripping circulators
  - No credit for active cooling systems (only passive RCCS cooling (SR-SSC))
  - No credit for retention of radionuclides in Reactor Building (SR-SSC)


NEI TECHNICAL REPORT 18-04

Modernization of Technical Requirements for Licensing of Advanced Non-Light Water Reactors

Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development

Report Revision 1

nei.org

ASME/ANS RA-S-1.4-202

Probabilistic Risk Assessment Standard for Advanced Non-Light Water Reactor Nuclear Power Plants

AN AMERICAN NATIONAL STANDARD

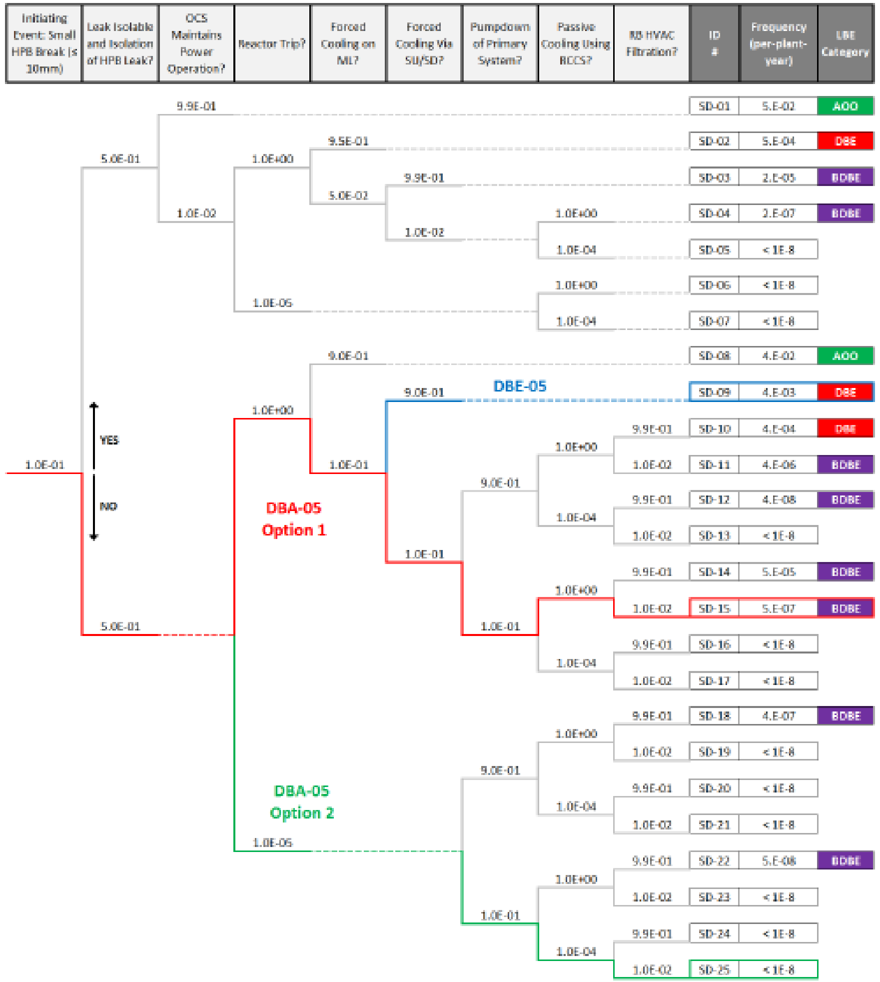
The American Society of Mechanical Engineers

