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Public Meeting on Possible Regulatory Process Improvements for Advanced Reactor Designs

September 28, 2017

Telephone Bridge
(888) 793-9929
Passcode: 7223761

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Public Meeting

- Telephone Bridge

  (888) 793-9929

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- Opportunities for public comments and questions at designated times

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Outline

- Introductions

  Summary of NRC Standards Forum
- Licensing Modernization Project
  - Follow up on PRA Approach Whitepaper
  - Safety Classification White Paper
- Lunch
- Advanced Reactor Design Criteria
- Policy Issues
  - Insurance
  - Functional Containment
- Public Comment Period

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NRC Standards Forum 2017

NRC Standards Forum 2017
September 26, 2017; 08:00 – 17:00

NRC Three White Flint North, HQ-3WFN-1C03
11601 Landsdown Street
Rockville, MD 20852
AGENDA

Time	Topic	Presenter
8:00 – 8:05	Welcome & Opening Remarks	Brian Thomas, NRC
8:05 – 8:30	NRC Standards Forum Overview	Tom Boyce, NRC
8:30 - 9:30	Summary Review of Standard Forum Activities - Report on 2016 Forum Action Items	NRC/NEI/ASME/ANS/IEEE
9:30-9:45	Break	
9:45:10:15	EPRI presentation - TBD	David Scott, EPRI
10:15-10:30	NEI Presentation - TBD	Stephen Kraft, NEI
10:30 - 11:30	Wrap up of Operating Reactor topics; Identification of codes/standards/topics that need "coalitions"	Shivani Mehta, NRC
11:30 - 12:30	Lunch (see handout for options)	
12:30-1:00	Update on NRC non-LWRs work	Amy Cubbage, NRC
1:00-1:15	NRC Staff involvement with codes and standards development related to non-LWRs	Shivani Mehta, NRC
1:15-1:45	DOE Perspectives	James Kinsey, INL
1:45-2:15	DOE/ASME Gap analysis	George Flanagan, ORNL
2:15-2:30	Break	
2:30-3:15	Risk-Informed Performance Based Discussions	Bill Reckley, NRC Prasad Kadambi,ANS
3:15-4:15	TWG report out on licensing and technical areas	Jake DeWitt, Oklo Farshid Shahrokhi, Areva Nick Smith, Southern Co
4:15-5:00	Wrap up of Advanced Reactor topics; Identification of codes/standards/topics that need "coalitions"	Tom Boyce, NRC

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Licensing Modernization Project

- Follow up on PRA Approach Whitepaper
  - White Paper – ML17158B543
  - NRC staff comments/questions - ML17233A187
- Safety Classification White Paper

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PRA Approach Paper Staff Comments/Questions

1) NRC staff participating in ASME/ANS Standard for Advanced Non-LWR PRA and planning to review for endorsement
2) Organization and relationships between PRA and LBE
3) PRA/LBE white paper relationships to efforts on advanced reactor design criteria (ARCD)
4) PRA within larger regulatory framework
5) Usefulness of PRA in design process beyond regulatory role of NRC

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PRA Approach Paper Staff Comments/Questions

6) Risk metrics and top level regulatory requirements to align with revisions to LBE white paper
7) Examples useful but specific discussions may need revised as broader concepts are addressed
8) Comparison/crosswalk between LWR PRA Standard and Non-LWR Standard would be helpful
9) Useful to understand role of PRA in broader regulatory framework
10) Standard approach for determining risk significance of non-LWR design features
11) Guidance for developing site parameter envelopes

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PRA Approach Paper
Staff Comments/Questions

12) Operational program for maintaining and updating PRA

13) Interactions between reactor and potential portions of facility for fuel/waste processing and storage

14) Use of large release frequency (LRF) and consideration of prevention/mitigation in addition to overall risks

15) Multi-unit or integrated risk included in ASME/ANS Standard or more immediate issue

16) Output Objectives – observations
    - ASME/ANS PRA Standard as vehicle
    - Issues - F/C figure, external events, MST
    - NRC focus – applications and pre-application interactions

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Licensing Modernization Project

Presentations

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Public Meeting

- Updates
- Public Questions / Comments
- Lunch Break
  - Meeting/Webinar will resume at 1:00pm

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Advanced Reactor Design Criteria

Discussions from Public Meeting

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Policy Issues

Policy Issues – nonLWRs (ongoing)	
Prototype	Draft issued, discussed Aug 3, plans are to incorporate into revision of roadmap document – topic at Nov meeting
Source Term, Dose Calculations, Siting	Future discussion of existing Commission Policy on siting in relation to population centers
Key SSC Design Issues	
Use of PRA	Licensing Modernization Project
Defense in Depth	
Licensing Basis Events	
Functional Containment	
Offsite EP	Final regulatory basis document to Commission
Insurance and Liability	On agenda for November 2 – preliminary discussion to prepare
Security	October 12 Public Meeting

