Introduction to RIPB Framework (licensing Modernization Project, LMP) for Advanced Reactors

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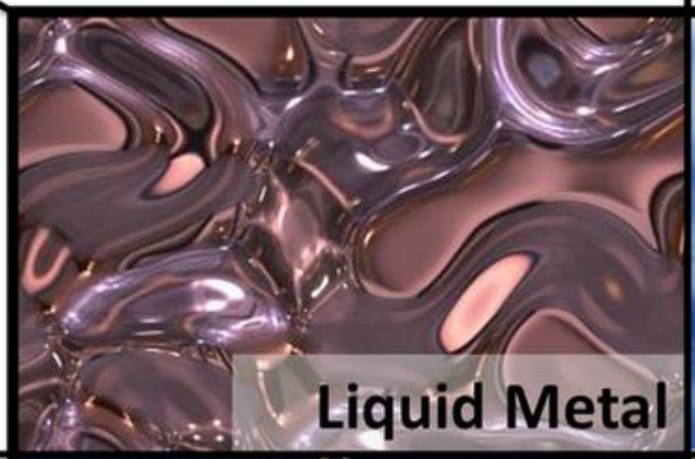
Licensing

- Regulator Objectives
  - Protect public health and safety (+)
  - Meet principals of good regulation (independence, openness, efficiency, clarity, and reliability)
- Current Regulatory Approach
  - Prescriptive to create efficiency and clarity for existing fleet
  - Inadequately technology inclusive, risk informed, or performance-based
- Resulting Regulation
  - Reductionist
  - Ineffective to deal with change in knowledge state in timely way
  - Patchwork solutions

2

COOLANT CHOICE

Coolant Temperature \ Pressure	Atmospheric-Pressure Operation	High-Pressure Operation
Moderate Temperature (250-350 C)	 Liquid Metal	 Water
High Temperature (600-1000 C)	 Liquid Salt	 Gas

Modernized Licensing Framework Attributes

- Provides regulator with the necessary tools to carry out its mission more efficiently and more effectively
- Is technology inclusive to create agility
- Is performance-based and risk-informed to enable innovation and to create systematic basis for requirements
- Builds on collective and individual objectives
    a) NRC's objective of meeting "Principles of Good Regulation"
    b) Vendors objective of being able to innovate
    c) Utilities goal of continuous performance improvement
    d) Collective goal of reducing cumulative effects of regulation

4

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

Quantitative Risk-Informed Decision Making

- LMP proposals present a formal and transparent risk-informed and performance-based process for making key licensing decisions
- A PRA for non-LWRs is an essential element of the proposed RIPB LMP framework.
- ASME/ANS RA-S-1.4-2013, Probabilistic Risk Assessment Standard for Advanced Non-LWR Nuclear Power Plants, 2013.

Cornerstones of RIPB Framework

- Selection and evaluation of licensing basis events (LBEs)
- Frequency - Consequence (F-C) target and LBE risk-significance criteria
- Structures, systems, and components (SSC) classification and performance requirements
- Defense in depth adequacy evaluations

