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RIPB Aspects in Part 53 Draft Rule Package

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October 28, 2022

Traditional – Safety Case

Key elements of the "safety case"

- Anticipated Operational Occurrences
  - Challenge for Reactor Protection System
  - Safety Limits for Cladding & Reactor Coolant System
- Design Basis Accident (e.g., loss of coolant)
  - Cladding Acceptance Criteria
  - Challenge for Containment Structure
- Conservative Source Term (TID-14844; 1962)
  - Offsite Consequences
  - Siting
- Additional requirements added (e.g., SBO, ATWS) based on operating experience and risk insights

EVENT FREQUENCY RANGE (per reactor-year)	PLANT CONDITIONS CATEGORIES	OTHER CATEGORIZATION SCHEMES: NRC 10 CFR	NRC RG 1.48 ASME Code*	NRC RG 1.70 Rev. 2	ANS 51.1 (N18.2)	ANS 52.1 (N212)	ANS 53.1 (N213)
Planned Operations	PC-1	Normal	Normal	Normal	Condition I	Normal PPC	Plant Condition A
	PC-2	Anticipated Operational Occurrences	Upset	Moderate Frequency	Condition II	Frequent PPC	Plant Condition B
10^{-1}	PC-3			Infrequent Incidents	Condition III		
10^{-2}	PC-4	Accidents	Emergency	Limiting Faults	Condition IV	Infrequent PPC	Plant Condition C
10^{-3}							
10^{-4}	PC-5		Faulted			Limiting PPC	Plant Condition D
10^{-5}							
10^{-6}	Not Considered						

*This terminology has been eliminated from 1977 version of the ASME Code.

a. Consider events that can result in the basic parameter changes listed below and identify potential limiting events:

Increase of core reactivity,
Changes of reactor coolant flow,
Changes of reactor coolant pressure,
Changes of reactor coolant temperature,
Changes of reactor coolant inventory,
Changes in energy supplies to the plant,
Changes in coolant supplies to the plant,
Changes in the nuclear safety-related equipment status,
Changes in core power distribution,
Changes in radioactive releases, or
Changes of any other variable that has a limiting value.

ANSI/ANS-51.1-1983; nuclear safety criteria for the design of stationary pressurized water reactor plants (withdrawn 1989)

New Reactors – Part 52

Key elements of the "safety case"

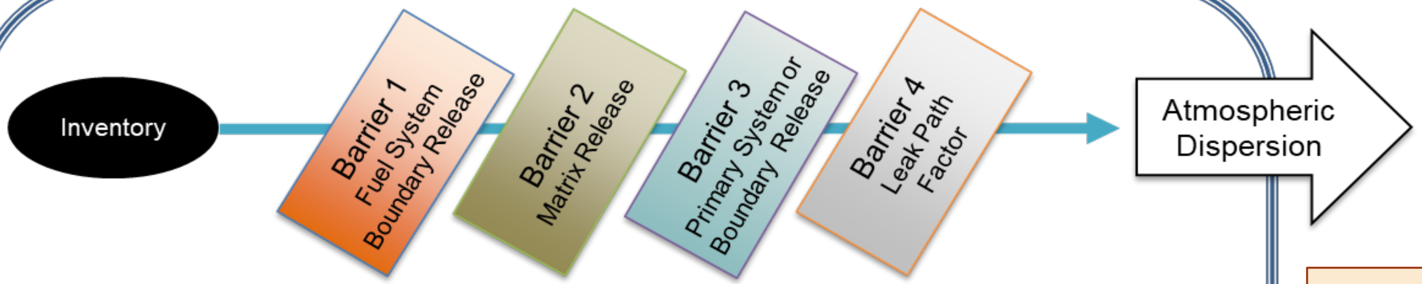
- Anticipated Operational Occurrences
- Design Basis Accident (e.g., loss of coolant)
- Alternate Source Term (NUREG-1465; 1995)
- Additional requirements
  - Probabilistic Risk Assessment
  - Severe Accident Design Features
  - Aircraft Impact Assessment

Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition — Severe Accidents (NUREG-0800, Chapter 19)	
Section	Title
19.0	Probabilistic Risk Assessment and Severe Accident Evaluation for New Reactors
19.1	Determining the Technical Adequacy of Probabilistic Risk Assessment Results for Risk-Informed Activities
19.2	Review of Risk Information Used to Support Permanent Plant-Specific Changes to the Licensing Basis: General Guidance
19.3	Regulatory Treatment of Non-Safety Systems (RTNSS) for Passive Advanced Light Water Reactors
19.4	Strategies and Guidance to Address Loss-of-Large Areas of the Plant Due to Explosions and Fires
19.5	Adequacy of Design features and functional capabilities identified and described for withstanding Aircraft Impacts

See NUREG-0800, "Standard Review Plan … (LWR Edition)"

Considering first principles *(technology-inclusive)*

Recent NRC activities related to advanced reactors (e.g., functional containment performance criteria, possible changes to emergency planning & security, and DG-1353) recognize the limitations of existing LWR-related guidance, which requires a return to first principles such as fundamental safety functions supporting the retention of radionuclides



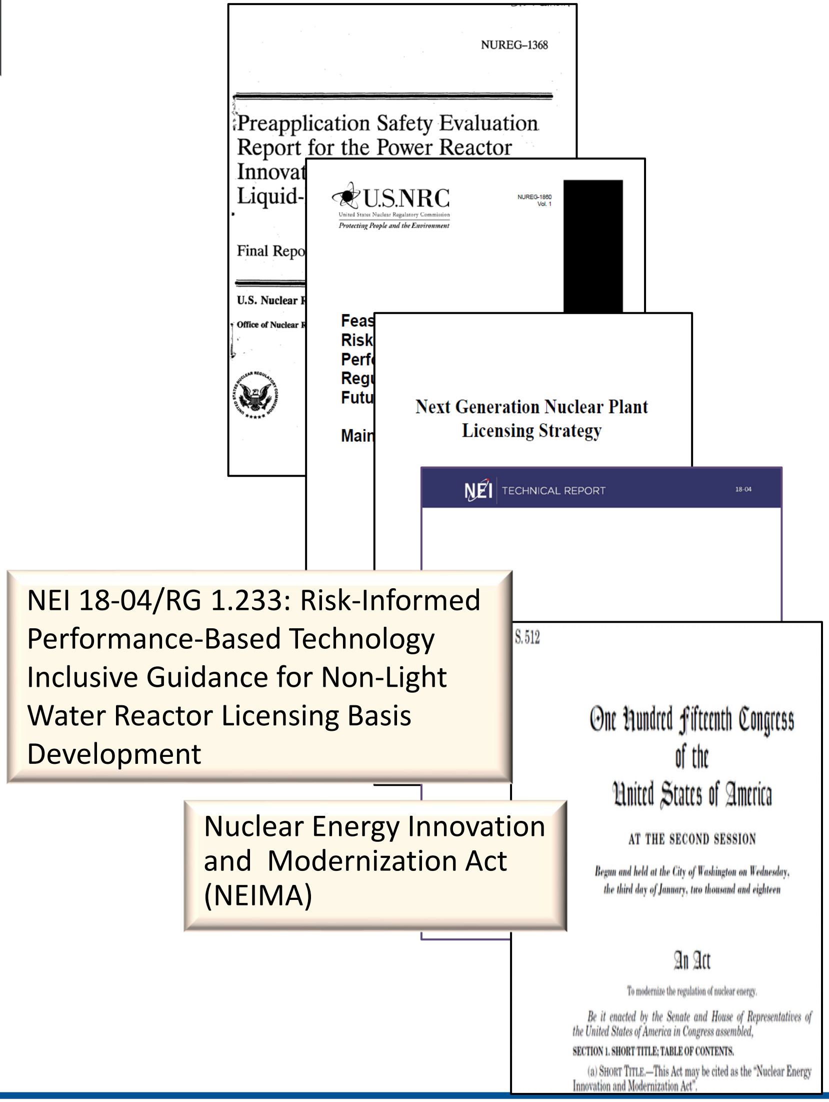
$$\underbrace{I(RN_j)}_{\text{Initial inventory}} \cdot \underbrace{F(S_i,t) \cdot MR(S_i,RN_j,t) \cdot PSR(S_i,RN_j,t) \cdot LPF(S_i,RN_j,t)}_{\text{Factors that determine how much of the inventory is released across a given barrier and thus persists to the source term}} = ST(S_i,RN_j,t)$$

Each factor is, in turn, a function of its initial design characteristics (e.g., materials), operating conditions (e.g., burnup, aging) and *transient/accident conditions (e.g., time, temperatures, pressures, chemistry)*.