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Policy Issues

Policy Issues – nonLWRs (ongoing)	
Fuel Qualification	Discussed Aug 3, plans to interact with technology working groups
Increased Enrichments	Awaiting paper
No current activities	
Annual Fees	Multi-module License Structure
Manufacturing License	Operator Staffing
Process Heat/Industrial Facilities	Operational Programs
Fuel Cycle Facilities (front end)	Module Installation During Operation
Waste Issues (back end)	Decommissioning Funding
	Aircraft Impact Assessments

Research/Test Reactor Guidance	*Awaiting paper*

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Insurance

- SECY-10-0034, "Potential Policy, Licensing, and Key Technical Issues for Small Modular Nuclear Reactor Designs"
- SECY-11-0178, "Insurance and Liability Regulatory Requirements for Small Modular Reactor Facilities"
  - Thermal Power vs Electrical Power
  - Multi-module with reactors < 100 Mwe
    - Comparative Analysis
- NEI Position Paper / ANS Special Committee / Other Assessments
- Periodic Report to Congress

> The Commission and the Secretary shall submit to the Congress by December 31, 2021, detailed reports concerning the need for continuation or modification of the provisions of this section, taking into account the condition of the nuclear industry, availability of private insurance, and the state of knowledge concerning nuclear safety at that time, among other relevant factors, and shall include recommendations as to the repeal or modification of any of the provisions of this section.

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Insurance

Problem Statement

Interactions between the NRC staff and stakeholders are intended to identify potential issues associated with requirements for financial protection to cover public liability claims for advanced reactor designs, and to subsequently identify relevant information or needed research/studies to resolve those issues. These activities will support developing recommendations for possible modifications, if warranted, to the Price-Anderson Act, NRC regulations or both.

An example of a previous report to Congress is NUREG/BR-6617, "The Price-Anderson Act – Crossing the Bridge to the Next Century: A Report to Congress"

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Functional Containment

- SECY Paper for FY 2018
- Identified in previous stakeholder meeting as a high-priority issue
- Outline
  - Background/history
  - Proposed Approach
    - Safety Function
    - Physical Building

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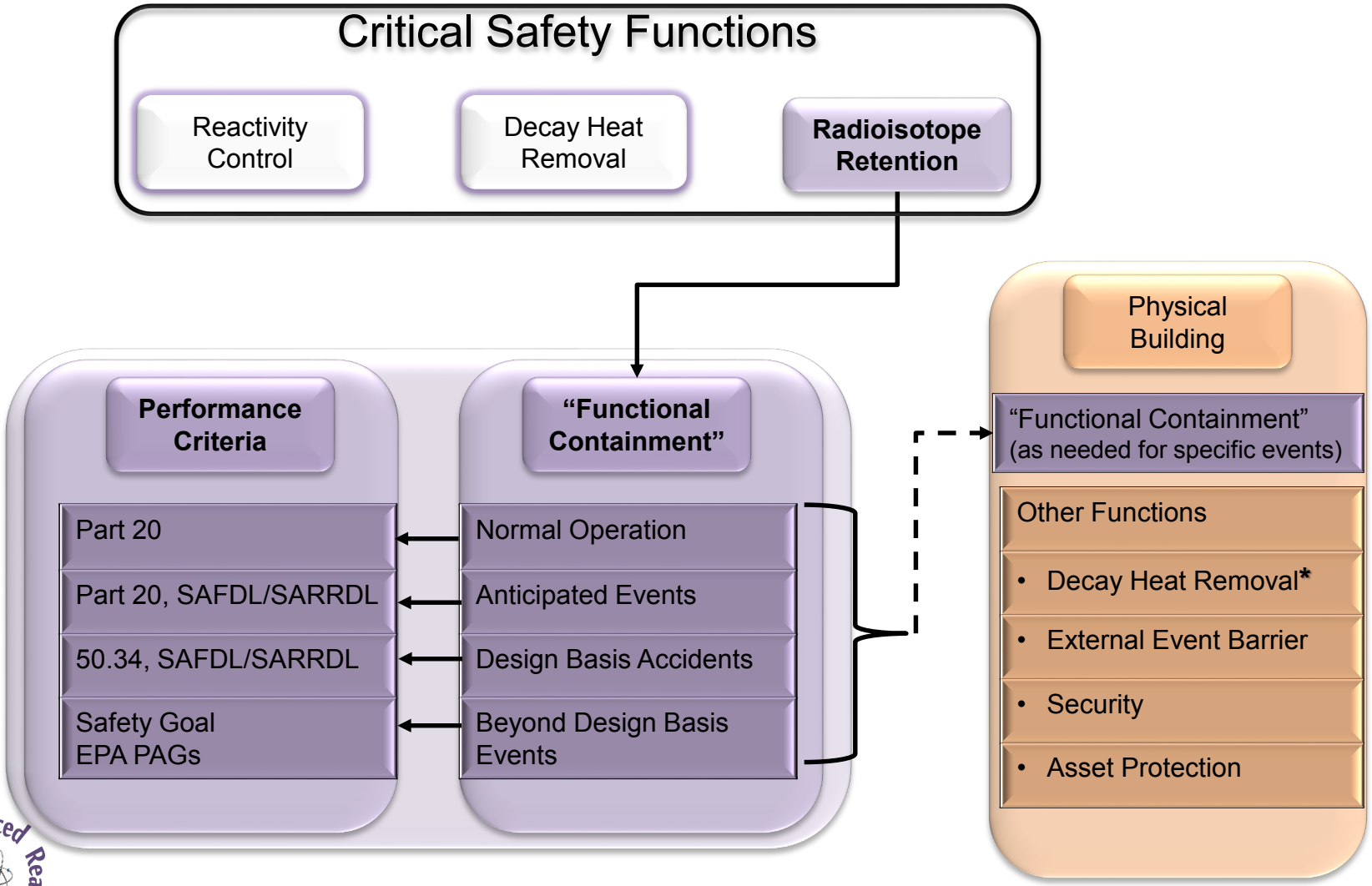
Functional Containment