ANS

Summary of Major NEI 18-04 Elements

Selection of LBEs

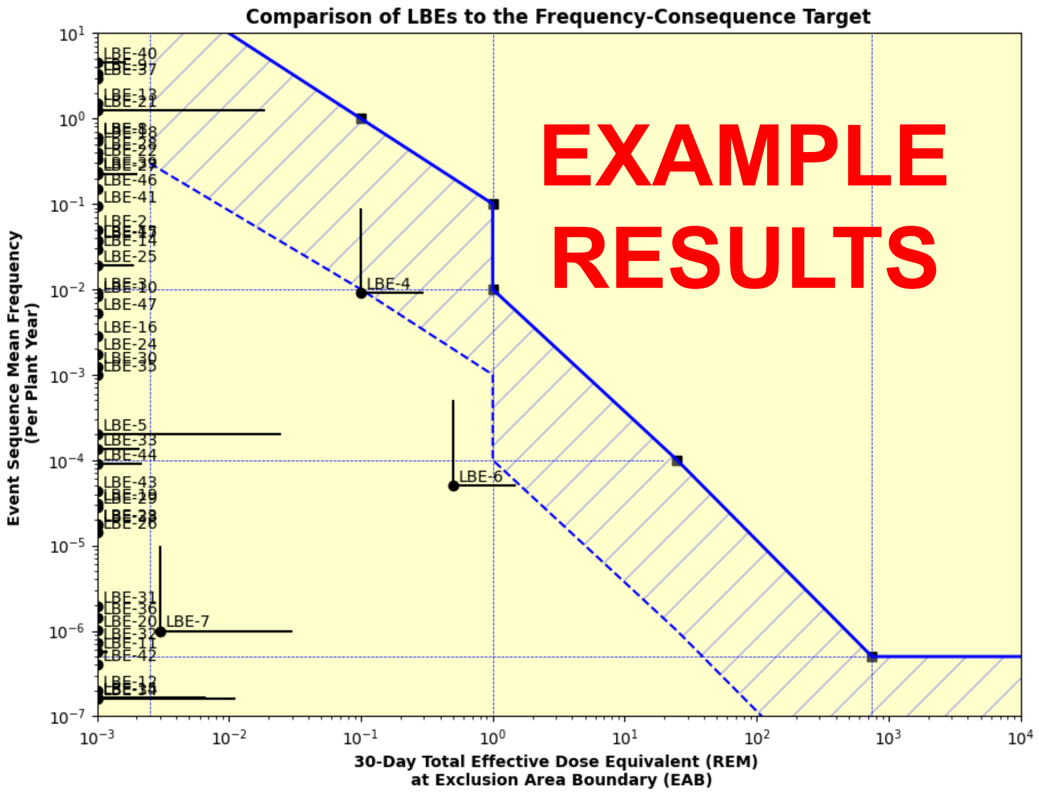
- Driven by event sequences that come out of the PRA
- Classified into
  - AOO: frequency > 1e-2 per year
  - DBE: frequency between 1e-4 and 1e-2 per year
  - BDBE: frequency between 5e-7 and 1e-4 per year
    - BDBE cutoff frequency at 5e-7 per year (although "cliff-edge" effects need to be considered if they exist)
- Design Basis Accidents (DBAs)
  - Deterministic construct derived from DBEs where only safety-related SSCs are credited
  - Analyses will show that the SR SSCS perform their RSFs adequately, meaning the 10 CFR 50.34 dose acceptance criteria is met
- The PRA defines event sequences and quantifies the frequency
- Sequences of high enough frequency are analyzed to evaluate the plant response and quantify the dose consequences



Example Fault Tree for the Xe-100

Summary Evaluation of AOOs, DBEs, and BDBEs

- Tables with brief narrative descriptions of the AOOs, DBEs, and BDBEs
- Identification of the radionuclide sources associated with each of the PRA LBEs
- A plot of the frequencies, consequences, and uncertainties of these PRA LBEs with comparison to the NEI 18-04 Frequency-Consequence Target in Figure 3-1 of NEI 18-04
  - LBEs will not include 5th percentile uncertainties
  - LBEs with a mean dose consequence less than 1E-03 rem will be plotted on the Y-axis will only include uncertainty bars for 95th percentile dose values exceeding 1E-03 rem



Summary Evaluation of AOOs, DBEs, and BDBEs

- Identification of all risk-significant LBEs
  - Uses definition of risk significance from NEI 18-04
  - Note: Due to the use of absolute risk significance criteria, it's possible no LBEs are identified as risk-significant
- Identification of PRA LBEs used to classify SSCs as NSRST for adequate DID
- Identification of any high consequence BDBEs as defined in NEI 18-04, i.e., those BDBEs with EAB doses greater than 25 rem TEDE – None expected

