Licensing Modernization Project
Enabling Advanced Reactor Deployment

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**Purpose:** Introduce the Licensing Modernization Project’s (LMP) proposals as documented in NEI 18-04

**Desired Outcome:** RAMP Users Group’s

- Familiarization with licensing modernization objectives, proposals, and activities
- Adaptation of its tools to support modernization’s objectives
Systematic, Wholistic, Technology Inclusive Licensing is a Must

COOLANT CHOICE

- Pressure
  - Coolant Temperature
  - Moderate Temperature (250-350°C)
  - High Temperature (600-1000°C)
  - Atmospheric-Pressure Operation
  - Liquid Metal
  - Liquid Salt
  - High-Pressure Operation
  - Water
  - Gas
Potential Regulatory Structure Development Options

- LMP Products
- Application Content
- Functional Containment
- Risk-Informed Consequence Based
  - EPZ
  - Control Room Staffing
- Etc.

Coherency and consistency of the design specific requirements are critical for fairness and commercial competitiveness

Option 1 - Top Down Approach
Option 2 - Bottom Up Approach
Progressive Licensing Technical Requirements Modernization Pathway

Current Technical Requirements
- Prescriptive Detailed Large Light Water Specific Technical Requirements

2016
- TI RI-PB Coherent Processes for Setting LBE, SSC Classification, & DiD Determination

2020
- RIPB Part 53

2025
- TI RIPB Processes for Setting Containment Function, EPZ, Offsite Power

2050s
- Performance-Objective, Risk-Informed Processes for Setting Requirements For Parts 20, 40, 51, etc.

Progressive transition to setting requirements through use of RIPB processes
Principle LMP Objectives

– Create foundation for an integrated approach to licensing modernization embracing three highly interdependent risk-informed and performance-based topics
– Integrate new advances in RIPB methods and applications that can be used in a technology-inclusive manner for advanced reactor design and licensing
– Reflect the culmination of methods and practices available today to operationalize technology-inclusive RIPB practices recognized across decades of policy and incremental progress
– Pave a coherent path to efficient and effective licensing of advanced reactors
NEI 18-04 Endorsement

- NEI 18-04 transformational methodology was developed based on:
  - several years (over 15 years) of industry’s close collaboration with the staff
  - millions of dollars of investment by public and private sectors
  - was subject of many public reviews and discussions
  - was subject of a number of industry tabletop exercises, covering different technologies and designs
- NRC management support of the initiative (e.g., Letter to Steve Kuczynski, Feb. 2018, etc.)
- NRC commitments (e.g., July-2019 NRC status report to Congress)
- Positive support of Draft Guide-1353 which endorses NEI 18-04:
  - ACRS letter of support, following a number of meetings with the industry and NRC staff.
  - Only one public comment received during the public comment period.
Overview of LMP Proposals

• Review LMP processes for:
  – Selection and evaluation of licensing basis events
    • Systematic RIPB process to identify DBAs
  – Safety classification and performance-based requirements for SSCs.
    • As part of this structured SSC classification process, establish better RIPB-focused special treatment that includes input from DID adequacy evaluation process
  – Defense-in-depth adequacy determination
    • Mechanism to apply RIPB practices to determining DID adequacy and design and programmatic sufficiency (i.e., When is enough, enough?)
Addressing LBE selection should be top priority because it is the basis for all other licensing inputs.
The Key Consideration

• SRP Chapter 15.0 statement:
  “If the risk of an event is defined as the product of the event’s frequency of occurrence and its consequences, then the design of the plant should be such that all the AOOs and postulated accidents produce about the same level of risk (i.e., the risk is approximately constant across the spectrum of AOOs and postulated accidents). This is reflected in the general design criteria (GDC), which generally prohibit relatively frequent events (AOOs) from resulting in serious consequences, but allow the relatively rare events (postulated accidents) to produce more severe consequences.”

• Conclusion: To meet this requirement LBE Selection has to be RIPB

• Options: Ad hoc RIPB Approach vs. Systematic RIPB Process
<table>
<thead>
<tr>
<th>LBE Selection Options</th>
<th>Process</th>
<th>Tools used for identification and consequence analysis</th>
<th>Frequency estimate</th>
<th>Uncertainty Analysis</th>
<th>Technical Adequacy</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ad Hoc RIPB</td>
<td>Events are identified and analyzed based on Engineering Judgment; revised to reflect service experience</td>
<td>Ad hoc approach similar to FMEA; reproducible process to select LBEs for new reactors does not exist</td>
<td>Qualitative based engineering judgment</td>
<td>Not explicitly identified, addressed primarily using conservative assumptions based on engineering judgment.</td>
<td>No consensus standards as the LBE procedures do not exist; rests solely on regulatory review judgments.</td>
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<tr>
<td>Systematic RIPB</td>
<td>Incorporates approaches used in Ad hoc method in a systematic, reproducible PRA procedure.</td>
<td>FMEA, HAZOPs, MLD, PERT, PRA methods for systematic search for initiating events and defining accident sequences</td>
<td>Quantitative based on applicable service experience, engineering judgment and PRA data analysis methods</td>
<td>Explicitly identified and listed via structured PRA process,. Systematically analyzed and accounted for; defense-in-depth approach to capture uncertainties not well represented in PRA</td>
<td>ASME non-LWR PRA Standards, EPRI research, experience with HTGR and LMFR PRAs</td>
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</tbody>
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Selection And Evaluation Of LBEs
LBE Categories

Anticipated Operational Occurrences (AOOs). AOOs encompass planned and anticipated events whose frequencies exceed $10^{-2}$/plant-year where a plant may be comprised of one or more reactor modules. The radiological doses from AOOs are required to meet normal operation public dose requirements. AOOs are utilized to set operating limits for normal operation modes and states.

