Using NEI 18-04 to Risk Inform Design, and Considerations for QA Practices for Structures

John Richards
Senior Technical Executive
Risk & Safety Management, EPRI

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LMP Risk-Informed Performance-Based (RIPB) Design

- NEI 18-04, Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development
  - NEI 18-04 provides alternate criteria under the Licensing Modernization Project (LMP)
  - Uses a RIPB process for selection of Licensing Basis Events (LBEs), safety classification of structures, systems, and components (SSCs), and associated risk-informed special treatments
  - A key tool in that process is the Frequency-Consequence Target
- EPRI performed research to explore use of the criteria for external hazards, using seismic hazard as an example
- Selection of SSC codes and standards was integral to establishing the seismic performance base, in terms of fragilities

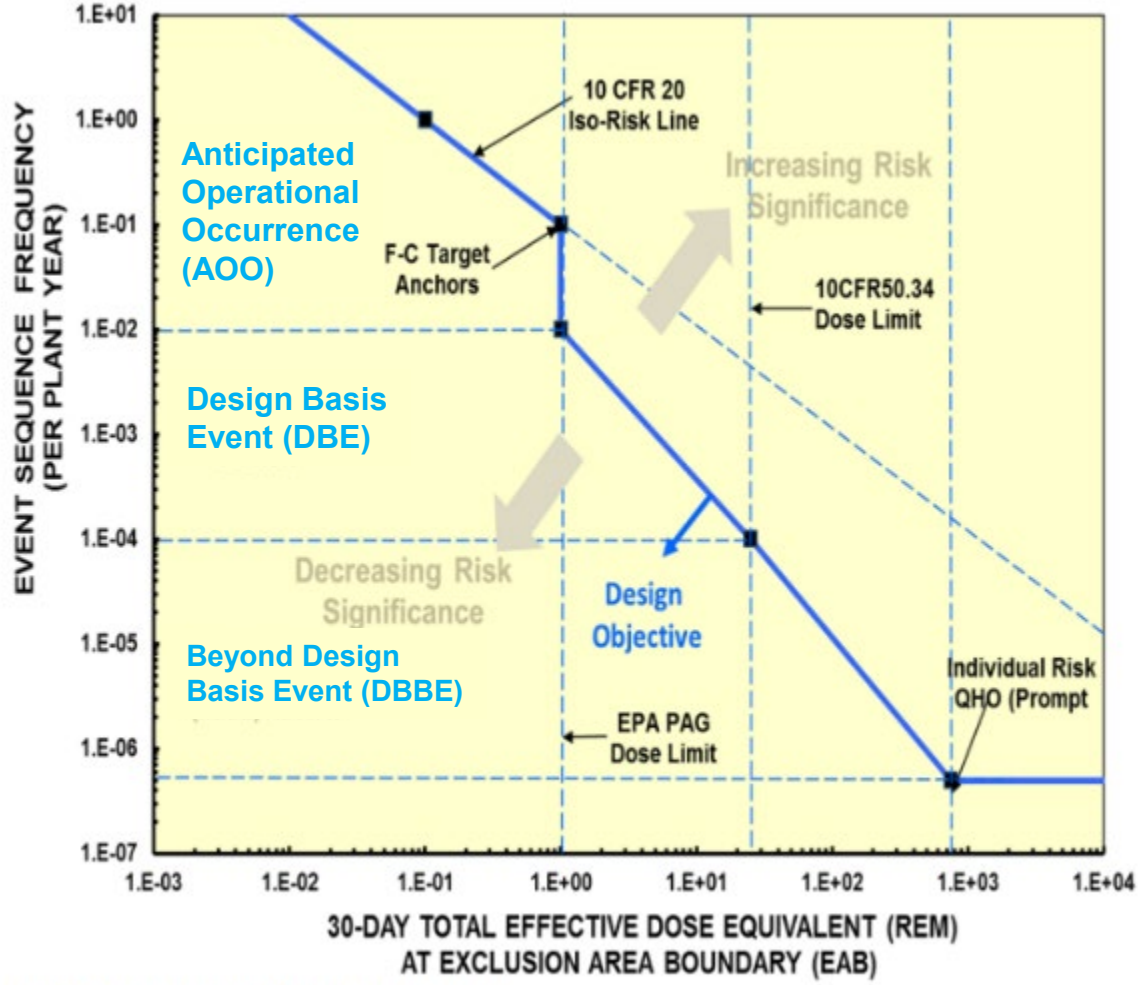
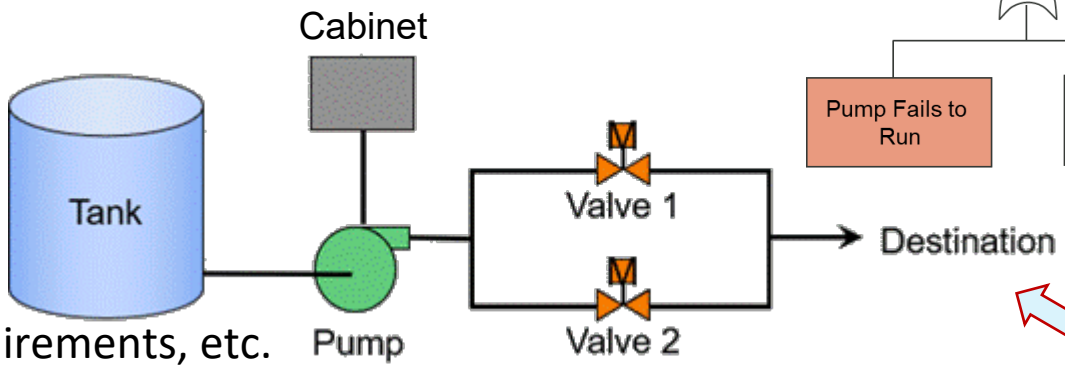