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Future Meetings

Oct 12	Physical Security
Nov 2	Licensing Modernization – topics ?
	Insurance
	Roadmap, SDA, Prototype (draft in mid-Oct)
	"Functional Containment"
Dec 14	Licensing Modernization – topics ?
	Siting (populations)
	"Functional Containment"
	?
TBD	Physical Security
Feb 1	
Mar 22	NEI (Consolidated) RIPB Guidance

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Public Comments / Questions

Utility-Led Initiative for Licensing Modernization of Technical Requirements for Licensing of Non-Light Water Reactors

NRC Review of PRA and SSC White Papers

Karl Fleming, LMP Team

September 28, 2017 • USNRC, Rockville MD

Discussion Topics

- LMP Response to NRC comments on PRA Approach
- Introduction to LMP approach to SSC safety classification and performance requirements

NRC COMMENTS AND QUESTIONS ON LMP PRA WHITE PAPER

NRC PRA Review Topics and LMP Responses

1. NRC participation and plan to review and endorse non-LWR PRA standard.
   - Critical to successful implementation of LMP framework
2. Uses of non-DBA LBEs beyond LBE/DBA selection and evaluation
   - Technical basis for the risk inputs to selection of LBEs is integral to the PRA
   - Further analysis of non-DBA LBEs is used in SSC safety classification, DID evaluation, and other RIPB decisions

NRC PRA Review Topics and LMP Responses

3. Interface with ARDC
   - Pending regulatory guide for developing principal design criteria from ARDCs
   - Some guidance for developing reactor and design specific criteria in SSC white paper
   - RIPB process expected to be useful in establishing design-specific PDCs
4. Broader use of PRA in RIPB decisions
   - LMP agreement on PRA applications for LBE, SSC, and DID
   - Specific additional applications not considered within LMP scope

NRC PRA Review Topics and LMP Responses

5. Pre-application interactions including risk-informed design decisions
   - LMP general agreement
6. Alignment with LBE paper comments regarding TLRC and risk metrics
   - LMP general agreement
7. Limited NRC review of examples
   - LMP general agreement

NRC PRA Review Topics and LMP Responses

8. LWR/non-LWR PRA standard cross walk
   - Have color codes for existing standard identifying sources of requirements
   - Need to revisit for revised standard
9. Role of PRA in broader regulatory framework; Interface with consensus codes and standards
   - LMP objective to identify needs from supporting standards
   - Reliability and Integrity Management approach in ASME Section XI
   - LMP to address PRA role in SSC, DID, and integrated guidance document

NRC PRA Review Topics and LMP Responses

10. Risk significance of design features and SSCs
    - SSC paper to propose absolute TI risk metrics for this purpose
    - Topic to be addressed in revised non-LWR PRA standard per PRA pilot feedback
11. Guidance needed for site parameter envelope
    - Non-LWR PRA standard accommodates external hazard treatment for range of sites
12. Guidance needed for PRA maintenance and updates
    - Agree that PRA maintenance and update process will be required
    - Revisit RIPB decisions supported by PRA
    - Some aspects of this process addressed in SSC paper

NRC PRA Review Topics and LMP Responses

13. PRA and harmonization of non-reactor facilities and worker risk
    - Questions outside scope of non-LWR PRA Standard
    - Best addressed separately
14. Risk metrics questions: LRF, risk contributors; evaluation of prevention and mitigation balance
    - SSC paper defines risk significance for SSCs and LBEs
    - LBE, SSC, and DID papers discuss roles of SSCs in prevention and mitigation
    - Need for LRF is preempted by requirements for dose

NRC PRA Review Topics and LMP Responses

15. Integrated site risk
    - Non-LWR PRA Standard and LMP framework address multi-module plant risk for advanced reactor applicants
16. Observations regarding PRA paper outcome objectives
    - LMP acknowledges that full realization of outcome objectives will require resolution of identified issues, successful completion of a revised and endorsed PRA standard

LMP SSC SAFETY CLASSIFICATION APPROACH

LMP SSC Paper Scope

- Complete the process of SSC safety classification started in LBE paper
- Describe proposed approach to the definition of **risk significant** SSCs and LBEs
- Describe proposed approach for defining **safety significant** SSCs in terms of their risk significance and role in supporting defense-in-depth (DID), and
- Provide guidance for the development of
  - functional design criteria (FDC)
  - performance requirements for the reliability and capability of SSCs in the prevention and mitigation of licensing basis events (LBEs)
  - special treatment requirements

