Licensing Modernization Project

SSC Safety Classification and Performance Requirements for Advanced Non-LWRs

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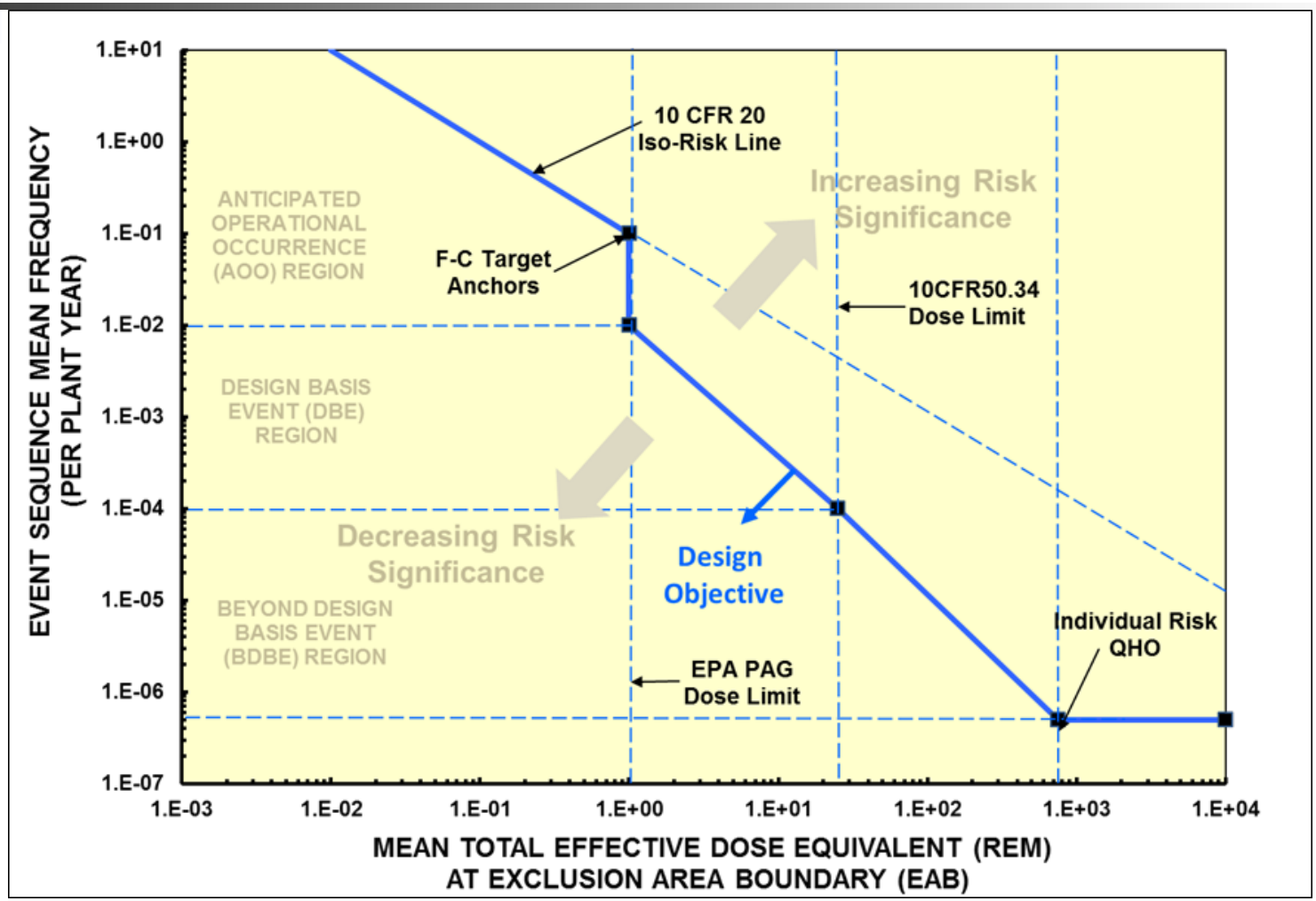
SSC Approach Highlights

- Adopts three SSC safety classification categories in NGNP SSC white paper
- Proposes criteria for SSC risk significance based on absolute risk metrics
- Incorporates concepts from 10 CFR 50.69 and NEI-00-04 in the context of a "forward fit" process
- SSC safety classes and performance requirements linked to LBEs
- Includes SSC requirements to address single and multi-module risks
- Expands on guidance for deriving performance requirements beyond those in NGNP SSC white paper
- Selection of special treatment requirements linked to evaluation of defense-in-depth adequacy