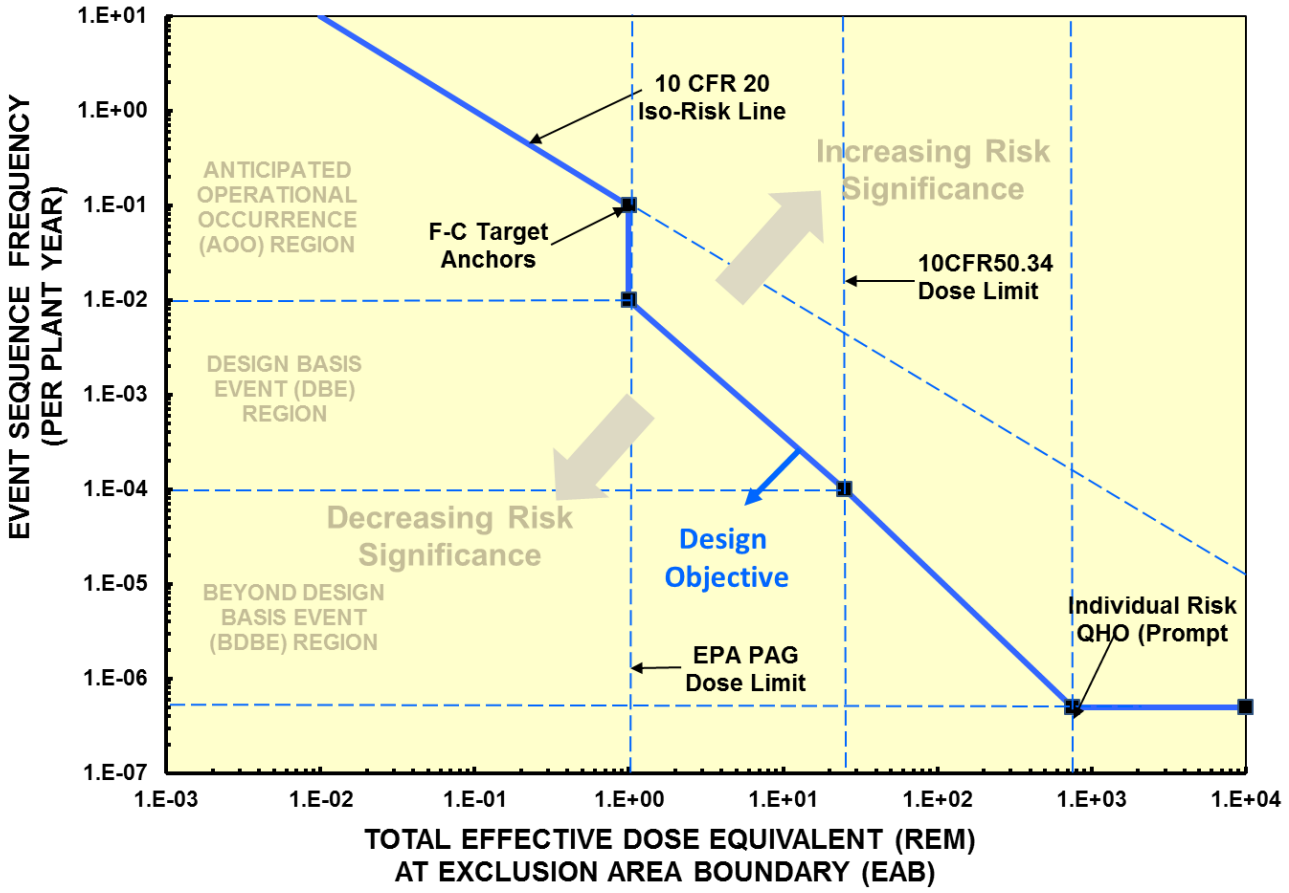
Licensing Basis Events (LBEs)

- 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)