Summary Evaluation of AOOs, DBEs, and BDBEs

- Definition of the reactor-specific safe, stable end states, described previously and used to establish the success criteria for the safety functions modeled in the PRA, referred to in NEI 18-04 as PRA Safety Functions and reflected in the LBE descriptions
- Identification of PRA assumptions, limitations in scope, and uncertainties that impact the identification of AOOs, DBEs, and BDBEs

Summary Evaluation of DBAs

- In this section, a summary of the evaluation of DBAs is presented, including:
  - A table that shows the mapping of DBEs into DBAs with brief narrative descriptions of the DBEs and DBAs
  - Will also include a mapping of Design Basis Hazard Level events to bounding DBAs
  - A table that shows the dose consequences of the DBAs for comparison against the 25 rem TEDE criterion derived from 10 CFR 50.34 (Some DBAs may have no releases and, therefore, no doses.)
- X-energy plans to include a table like NEI 21-07, “Table 3-2: Example Summary Table of DBEs and DBAs”

3.3 – 3.6 Analysis of AOOs, DBEs, BDBEs, and DBAs

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3.3 AOOs, 3.4 DBEs, and 3.5 BDBEs

- Sections will provide the information as discussed in line with NEI 21-07 including the clarifications in DG-1404
- LBEs are limited to PRA scope described in Section 3.1.1 (full-power, internal events, reactor sources)
- PRA LBEs will reflect the release from multiple modules for initiating events that affect multiple modules
- No PRA LBEs will include non-reactor sources for the PSAR, but they will for the FSAR
- Will provide *total* source term for LBEs that have a 30-day EAB dose of 2.5 mrem TEDE or greater. No information on release timing will be included.
- Mean and 95th percentile dose values will be included along with a commitment to provide the 5th percentile values in the FSAR
  - LBE consequence uncertainties will be bounding values that are more conservative than the 95th percentile (and treated in the same way as the 95th percentile)

Licensing Basis Event Overviews

Sections 3.3 - 3.6 presentation LBE information consistent with NEI 21-07 and DG-1404

Event summary
- 1-2 paragraph summary of the event sequence initiation, plant response, and end state

Event description
- More detailed description of plant response than the summary section
- Quantitative information for key plant and event sequence parameters

Methodology
- Explanation of the codes used for analysis
- List of key assumptions

Results
- Several-paragraph discussion of the event outcome
- Figures plotting key plant parameters over time (including the source term)

Figure of merit
- Total Effective Dose Equivalent (TEDE) rem at the Exclusion Area Boundary (EAB)

3.7 Civil and Structural Analyses

3.7 Civil and Structural Analyses

- Will include results of civil and structural analyses where results have been developed
  - Expect to include results for SR-SSCs (e.g., Reactor Building)
- Where results are needed, but not yet developed: Will include commitment to provide civil and structural analysis results in the FSAR, design criteria, and the plan for how the results will be developed (i.e., ARCAP ISG, App. C-based commitment)
  - Expect to include a commitment to provide results for NSRST-SSCs in the FSAR

3.8 Stress Analyses

3.8 Stress Analyses

- SAR will describe the results of stress analysis described in Section 3.1.4
  - Plan to include results for SR-SSCs
  - SR-SSCs will be analyzed in accordance with ASME Section III Div 5 as endorsed in RG 1.87 Rev 2
- Where results are needed, but not yet developed: Will include commitment to provide results in the FSAR, along with criteria and plan for how the results will be developed
  - Plan to include a commitment to provide results for NSRST-SSCs in the FSAR
  - For fuel and graphite, methodologies and testing plans will be completed by the expected CPA submittal date. Preliminary analyses may be ongoing and will be available for NRC audit as part of the CPA review.
    - Additional NRC engagements on fuel and graphite will provide more information on the stress analysis methods, results, and expected completion timeline
    - Analysis will be prioritized by expected importance in supporting the fuel and graphite RSFs

3.9 Criticality Analyses

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3.9 Criticality Analyses

- (Technical Report) Xe-100 Ex-core Criticality Analysis Methodology
  - This report will present the Ex-core and Criticality Analysis Methods for the Xe-100
  - High-level summary of the results and reference to report in the PSAR