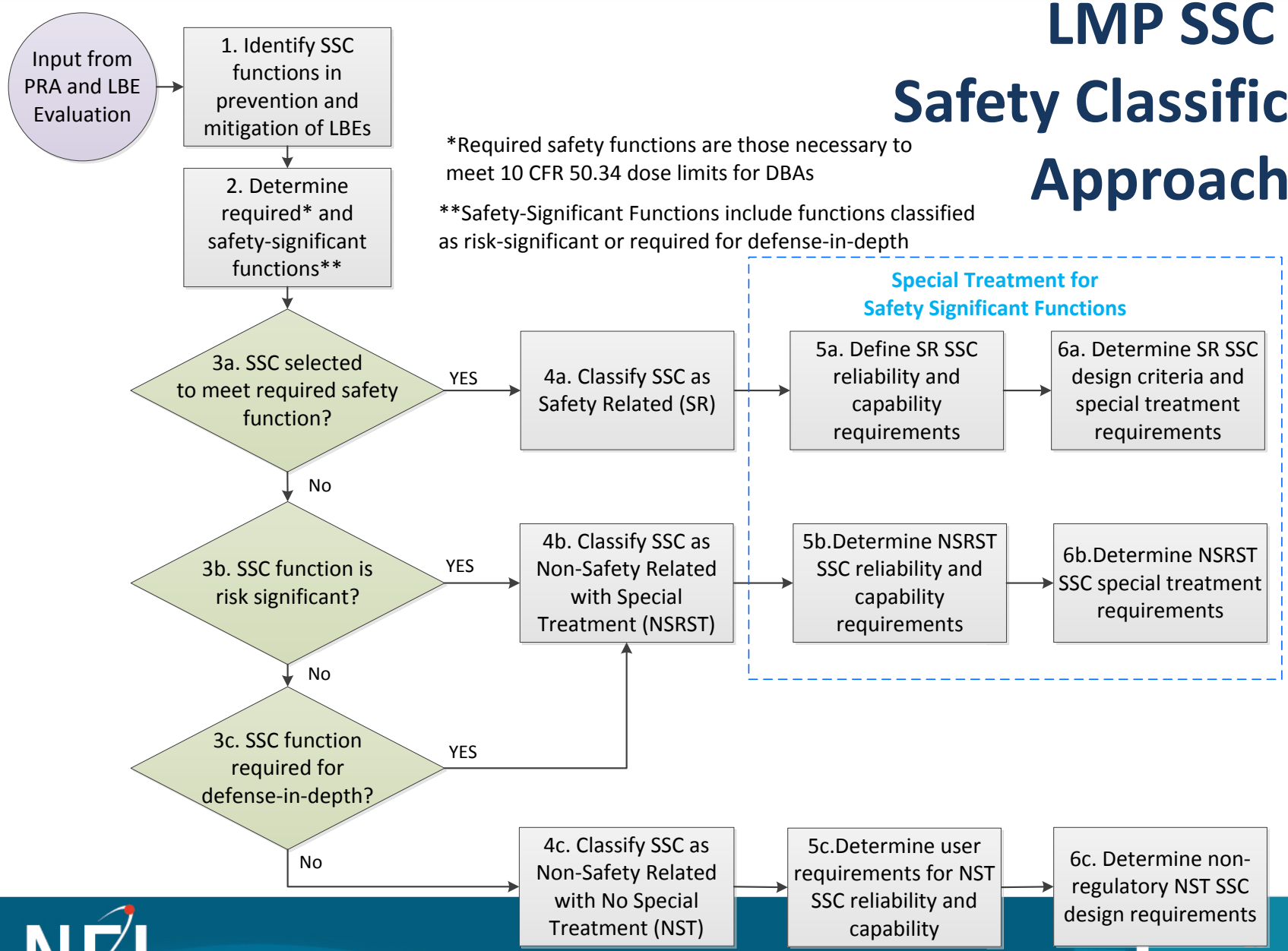
SSC Safety Classification Attributes

- 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

SSC Approach Highlights

- Adopts three SSC safety classification categories in NGNP SSC white paper
- Proposes criteria for SSC risk significance based on absolute risk metrics
- Incorporates elements from 10 CFR 50.69 and NEI-00-04 in the context of a “forward fit” process
- Includes SSC requirements to address single and multi-module risks
- Expands on guidance for special treatment* requirements beyond that in NGNP SSC white paper
  - *Terminology TBD