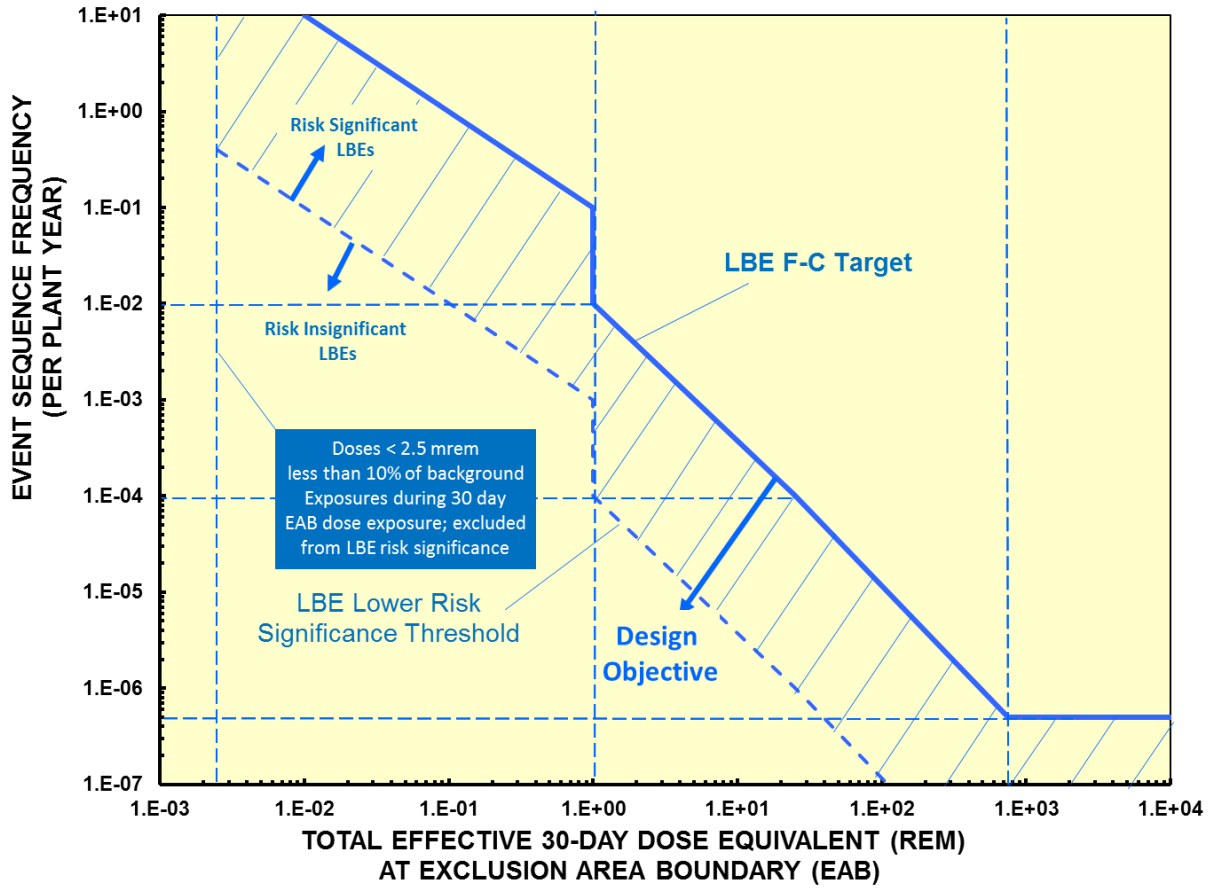
Selection and Evaluation of LBEs

- 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


1.E+01
1.E+00
1.E-01
1.E-02
1.E-03
1.E-04
1.E-05
1.E-06
1.E-07
EVENT SEQUENCE FREQUENCY (PER PLANT YEAR)
10 CFR 20 Iso-Risk Line
ANTICIPATED OPERATIONAL OCCURRENCE (AOO) REGION
F-C Target Anchors
Increasing Risk Significance
10CFR50.34 Dose Limit
DESIGN BASIS EVENT (DBE) REGION
Decreasing Risk Significance
Design Objective
BEYOND DESIGN BASIS EVENT (BDBE) REGION
Individual Risk QHO (Prompt
EPA PAG Dose Limit
1.E-03
1.E-02
1.E-01
1.E+00
1.E+01
1.E+02
1.E+03
1.E+04
TOTAL EFFECTIVE DOSE EQUIVALENT (REM)
AT EXCLUSION AREA BOUNDARY (EAB)

LBE Risk-Significance Criteria



LMP Proposed SSC Safety Categories

- **Safety-Related (SR):**
  - SSCs selected by the designer to perform required safety functions to mitigate the consequences of DBEs to within the F-C target, and to mitigate DBAs to meet the dose limits of 10 CFR 50.34 using conservative assumptions.
  - SSCs selected by the designer to perform required safety functions to prevent the frequency of BDBEs with consequences greater than 10 CFR 50.34 dose limits from increasing into the DBE region and beyond the F-C target.
- **Non-Safety-Related with Special Treatment (NSRST)**:
  - Non-safety related SSCs relied on to perform risk significant functions. Risk significant SSCs are those that perform functions that keep LBEs from exceeding the F-C target, or make significant contributions to the cumulative risk metrics selected for evaluating the total risk from all analyzed LBEs.
  - Non-safety related SSCs relied on to perform functions requiring special treatment for DID adequacy.
- **Non-Safety-Related with No Special Treatment (NST)**:
  - All other SSCs.

SSC Risk Significance

- **A prevention or mitigation function of the SSC is necessary to meet the design objective of keeping all LBEs within the F-C target.**
  - The LBE is considered within the F-C target when a point defined by the upper 95%-tile uncertainty of the LBE frequency and dose estimates are within the F-C target.
- **The SSC makes a significant contribution to one of the cumulative risk metrics used for evaluating the risk significance of LBEs.**
  - A significant contribution to each cumulative risk metric limit is satisfied when total frequency of all LBEs with failure of the SSC exceeds 1% of the cumulative risk metric limit. The cumulative risk metrics and limits include:
    - The total frequency of exceeding of a site boundary dose of 100 mrem < 1/plant-year (10 CFR 20)
    - The average individual risk of early fatality within 1 mile of the Exclusion Area Boundary (EAB) < 5×10^{-7}/ plant-year (QHO)
    - The average individual risk of latent cancer fatalities within 10 miles of the EAB shall not exceed 2×10^{-6}/plant-year (QHO)

LMP Approach to safety margins

- Plant Level Safety Margins
  - Reflected in the margins between LBE frequencies and consequences and the F-C target;
  - One way to demonstrate enhanced margins consistent with NRC Advanced Reactor Policy.

- SSC Level Safety Margins
  - Margins in design codes selected to provide a robust capability to support the mitigation function of safety significant SSCs;
  - Margins in the performance requirements selected to ensure that SSC will perform their prevention functions with adequate reliability.

- Overall Safety Margins
  - Confirmation of adequate plant and SSC margins addressed as part of the DID adequacy evaluation.