Figure 3-1. Frequency-Consequence Target

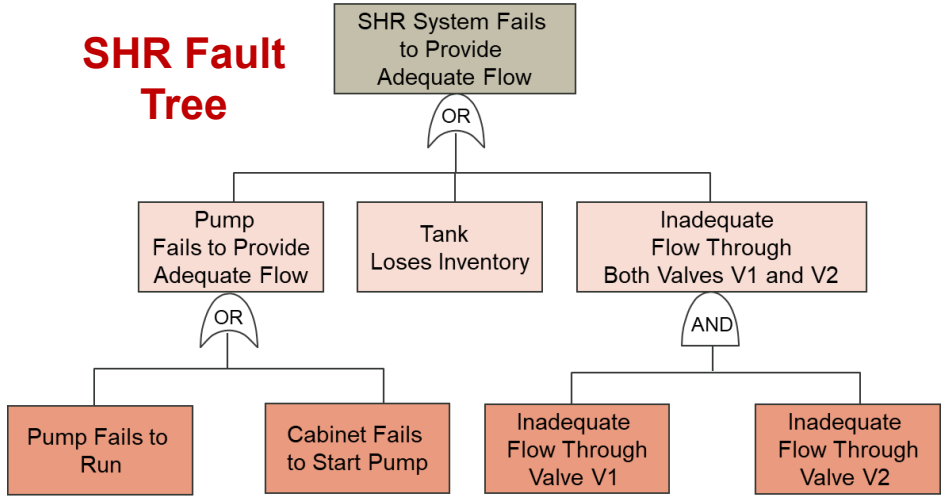
Example PRA System Model

- Example model is general and relevant to multiple AR designs
- For each item in the model, establish initial design assumptions:
  - Safety-Related
    - Safety-Related design standards, factors of safety, performance requirements, etc.
  - Non-Safety-Related with Special Treatment
    - Commercial standards with special treatment necessary to achieve the performance target
  - Non-Safety-Related
    - Commercial standards, factors of safety, performance requirements, QA, etc.
- Each of these choices establishes the performance basis, and the resulting seismic fragility

System for Heat Removal (SHR)