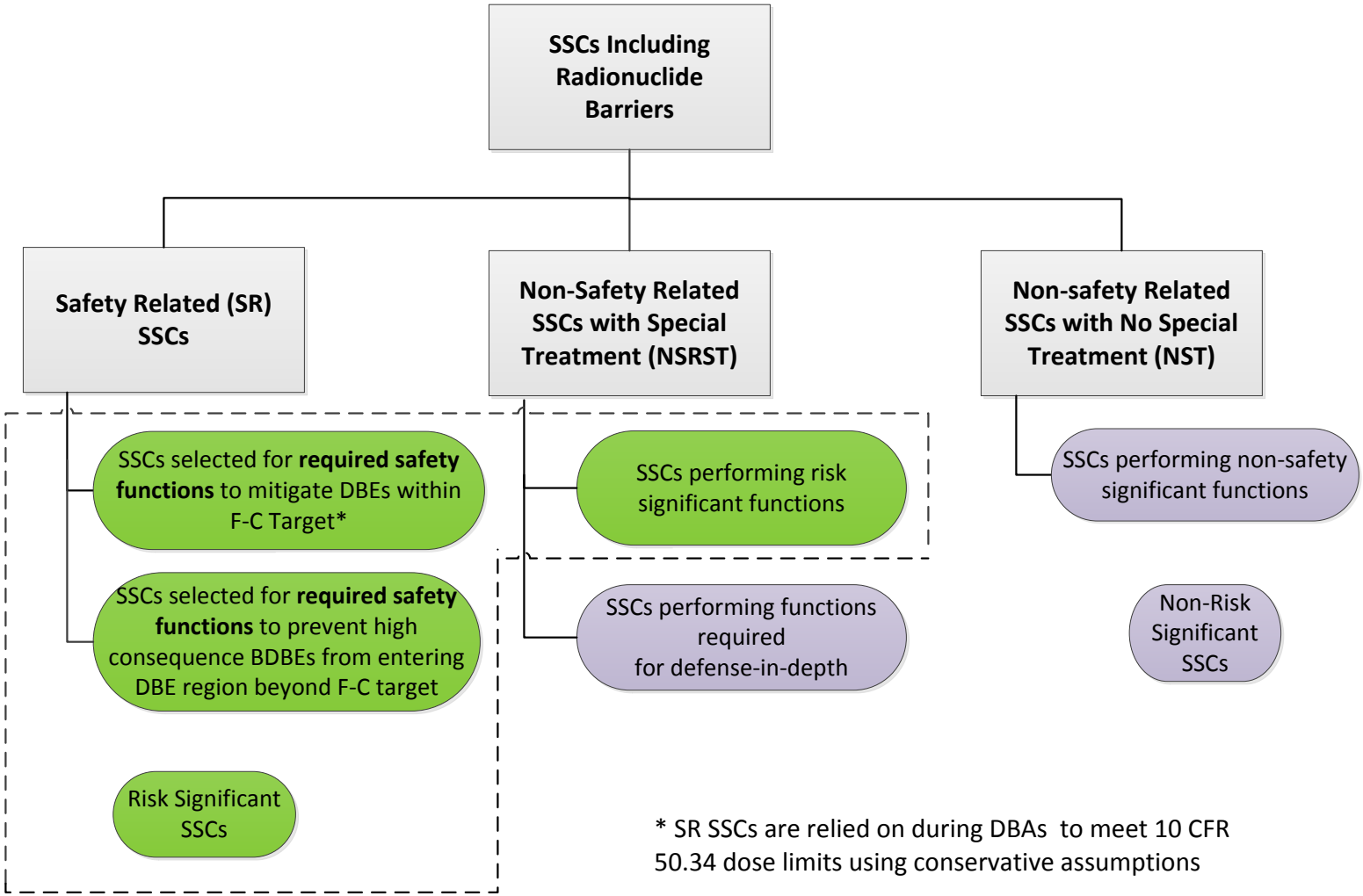
LMP SSC Safety Classification Approach



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.