See: SECY-18-0096, “Functional Containment Performance Criteria for Non-Light-Water-Reactors,”
SECY-19-0117, “Technology-Inclusive .. Methodology to Inform the Licensing Basis..,” and INL/EXT-20-58717, “Technology-Inclusive Determination of Mechanistic Source Terms for Offsite Dose-Related Assessments for Advanced Nuclear Reactor Facilities”

Licensing Modernization (LMP)

- Methodology evolved from 1980s approach developed for MHTGR and related preapplication reports following the release of the NRC's Advanced Reactor Policy Statement
  - Policy Statement encourages design attributes such as passive systems, increased thermal capacities, reduced reliance on operator actions
- Further developed as part of Next Generation Nuclear Plant (NGNP) program and related efforts such as issuance of ANS 53.1, "Nuclear safety design process for modular helium-cooled reactor plants"
- More recently used as basis for licensing modernization project (LMP) and issuance of NEI 18-04, " Modernization of Technical Requirements for Licensing of Advanced Non-Light Water Reactors" as endorsed by Regulatory Guide 1.233
- Currently providing a basis for developing a technology-inclusive, risk-informed regulatory framework for advanced reactors (Part 53)



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Part 53 Licensing Frameworks

Subpart A - General Provisions

Rule Package (ML22272A034)

Subpart B - Safety Requirements
Subpart C - Design Requirements
Subpart D - Siting
Subpart E - Construction/Manufacturing
Subpart F - Operations
Subpart G - Decommissioning
Subpart H – Application Requirements
Subpart I - License Maintenance
Subpart J - Reporting
Subpart K - Quality Assurance

Framework A

- Probabilistic Risk Assessment (PRA)-led approach
- Functional design criteria

Subpart N - Siting
Subpart O - Construction/Manufacturing
Subpart P - Operations
Subpart Q - Decommissioning
Subpart R - Application Requirements
Subpart S - License Maintenance
Subpart T - Reporting
Subpart U - Quality Assurance

Framework B

- Traditional use of risk insights
- Principal design criteria
- Includes an AERI approach

Framework A

General Construct (Subpart B)

Additional discussion in Preamble on how several performance measures used within Framework A. **Including the QHOs as one of several performance measures does not equate to the QHOs defining adequate protection of public health and safety.***

*Existing Paradigm
- Does not specifically define "adequate protection" but compliance with NRC regulations and guidance may be presumed to assure adequate protection at a minimum
- Additional requirements as necessary or desirable to protect health or to minimize danger to life or property

Safety Objectives & Criteria

No immediate threat & consider potential risks

§ 53.210 Safety criteria for DBAs
§ 53.220 Safety criteria for other LBEs
- Address LBEs and provide defense in depth
- Cumulative risks (QHOs)

§ 53.450(e) Evaluation criteria for each LBE or event category

Example § 53.450(e) evaluation criteria

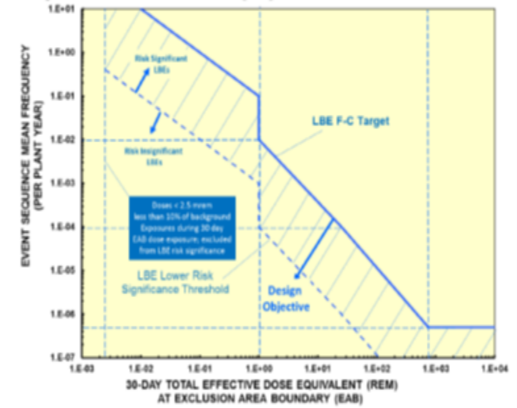

Figure 3-4. Use of the F-C Target to Define Risk-Significant LBEs

Licensing Modernization Project (LMP)

Safety Criteria

What function(s) (e.g., a barrier, cooling) are needed to satisfy safety criteria

Safety Functions

What design features (e.g., a structure, system) are provided to fulfill the safety function(s)

Design Features (and Human Actions)

What design criteria (e.g., leak rate, cooling capacity) are needed for design feature

Functional Design Criteria (Personnel; Concept of Operations)