SHR Fault Tree



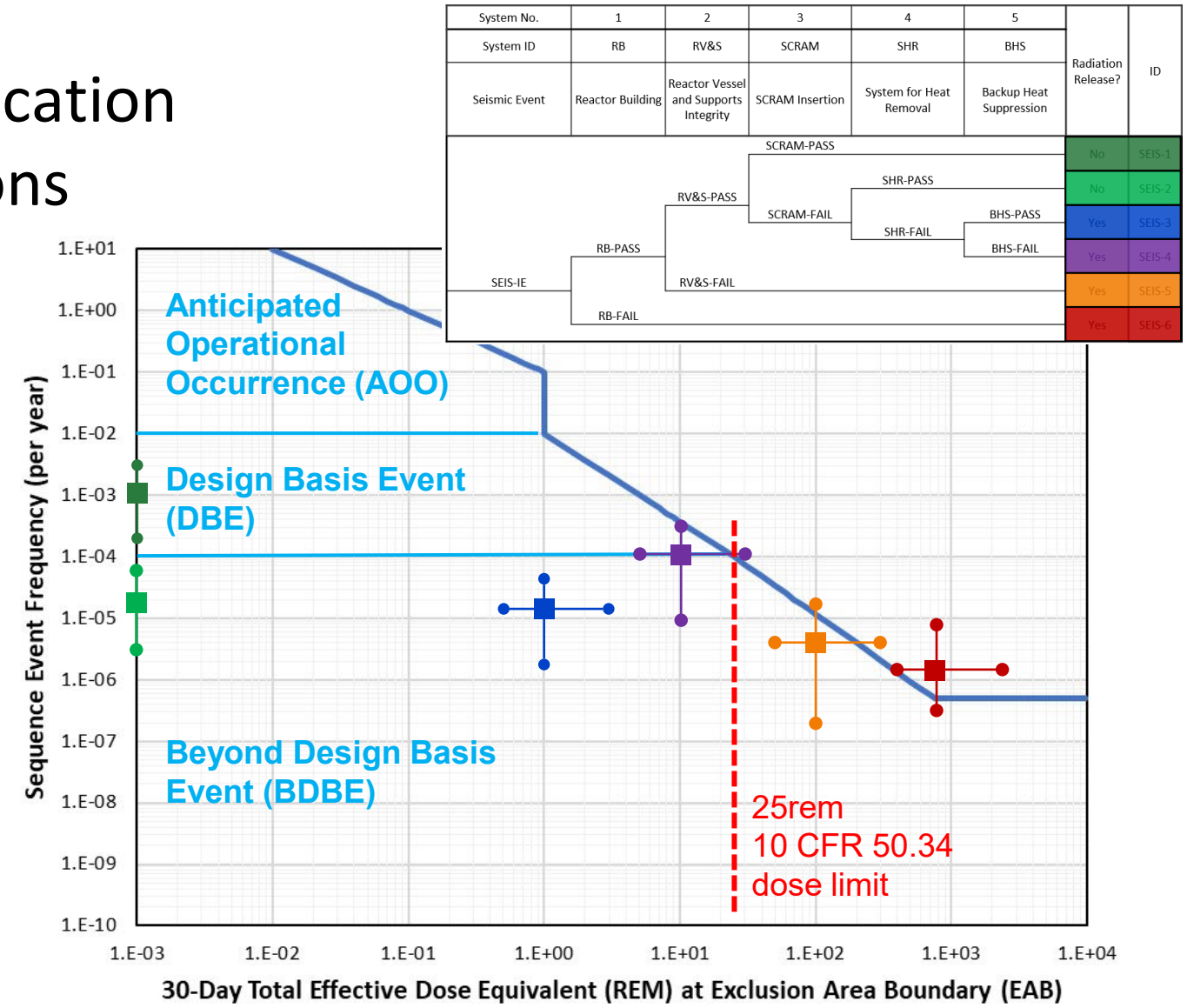
Event Tree

System No.	1	2	3	4	5	Radiation Release?	ID
System ID	RB	RV&S	SCRAM	SHR	BHS		
Seismic Event	Reactor Building	Reactor Vessel and Supports Integrity	SCRAM Insertion	System for Heat Removal	Backup Heat Suppression		
SEIS-IE	RB-PASS	RV&S-PASS	SCRAM-PASS			No	SEIS-1
				SHR-PASS		No	SEIS-2
			SCRAM-FAIL		BHS-PASS	Yes	SEIS-3
				SHR-FAIL	BHS-FAIL	Yes	SEIS-4
		RV&S-FAIL				Yes	SEIS-5
	RB-FAIL					Yes	SEIS-6