LMP Proposed SSC Safety Categories

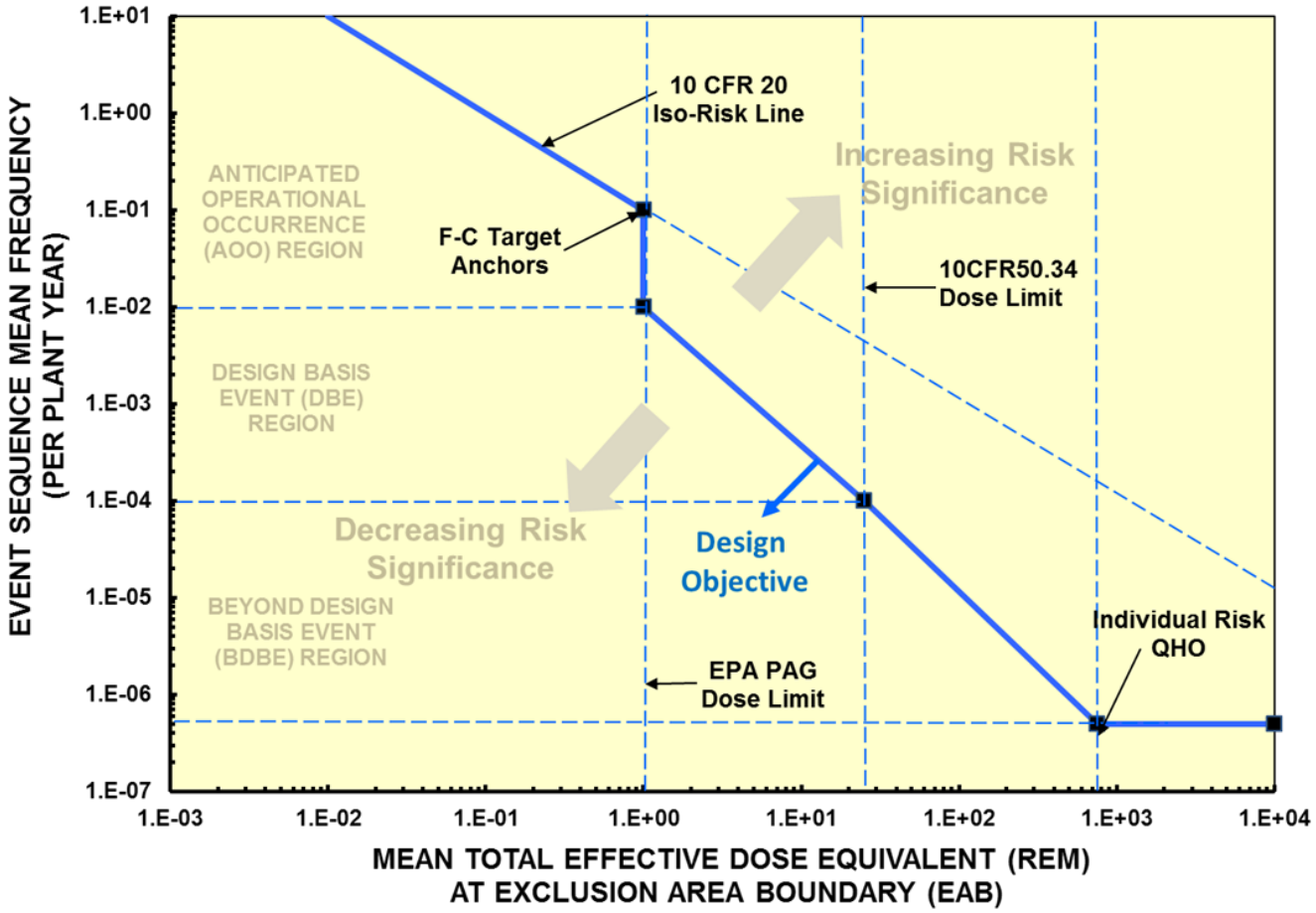


* SR SSCs are relied on during DBAs to meet 10 CFR 50.34 dose limits using conservative assumptions

