Licensing Modernization Project

Use of PRA to Select Licensing Basis Events

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Presented to
PSAM-14
Los Angeles, CA September 2018

Licensing Modernization Project

- Nuclear industry initiative cost shared by U.S. Department of Energy and administered by Idaho National Laboratory
- Developed a technology-inclusive (TI), risk-informed, and performance based (RI-PB) methodology for developing licensing bases for advanced non-LWRs
- Focuses on RI-PB decisions associated with
  - Selecting and evaluating Licensing Basis Events
  - Safety classification and performance requirements for SSCs
  - Evaluation of defense-in-depth adequacy
- Documented in a series of white papers and a guidance document (NEI 18-04) which have been reviewed by the NRC staff and discussed in a series of public meetings
- NRC staff is preparing a draft regulatory guide (DG-1553) that endorses the LMP methodology

LMP seeks to define processes that are:

- 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 Events (LBEs)

- LBEs are defined broadly to include all the events used to support the safety aspects of the design and to meet licensing requirements. They cover a comprehensive spectrum of events from normal operation to rare, off-normal events.
- Categories defined as Normal Operations (NO), Anticipated Operational Occurrences (AOO), Design Basis Events (DBE), Beyond Design Basis Events (BDBE) and Design Basis Accidents (DBA)
- LBE definitions and approach build on those developed in NGNP white papers
- LMP guidance document includes glossary to clarify differences in terminology with regulatory terms

LBE Categories

Anticipated Operational Occurrences (AOOs). Anticipated event sequences expected to occur one or more times during the life of a nuclear power plant, which may include one or more reactor modules. Event sequences with mean frequencies of 1×10^{-2}/plant-year and greater are classified as AOOs. AOOs take into account the expected response of all SSCs within the plant, regardless of safety classification.

Design Basis Events (DBEs). Infrequent event sequences that are not expected to occur in the life of a nuclear power plant, which may include one or more reactor modules, but are less likely than an AOO. Event sequences with mean frequencies of 1×10^{-4}/plant-year to 1×10^{-2}/plant-year are classified as DBEs. DBEs take into account the expected response of all SSCs within the plant regardless of safety classification. The objective and scope of DBEs is to form the design basis of the plant

Beyond Design Basis Events (BDBEs). Rare event sequences that are not expected to occur in the life of a nuclear power plant, which may include one or more reactor modules, but are less likely than a DBE. Event sequences with mean frequencies of 5×10^{-7}/plant-year to 1×10^{-4}/plant-year are classified as BDBEs. BDBEs take into account the expected response of all SSCs within the plant regardless of safety classification.

Design Basis Accidents (DBAs). Postulated accidents that are used to set design criteria and performance objectives for the design Safety Related SSCs. DBAs are derived from DBEs based on the capabilities and reliabilities of Safety Related SSCs needed to mitigate and prevent accidents, respectively. DBAs are derived from the DBEs by prescriptively assuming that only Safety Related SSCs classified are available to mitigate postulated accident consequences to within the 10 CFR 50.34 dose limits.