Design Basis Events (DBEs). DBEs encompass unplanned off-normal events not expected in the plant’s lifetime whose frequencies are in the range of $10^{-4}$ to $10^{-2}$/plant-year, but which might occur in the lifetimes of a fleet of plants. DBEs are the basis for the design, construction, and operation of the structures, systems, and components (SSCs) during accidents and are used to provide input to the definition of design basis accidents (DBAs).

Beyond Design Basis Events (BDBEs). BDBEs which are rare off-normal events whose frequencies range from $5 \times 10^{-7}$/plant-year to $10^{-4}$/plant-year. BDBEs are evaluated to ensure that they do not pose an unacceptable risk to the public.

Design Basis Accidents (DBAs). The DBAs for Chapter 15, “Accident Analyses,” of the license application are prescriptively derived from the DBEs by assuming that only SSCs classified as safety-related are available to mitigate the consequences. The public consequences of DBAs are based on mechanistic source terms and evaluated using conservative or best estimate approaches with appropriate accounting for uncertainties.
Selection and Evaluation of LBEs

• AOOs, DBEs, and BDBEs are defined in terms of event sequence families from a reactor design-specific PRA
• AOOs, DBEs, and BDBEs are evaluated:
  • Individually for risk significance using a Frequency-Consequence (F-C) chart against a F-C Target
  • Collectively by comparing the total integrated risk against a set of cumulative risk targets
• DBEs and high consequence BDBEs are evaluated to define Required Safety Functions (RSFs) necessary to meet F-C Target
• Designer selects Safety Related SSCs to perform required safety functions among those available on all DBEs
• DBAs are derived from DBEs by assuming failure of all non-safety related SSCs and evaluated conservatively vs. 10CFR50.34
**F-C Target**

- **Event Sequence Frequency (Per Plant Year)**
  - 1.0 x 10^-1
  - 1.0 x 10^-2
  - 1.0 x 10^-3
  - 1.0 x 10^-4
  - 1.0 x 10^-5
  - 1.0 x 10^-6
  - 1.0 x 10^-7

- **Total Effective Dose Equivalent (REM) at Exclusion Area Boundary (EAB)**
  - 1.0 x 10^-3
  - 1.0 x 10^-2
  - 1.0 x 10^-1
  - 1.0
  - 1.0 x 10^0
  - 1.0 x 10^1
  - 1.0 x 10^2
  - 1.0 x 10^3
  - 1.0 x 10^4

- **Graph Key Points**
  - **Design Objective**
  - **EPA PAG Dose Limit**
  - **BEYOND DESIGN BASIS EVENT (BDBE) REGION**
  - **DESIGN BASIS EVENT (DBE) REGION**
  - **ANTICIPATED OPERATIONAL OCCURRENCE (AOO) REGION**
  - **F-C Target Anchors**
  - **10 CFR 20 Iso-Risk Line**
  - **Increasing Risk Significance**
  - **10 CFR 50.34 Dose Limit**
  - **Individual Risk QHO (Prompt)**

- **Date:** 6/19/2018
- **Source:** Southern Company
LBE Cumulative Risk Targets

- The total frequency of exceeding an offsite boundary dose of 100 mrem shall not exceed 1/plant-year to ensure that the annual exposure limits in 10 CFR 20 are not exceeded.

- The average individual risk of early fatality within the area 1 mile of the EAB shall not exceed $5 \times 10^{-7}$/plant-year to ensure that the NRC Safety Goal Quantitative Health Objective (QHO) for early fatality risk is met.

- The average individual risk of latent cancer fatalities within the area 10 miles of the EAB shall not exceed $2 \times 10^{-6}$/plant-year to ensure that the NRC safety goal QHO for latent cancer fatality risk is met.
SSC Classification

SSCs Including Radionuclide Barriers

Safety-Related (SR) SSCs
- SSCs selected for **required safety functions** to mitigate DBEs within F-C Target*
- SSCs selected for **required safety functions** to prevent high-consequence BDBEs from entering DBE region beyond F-C target

Non-Safety-Related SSCs with Special Treatment (NSRST)
- Non-SR SSCs performing Risk-significant functions
- Non-SR SSCs performing functions required for defense-in-depth

Non-Safety-Related SSCs with No Special Treatment (NST)
- SSCs performing non-safety-significant functions

* SR SSCs are also relied on during DBAs to meet 10 CFR 50.34 dose limits using conservative assumptions
SSC Classification


- Input to LBE selection
- Input to SSC safety classification
- Input to SSC performance requirements
- Evaluation of LBEs vs. layers of defense
- Evaluation of risk margins of LBEs vs. F-C and cumulative risk targets
- Evaluation of uncertainties and protective measures
- Demonstration of adequate defense-in-depth

Deterministic Evaluation

Risk insights and judgments to enhance plant capabilities

Risk insights and judgments to enhance programmatic assurance

Plant Capability Defense-in-Depth

- Inherent reactor, facility, and site characteristics
- Radionuclide physical and functional barriers
- Passive and active SSCs in performance of safety functions
- SSC reliability in prevention of events
- SSC capability in mitigation of events
- SSC redundancy and diversity
- Defenses against common cause failures
- Conservative design margins in SSC performance

Programmatic Defense-in-Depth

- Performance targets for SSC reliability and capability
- Design, testing, manufacturing, construction, operations, and maintenance programs to meet performance targets
- Tests, inspections, and monitoring of SSC performance and corrective actions
- Operational procedures and training to compensate for human errors, equipment failures, and uncertainties
- Technical specifications to bound uncertainties
- Capabilities for emergency plan protective actions
Questions?