Frequency-Consequence – Initial Design

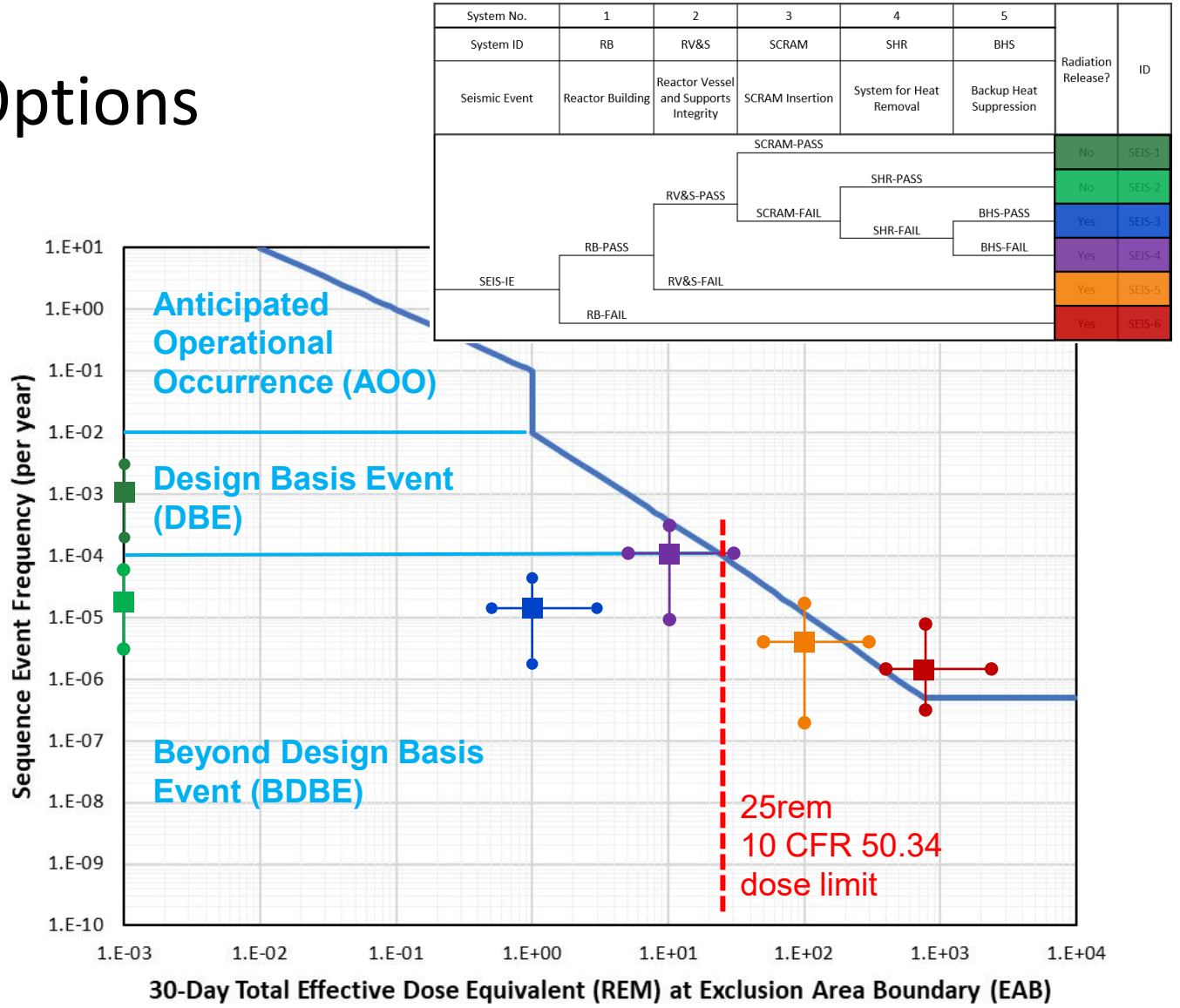
Key Results from Risk Quantification Using Initial Design Assumptions

- Several event sequences exceed the F-C Target (*Not favorable*)
- One Design Basis Accident based on the DBEs does not meet the 25rem dose regulatory limit in 10 CFR 50.34
  ➔*Design revision is necessary*