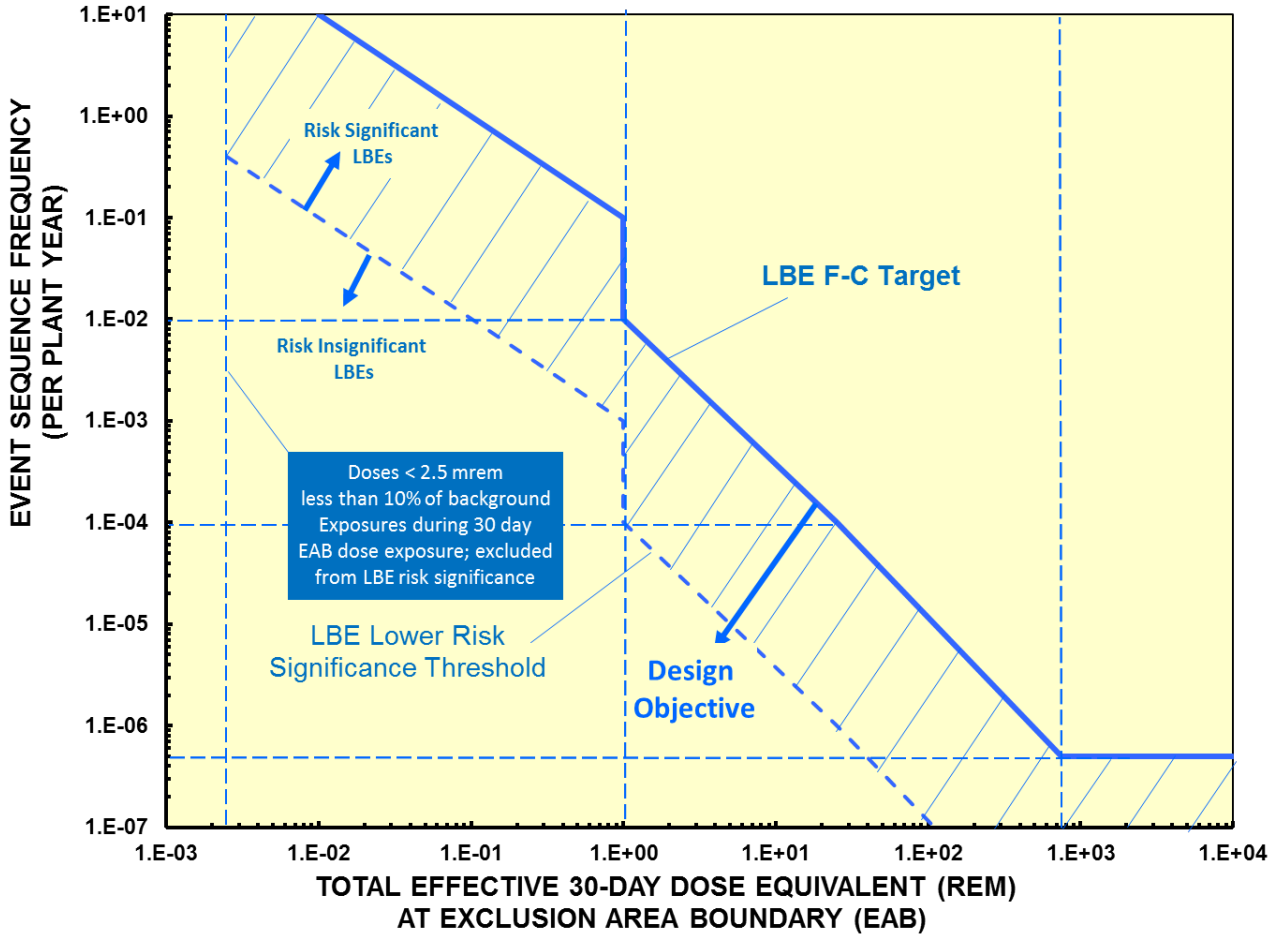
Selection and Evaluation of LBEs

- 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 RSFs 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

Frequency-Consequence (F-C)Target

- Purpose is to evaluate risk significance of individual LBEs and to help define the RSFs
- Derived from the NGNP F-C Target and frequency bins for AOOs, DBEs, and BDBEs
  - Addressed staircase issue with previous F-C targets
- F-C Target anchor points based on:
  - 10 CFR 20 annual dose limits and iso-risk concept
  - Avoidance of offsite protective actions for lower frequency AOOs
  - 10 CFR 50.34 dose limits for lower frequency DBEs
  - Consequences based on 30day TEDE dose at EAB
  - EAB doses selected to assure meeting QHO for prompt fatality individual risk

LBE Risk-Significance Criteria



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 $5x10^{-7}$/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 $2x10^{-6}$/plant-year to ensure that the NRC safety goal QHO for latent cancer fatality risk is met.

PRA Development

- Although not required, early introduction of PRA into design process facilitates risk-informing design decisions
- Scope and level of detail consistent with scope and level of detail of design and site information and fit for purpose in RIPB decisions
- Depending on the stage of the design and design, PRA event-sequences include those hazards that have state of practice PRA methods and involve single and multiple reactor modules and include risk significant non-reactor sources
- Supporting non-LWR PRA standard specifically designed to support LMP PRA applications
- Limitations and uncertainties associated with PRA addressed in the evaluation of defense-in-depth adequacy and deterministic inputs to RIPB decisions

Non-LWR PRA Standard

- ASME/ANS started the development of a non-LWR PRA standard in 2006 and produced a trial use standard ASME/ANS-Ra-S-1.4-2013
- Approximately 80% of the technical requirements are common to the LWR PRA standards; remaining 20% address:
  - Risk metrics appropriate for all advanced non-LWRs
  - PRAs on multi-module plants
  - PRAs that support event sequence frequencies and consequences
  - PRAs that are performed at early stages in design
- Trial use standard is currently being revised towards a ballot for an ANSI standard in 2019

Summary

- A plant and design specific PRA provides a systematic and reproducible way to define an appropriate set of LBEs for an advanced non-LWR
- LBEs are refined as the PRA matures through different stages of design and licensing
- LBEs provide a basis for SSC safety classification and evaluation of defense-in-depth adequacy