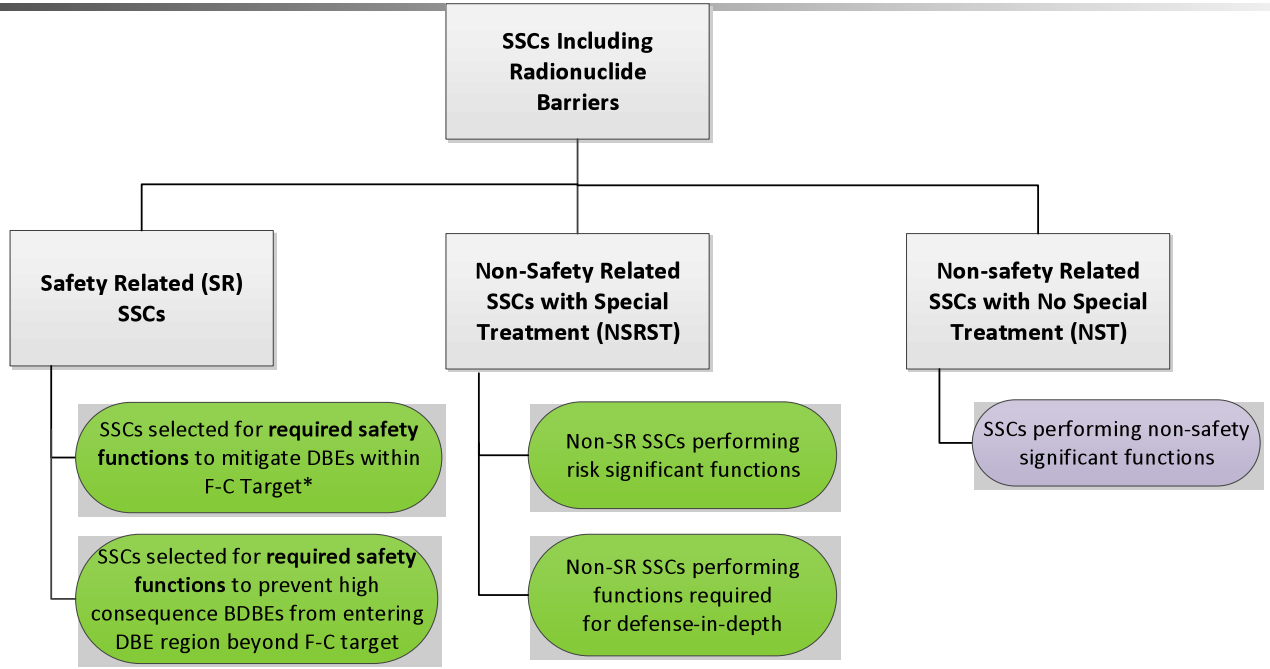
LMP Proposed SSC Safety Categories

- **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.