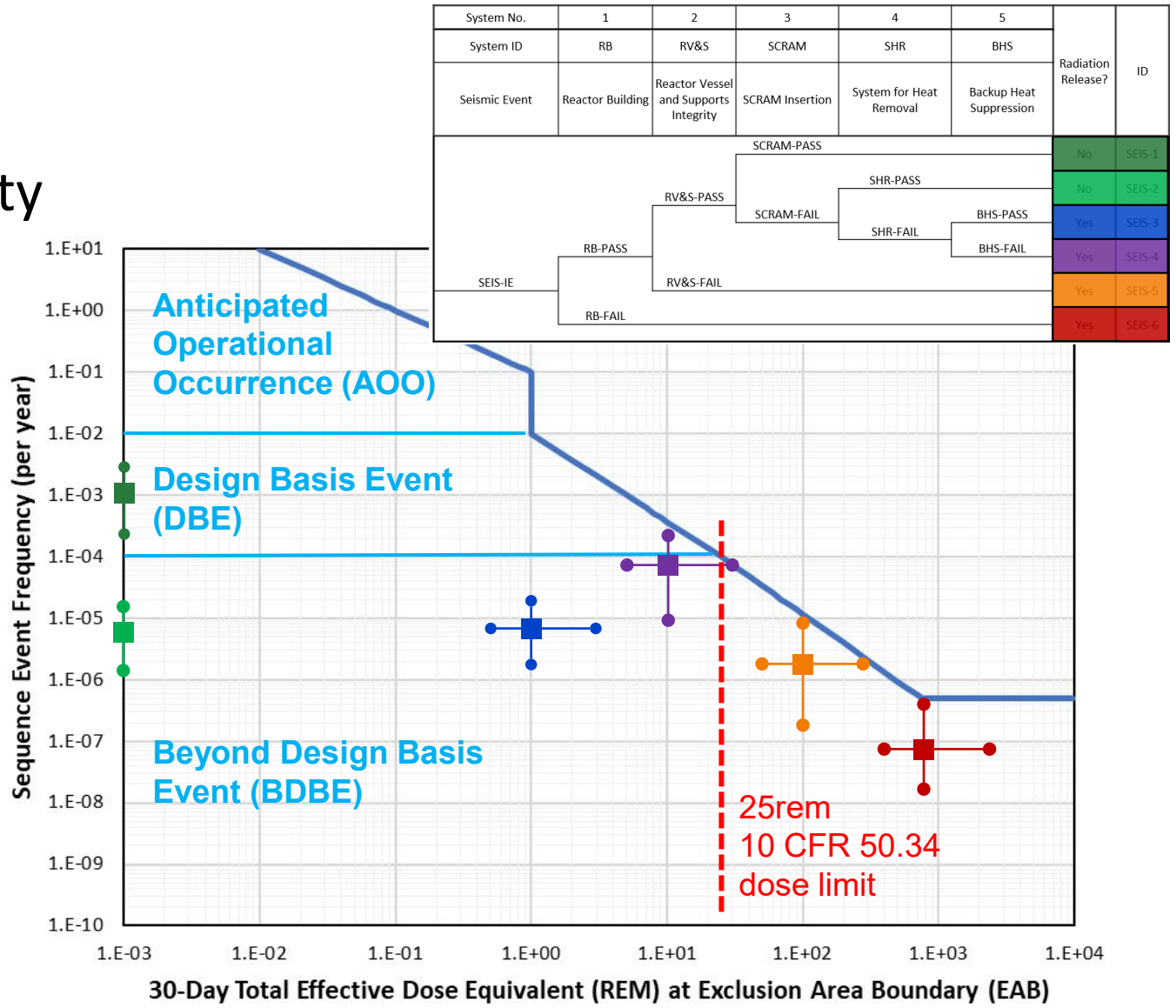
Frequency-Consequence – Revise Design

- Potential Design Revision Options
  - Reconsider the seismic design basis selected for SSCs
  - Impose additional or special requirements on SSC designs
  - Reclassify SSCs
  - Limit dose consequences by introducing barriers
  - A combination of the above options



Frequency-Consequence – Revised Design

- Selected Design Revisions
  - Limiting the demand-to-capacity ratio for RB, RV&S, and SCRAM
  - Best cost-benefit of several options considered
- Key Takeaway
  - LMP allows optimizing design for cost-benefit purposes as it progresses



LMP and RI Design for External Hazards – Insights

- Challenges
  - An initial PRA is needed at early RIPB design stages, which can be challenging since there is limited site-specific data and the early PRA insights may have high uncertainty
  - Implementing RIPB/LMP framework requires close collaboration between multiple technical disciplines in design and PRA teams
- Benefits
  - Risk-informed external hazards design can be used to risk-inform design requirements and holds potential to make plant designs more cost-effective, while maintaining high levels of safety
  - Risk-informed performance-based design considerations can inform the selection of codes and standards

Follow-Up Research

- Criteria for risk-informed codes & standards for structural design
  - Some Civil Standards already include performance-based criteria
    - ASCE/SEI 7-22, *Minimum Design Loads and Associated Criteria for Buildings and Other Structures*
    - ASCE/SEI 43-05, *Seismic Design Criteria for Structures, Systems, and Components in Nuclear Facilities*
  - For non-safety related (NSR) SSCs and non-safety related with special treatment (NSRST) SSCs, Commercial Standards could be used for structural design
  - For safety related (SR) SSCs, Nuclear Standards could be used for structural design for loadings associated with functions associated with Design Basis Events, and Commercial Standards for other loadings
    - For example, if the AR operates at atmospheric pressure, the reactor building safety function might be to provide shielding and avoid collapsing in a seismic or high wind event
- Criteria for construction QA
  - What criteria is necessary to support achieving the performance goals?

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