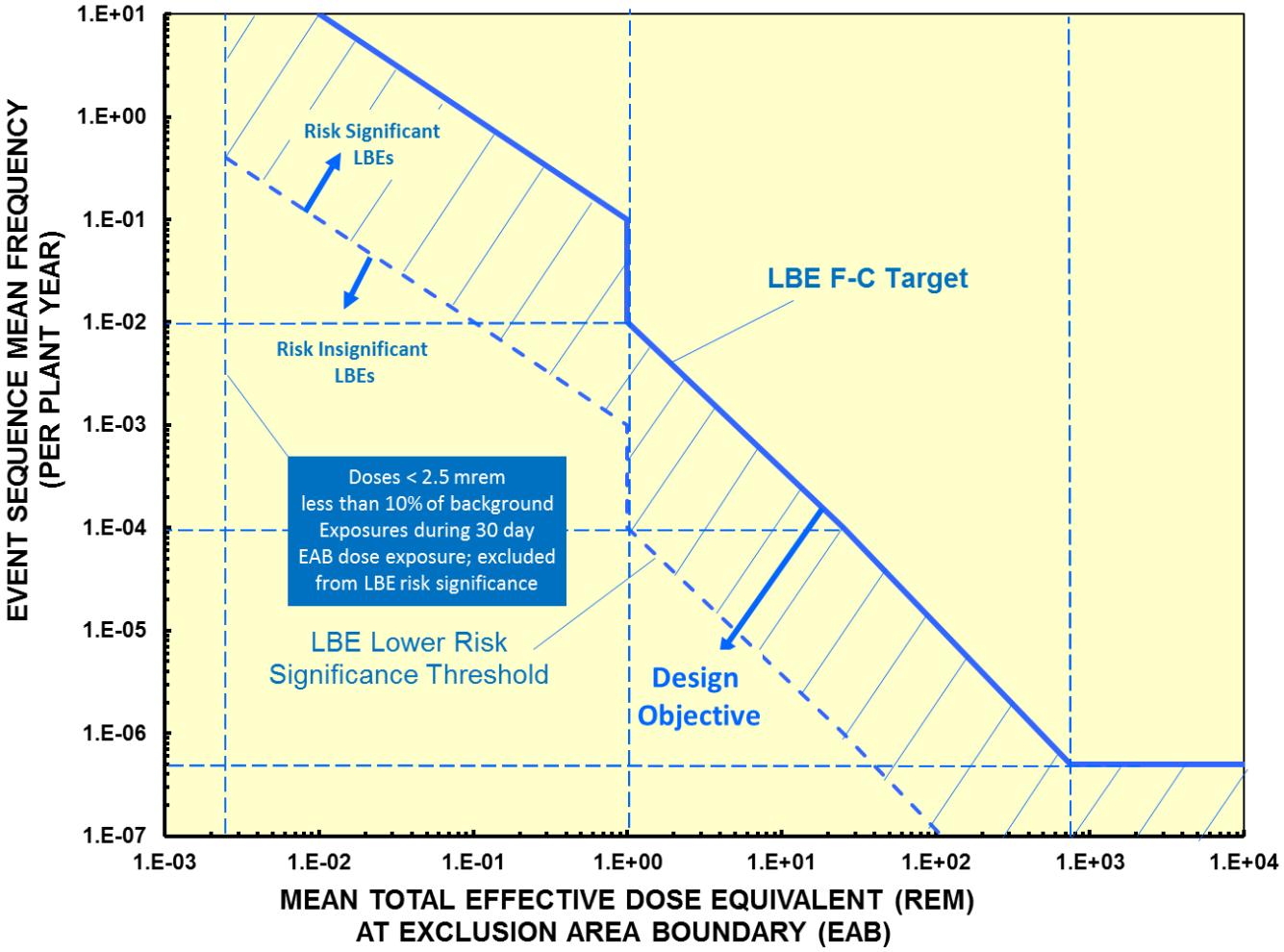
SSC Risk Significance

- **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)