Frequency-Consequence Target



LMP Proposed SSC Safety Categories

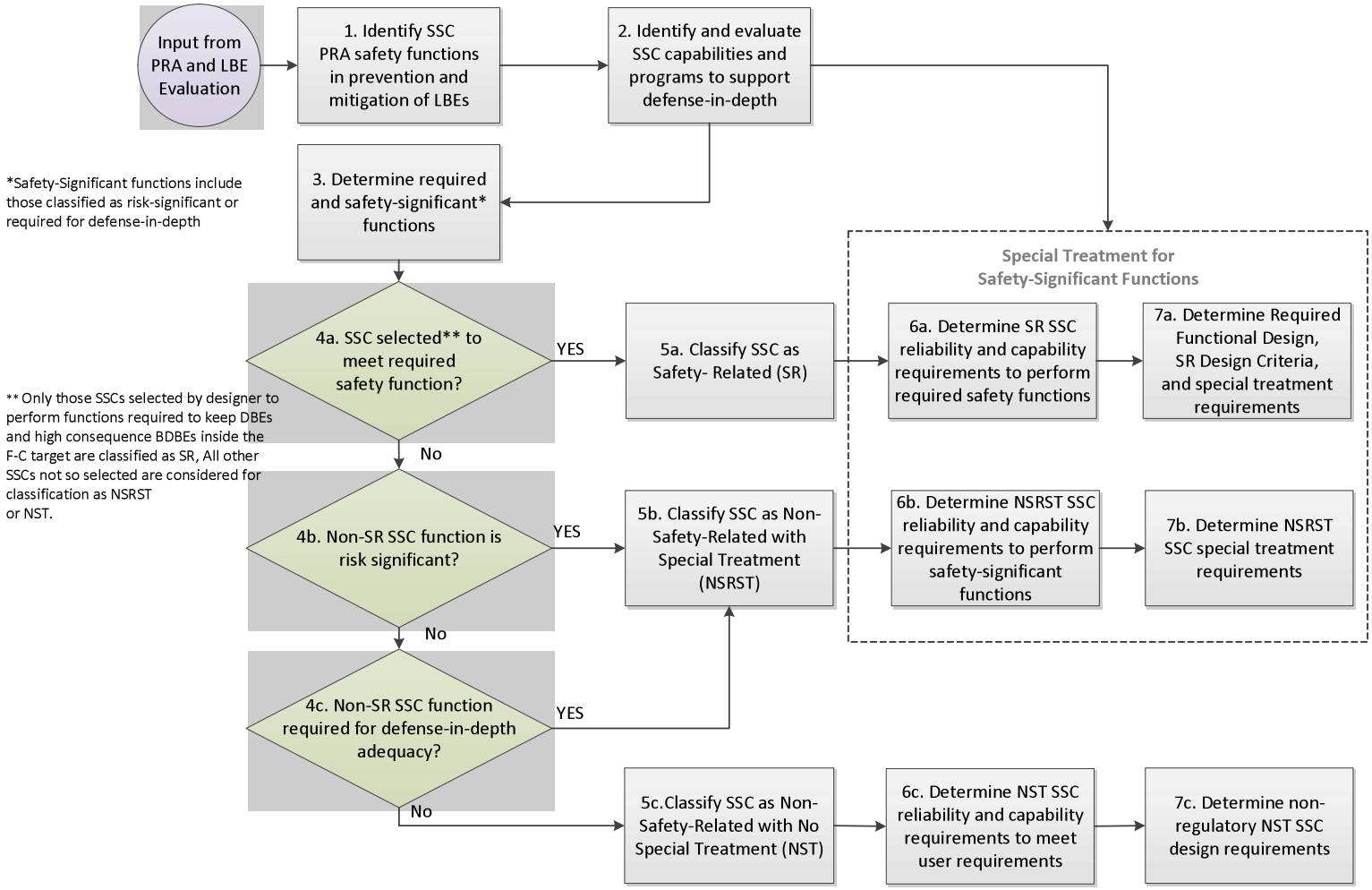


* SR SSCs are also relied on during DBAs to meet 10 CFR 50.34 dose limits using conservative assumptions

Safety Significant SSCs

Non-Safety Significant SSCs

LMP SSC Safety Classification Approach



SSC Risk Significance Criteria

- **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)

SSC Hierarchy

Derivation of Special Treatment Requirements

- SR SSCs
  - Functional Design Criteria 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
  - Reflects concepts from 10 CFR 50.69 and NEI-00-04 from existing reactors from a "forward fit" perspective
  - Reflects Commission's expectations for risk-informed and performance based regulation from SRM to SECY 98-0144

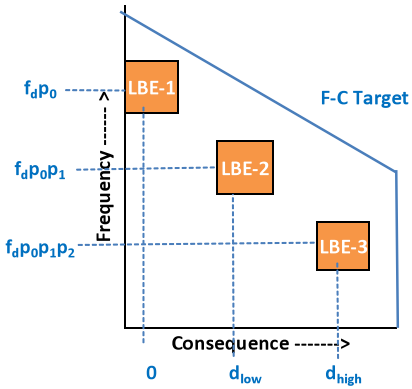
MHTGR Required Functional Design Criteria Examples

Required Safety Function	Functional 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.
Control with Movable Poisons	V: Two independent and diverse sets of movable poison equipment shall be provided in the design. Either set shall be capable of limiting the heat generation of the reactor to acceptable levels during off-normal conditions.
Shutdown Reactor	VI: The equipment needed to sense, command, and execute a trip of the control rods, along with any necessary electrical power, shall be designed, fabricated, and operated in such a manner that reactor core shutdown is assured during off-normal conditions.

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

Plant Distrubance	Plant features prevent Inititating event?	SSC_1 Prevents Fuel Damage?	SSC_2 Limits Release?	LBE	End State	Defense-in-Depth Layers Challenged [1]	Frequency	Dose
f_d	Yes			N/A	Disturbance controlled with no plant trip	Layer 1	f_d	0
	p_0 No	Yes		1	No fuel damage or release	Layer 2	$f_d p_0$	0
		p_1 No	Yes	2	Fuel damage w/ limited release	Layer 3	$f_d p_0 p_1$	d_{low}
			p_2 No	3	Fuel Damage w/ un-mitigated release	Layers 4 and 5	$f_d p_0 p_1 p_2$	d_{high}

[1] See Figure 2-4 for definition of defense-in-depth layers



SSC	LBEs	Function	SSC Performance Attribute for Special Treatment
Plant	N/A	Prevent initiating event	Reliability of plant features preventing 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 unmitigated release	Reliability of mitigation function

SSC Classification and Special Treatment 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