3.10 Non-Core Related Source Radiological Analyses

3.10 Non-Core Related Source Radiological Analyses

- Risk from non-core sources will be evaluated using simplified, conservative assumptions to bound the release
  - Preliminary LBEs will be deterministically selected for non-core sources using hazard analysis techniques
- Sources that lead to doses below the PRA Standard dose consequence screening criteria of 2.5 mrem will not have LBEs in the PSAR—these sources are expected to screen out of the PRA when the PRA scope expands in the future
  - These evaluations will be available in other records for the Seadrift plant
- For non-core radiological sources that do not screen out, Section 3 of the ASME/ANS non-LWR PRA Standard will be used to justify risk-informed decision making, which may involve using supplementary analysis and supplementary requirements

		NRC Presentation 4/18/23		X-energy Plan	
		Reactor	Non-reactor	Reactor	Non-reactor
Internal Events	At-power	PRA	PRA/SE[2]	PRA	SE
	LPSD[3]	PRA/SE	PRA/SE	SE	N/A
Other Hazards[1]	At-power	PRA/SE/DBHL	PRA/SE/DBHL	DBHL	DBHL
	LPSD	PRA/SE/DBHL	PRA/SE/DBHL	DBHL+SE	N/A

1*Other hazards* means hazards other than internal events (e.g., internal fires, seismic)
2Risk-informed supplemental evaluation (SE)
3Low-power shutdown (LPSD)

3.10 Non-Core Related Source Radiological Analyses

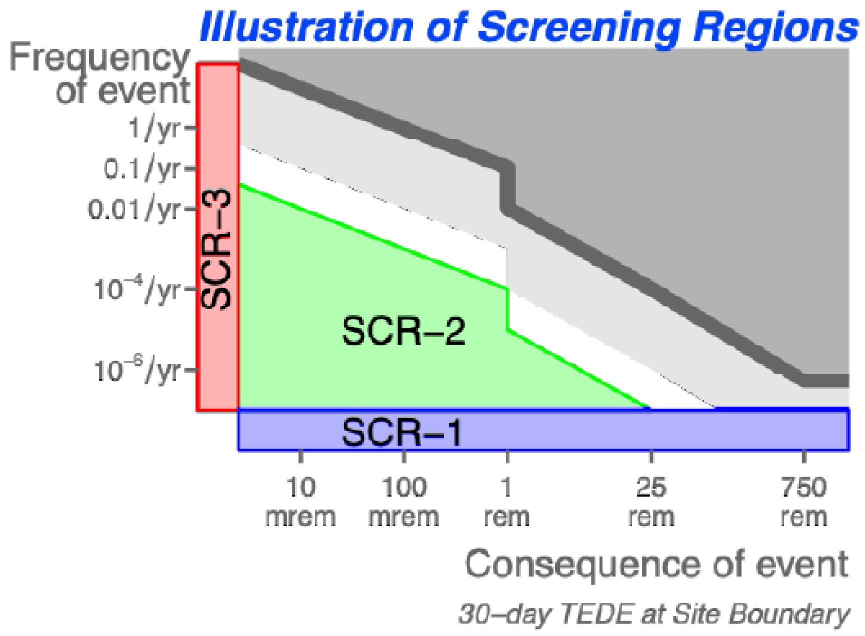
Radiological Sources	LBE Selection Method
Fuel within the reactor	PRA
Non-fuel sources within the helium pressure boundary	PRA
Fuel in Fuel Handling System outside the helium pressure boundary	Supplemental Evaluation
Non-fuel sources in Fuel Handling System outside the HPB	Supplemental Evaluation
Fuel in Spent Fuel Storage System	Supplemental Evaluation
Radwaste Treatment Building sources	Supplemental Evaluation
Helium Services System sources outside the HPB	Supplemental Evaluation
Neutron Start-up source	Supplemental Evaluation

3.10 Non-Core Related Source Radiological Analyses

- Supplemental evaluations performed using graded modeling and screening approach
- Bounding, conservative release (not event-specific)
  - Dose consequences less than 2.5 mrem → no LBEs selected because they are expected to screen out of the PRA using screening criteria

(b) SCR-3: Demonstrably conservative screening—this screening criteria is usually, but not always, conducted on the consequence axis of the F-C target. Event sequence families that can be shown to map to a release category before the start of the F-C target do not have a frequency target with which to determine risk significance. Thus, any event sequences with frequencies less than 2.5 mrem are screened from further analysis but should be retained in the model both for completeness checks and to ensure that future changes to the PRA do not increase this consequence above the screening threshold.