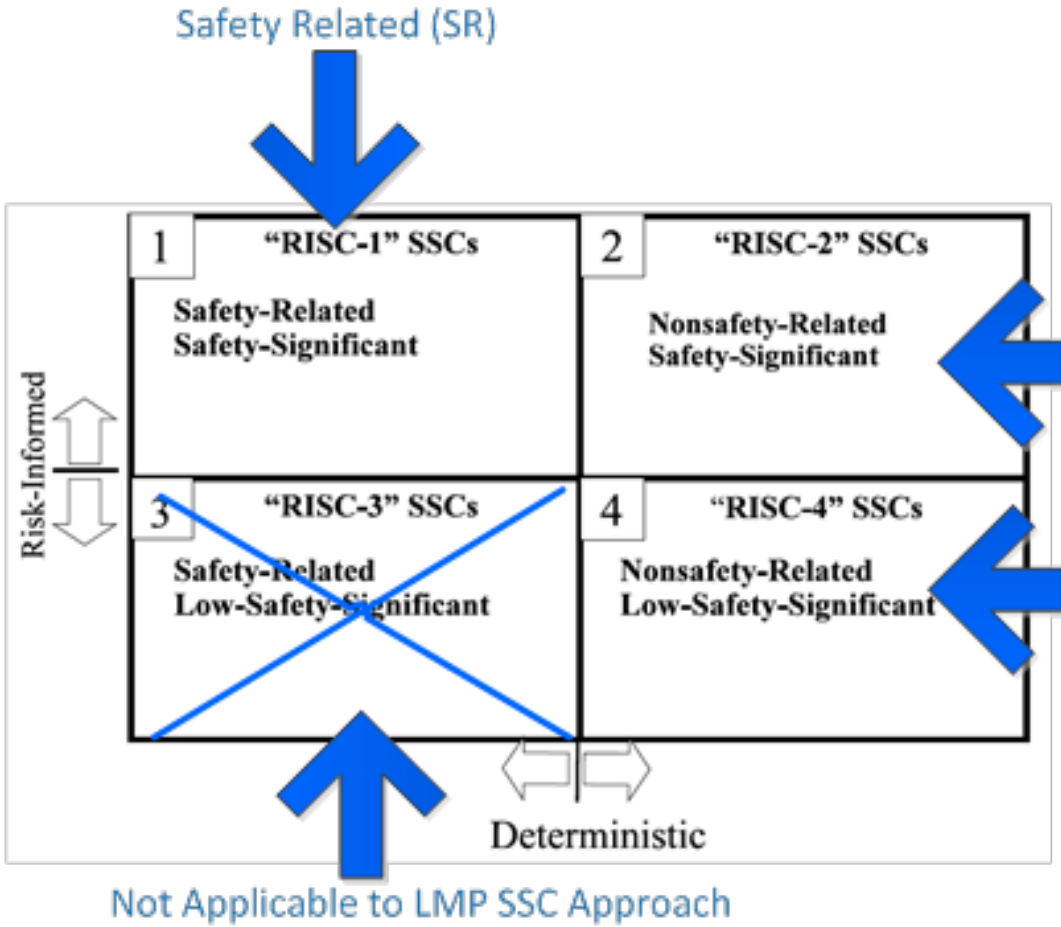
LMP Frequency-Consequence (F-C) Target



Risk Significant LBEs



Comparison of LMP and 10 CFR 50.69 SSC Safety Categories



*Terminology TBD

Derivation of Special Treatment Requirements

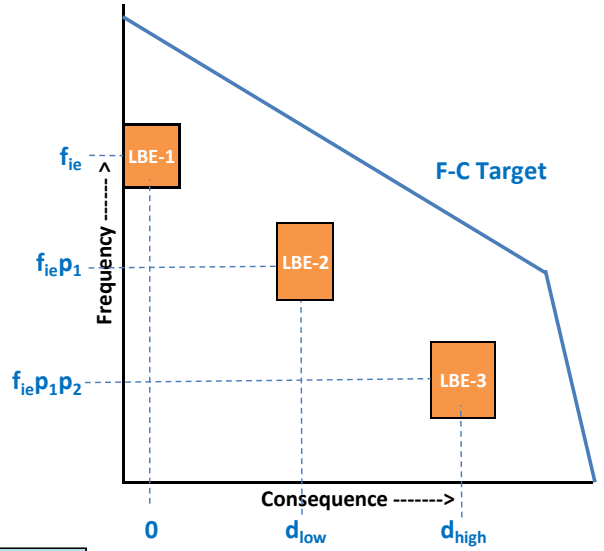
- SR SSCs
  - Functional Design Criteria (SRDC) derived from required safety functions
  - Lower level design criteria derived from SRDC
- SR and NSRST SSCs
  - SSC reliability and capability performance targets
  - Focus on prevention and mitigation functions from LBEs
  - Integrated decision making process to derive specific special treatment requirements
  - Incorporates guidance from 10 CFR 50.69 and NEI-00-04 from existing reactors from a “forward fit” perspective
  - Incorporates Commission’s expectations for risk-informed and performance based regulation from SRM to SECY 98-0144

MHTGR Representative Functional Design Criteria

Required Safety Function	Safety Related Design Criteria
Retain Radionuclides in Fuel Particles	I The reactor fuel shall be designed, fabricated, and operated in such a manner that minor radionuclide releases from the fuel to the primary coolant will not exceed acceptable values.
Control Chemical Attack	II The vessel and other components that limit or prevent the ingress of air or water shall be designed, fabricated and operated in such a manner that the amount of air or water reacting with the core will not exceed acceptable values.
Control Heat Generation	III The reactor shall be designed, fabricated, and operated in such a manner that the inherent nuclear feedback characteristics will ensure that the reactor thermal power will not exceed acceptable values. Additionally, the reactivity control system(s) shall be designed, fabricated and operated in such a manner that during insertion of reactivity, the reactor thermal power will not exceed acceptable values.
Control Heat Removal	IV The intrinsic dimensions and power densities of the reactor core, internals, and vessel, and the passive cooling pathways from the core to the environment, shall be designed, fabricated and operated in such a manner that the fuel temperatures will not exceed acceptable values.
Limit Fuel Oxidation	XII The primary system/boundary shall be designed and fabricated to a level of quality that is sufficient to ensure high reliability of the primary system/boundary integrity needed to prevent air ingress during normal and off-normal conditions. The plant shall be designed, fabricated, operated, and maintained in a manner that ensures that the primary system boundary design limits are not exceeded.

Roles of SSC Capability and Reliability in Prevention and Mitigation of Accidents

IE, Initiating Event	SSC_1 Prevents Fuel Damage?	SSC_2 Limits Release?	LBE	End State	Frequency	Dose
f_{ie}	*Yes*		1	No fuel damage or release	f_{ie}	0
	p_1 *No*	*Yes*	2	Fuel damage w/ Limited release	$f_{ie}p_1$	d_{low}
		p_2 *No*	3	Fuel Damage w/ large release	$f_{ie}p_1p_2$	d_{high}



SSC	LBEs	Function	SSC Performance Attribute for Special Treatment
IE	1,2,3	Prevent initiating event	Reliability of SSC causing initiating event
SSC_1	1	Mitigate initiating event	Capability to prevent fuel damage
	2	Prevent fuel damage	Reliability of mitigation function
	3	Help prevent large release	Reliability of mitigation function
SSC_2	2	Mitigate fuel damage	Capability to limit release from fuel damage
	3	Prevent Large release	Reliability of mitigation function

SSC Classification Summary

- LMP retains the NGNP SSC safety categories of SR, NSRST, and NST
- All safety significant SSCs classified as SR or NSRST
- Absolute risk metrics proposed for SSC and LBE risk significance
- All SR SSCs are classified as risk significant
- NSRST SSCs include other risk significant SSCs and SSCs requiring some special treatment for DID adequacy
- Specific special treatment for capabilities and reliabilities in the prevention and mitigation of accidents
- Special treatment defined via integrated decision panel using “forward fit” 10 CFR 50.69 process

Questions?

BACK-UP SLIDES

Categories of LBEs

- LBEs include all the events used to develop design bases and licensing requirements. They cover a comprehensive spectrum of events from normal operation to rare, off-normal events.
- There are four categories of LBEs:
  - **Anticipated Operational Occurrences (AOOs**) encompass planned and anticipated events. 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**) encompass unplanned off-normal events not expected in the plant's lifetime, but which might occur in the lifetimes of a fleet of plants. The radiological doses from DBEs are required to meet accident public dose requirements. DBEs are the basis for the design, construction, and operation of the structures, systems, and components (SSCs) during accidents.
  - **Beyond Design Basis Events (BDBEs**) are rare off-normal events of lower frequency than DBEs. 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 deterministically derived from the DBEs by assuming that only SSCs classified as safety-related are available to mitigate the consequences. The conservatively estimated dose of each DBA must meet the 10 CFR §50.34 consequence limit at the Exclusion Area Boundary (EAB).

Process For Selecting and Evaluating LBEs