Fig. RI-5 Mapping of Three Screening Criteria to the NEI 18-04 F-C Target Curve



3.10 Non-Core Related Source Radiological Analyses

- Supplemental evaluations performed using graded modeling and screening approach
- Fuel → Deterministic LBEs selected and analyzed
- Non-fuel sources → Bounding, conservative release (not event-specific)
  - Dose consequences less than 2.5 mrem → no LBEs selected because they are expected to screen out of the PRA using screening criteria
  - Dose consequences greater than 2.5 mrem → deterministic results presented in PSAR
    - Expected to screen out when incorporated into the PRA using more realistic modeling assumptions

Radiological Sources	Expected Treatment	In PSAR?
Fuel in Fuel Handling System outside the helium pressure boundary	LBEs selected and analyzed	Yes
Non-fuel sources in Fuel Handling System outside the HPB	Screened (< 2.5 mrem)	No
Fuel in Spent Fuel Storage System	LBEs selected and analyzed	Yes
Radwaste Treatment Building sources	Deterministic results (>2.5 mrem)	Yes
Helium Services System sources outside the HPB	Deterministic results (>2.5 mrem)	Yes
Neutron Start-up source	Deterministic results (>2.5 mrem)	Yes

3.10 Non-Core Related Source Radiological Analyses

- For the fuel outside the reactor, more detailed evaluation provides the basis for selected LBEs
- Fuel in the Fuel Handling System (FHS)
  - High-level FMEA performed to identify challenges to Required Safety Functions
  - DBHLs used to evaluate hazard-specific risks—beyond design basis hazards will be evaluated for the FSAR
  - One (deterministic) LBE selected: loss of cooling to fuel in the FHS
  - Outcomes
    - Preliminary LBEs from the fuel in the FHS are not expected to be risk-significant
    - May screen out in the future with more realistic modeling
- Fuel in the Spent Fuel Storage System
  - Operating experience and spent fuel storage PRAs used to identify initiating events
  - Master Logic Diagrams used to group and screen events
  - DBHLs used to evaluate hazard-specific risks—beyond design basis hazards will be evaluated for the FSAR
  - Two (deterministic) LBEs selected
  - Outcomes
    - Preliminary LBEs from the fuel in the Spent Fuel Storage System are not expected to be risk-significant

3.11 Non-full-power Mode Event Selection and Analyses

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3.11 Non-full-power Mode Event Selection and Analyses

- Low-power modes will be addressed using supplementary analysis and requirements in accordance with Section 3 of the ASME/ANS non-LWR PRA Standard
- Supplementary evaluations will compare the consequences of non-full-power operations relative to the consequences of at-power DBAs, which are selected using the full-power internal events PRA
- Non-full-power events that are not represented by or bounded by the risk of at-power events will be evaluated
  - Could include new initiating events, new plant responses, or more limiting initial conditions
- Supplementary evaluations will implement NEI 18-04, LBE Selection Process, "Task 1: Propose Initial List of LBEs"
  - Preliminary LBEs deterministically selected and evaluated

		NRC Presentation 4/18/23		X-energy Plan	
		Reactor	Non-reactor	Reactor	Non-reactor
Internal Events	At-power	PRA	PRA/SE[2]	PRA	SE
	LPSD[3]	PRA/SE	PRA/SE	SE	N/A
Other Hazards[1]	At-power	PRA/SE/DBHL	PRA/SE/DBHL	DBHL	DBHL
	LPSD	PRA/SE/DBHL	PRA/SE/DBHL	DBHL+SE	N/A

[1]*Other hazards* means hazards other than internal events (e.g., internal fires, seismic)
[2]Risk-informed supplemental evaluation (SE)
[3]Low-power shutdown (LPSD)

3.12 Aircraft Impact Assessment

3.12 Aircraft Impact Assessment

- Section will state the Xe-100 complies with 10 CFR 50.150
- X-energy will implement RG 1.217, “Guidance for the Assessment of Beyond-Design-Basis Aircraft Impacts”, which describes a method that the NRC staff considers acceptable for use in satisfying the regulations at 10 CFR 50.150.
  - As informed by ARCAP ISG (DANU-ISG-2022-01)
- Results will be included in an enclosure or otherwise made available to reviewers as controlled material (safeguards information)

3.12 Aircraft Impact Assessment

As noted in DANU-ISG-2022-01:

> *"the four functions identified in 10 CFR 50.150(a)(1) are applicable to LWRs and may not be applicable to non-LWR reactor designs or may have to be supplemented by other key functions. When reviewing non-LWR designs, the staff will evaluate the applicability of the acceptance criteria set forth in the aircraft impact rule and the possible need for other criteria. As noted in the statements of consideration for 10 CFR 50.150 (74 FR 28146, June 12, 2009) (Ref. 117), if necessary, the staff will issue exemptions and impose supplemental criteria to be used in the aircraft impact assessment for such non-LWR designs."*

- As identified in DANU-ISG-2022-01, the Xe-100 will use different acceptance criteria informed by the Required Safety Functions identified implementing the NEI 18-04 approach as endorsed by RG 1.233 and the SECY-11-0112.

3.13 Mitigation of Beyond Design Basis Events

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3.13 Mitigation of Beyond Design Basis Events

- Section will include a commitment to evaluate BDBEs for the FSAR to demonstrate compliance with 10 CFR 50.155

Conclusion & Next Steps

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Acronyms

Acronym	Description
AOO	Anticipated Operational Occurrence
ARCAP	Advanced Reactor Content of Applications
ASME	American Society of Mechanical Engineering
BDBE	Beyond Design Basis Event
CFR	Code of Federal Regulations
CPA	Construction Permit Application
DBA	Design Basis Accident
DBE	Design Basis Event
DBHL	Design Basis Hazard Level
DID	Defense-in-Depth
EAB	Exclusion Area Boundary
EPA	Environmental Protection Agency
F-C	Frequency-Consequence
FHS	Fuel Handling System
FMEA	Failure Modes and Effects Analysis
FOM	Figure of Merit
FSAR	Final Safety Analysis Report
HAZOP	Hazards and Operability Assessment
HPB	Helium Pressure Boundary
ISG	Interim Staff Guidance
LBE	Licensing Basis Event

Acronym	Description
LPSD	Low Power Shutdown
LTR	Licensing Topical Report
LWR	Light Water Reactor
MST	Mechanistic Source Term
NEI	Nuclear Energy Institute
NRC	Nuclear Regulatory Commission
NSRST	Non-Safety Related with Special Treatment
PAG	Protective Action Guideline
PRA	Probabilistic Risk Assessment
PSAR	Preliminary Safety Analysis Report
RCCS	Reactor Cooling Cavity Cooling System
RG	Regulatory Guide
RPV	Reactor Pressure Vessel
SE	Supplemental Evaluation
SFSS	Spent Fuel Storage System
SR	Supporting Requirements
SSC	Structures, Systems, and Components
TEDE	Total Effect Dose Equivalent
TRISO	Tristructural-isotropic
UCO	Uranium Oxycarbide

Transition to Closed Session

3.3 – 3.6 Analysis of AOOs, DBEs, BDBEs, and DBAs

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Licensing Basis Event Overviews

Sections 3.3 - 3.6 presentation LBE information consistent with NEI 21-07 and DG-1404

Event summary
- 1-2 paragraph summary of the event sequence initiation, plant response, and end state

Event description
- More detailed description of plant response than the summary section
- Quantitative information for key plant and event sequence parameters

Methodology
- Explanation of the codes used for analysis
- List of key assumptions

Results
- Several-paragraph discussion of the event outcome
- Figures plotting key plant parameters over time (including the source term)

Figure of merit
- Total Effective Dose Equivalent (TEDE) rem at the Exclusion Area Boundary (EAB)

Licensing Basis Event - EXAMPLE | Anticipated Operational Occurrence: Turbine Trip-1

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Licensing Basis Event - EXAMPLE | Anticipated Operational Occurrence: Turbine Trip-1

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