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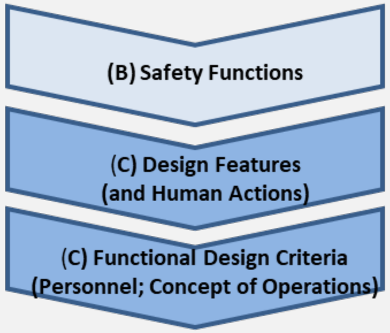
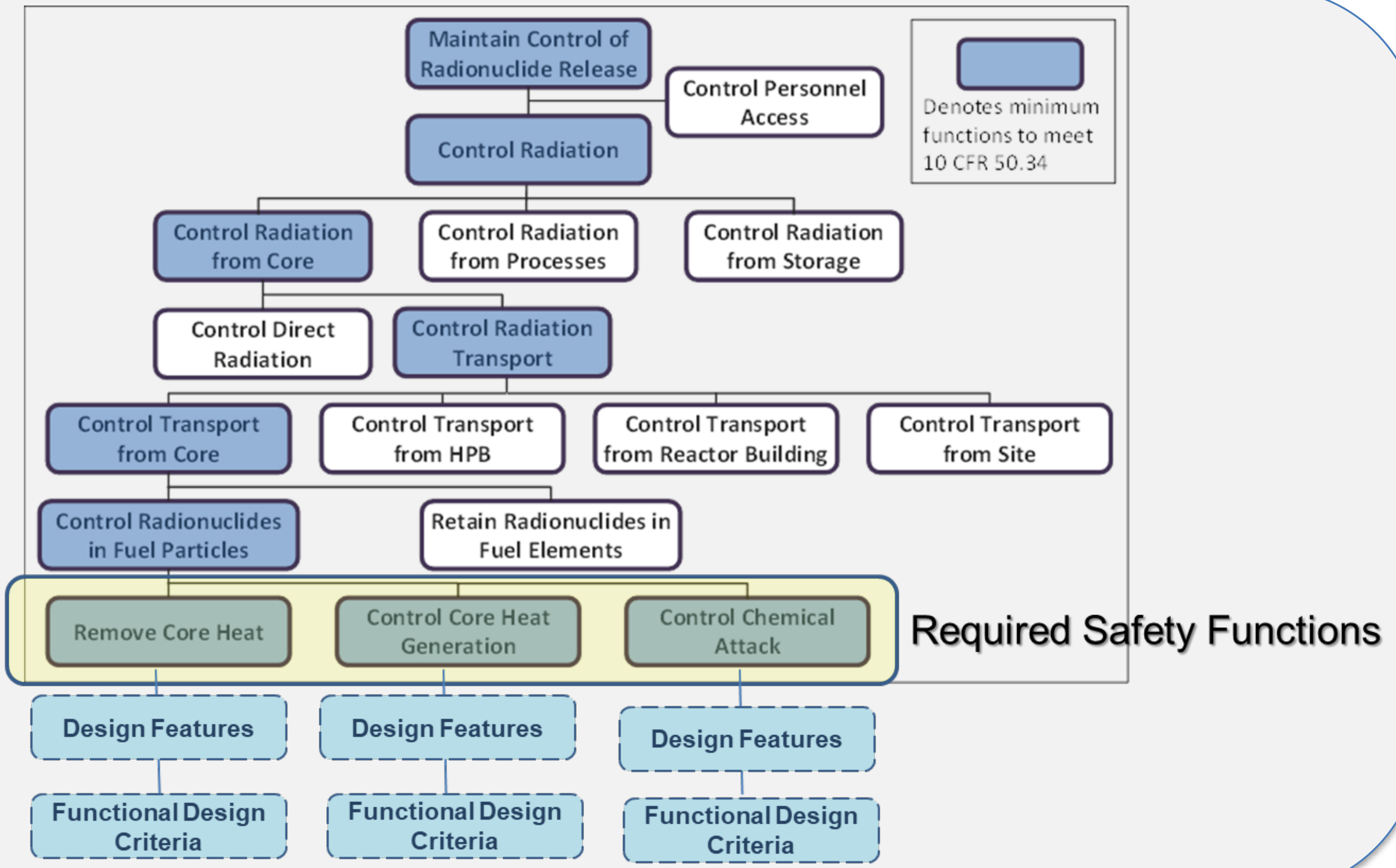
MHTGR (NGNP) Example

Similar to Objectives Hierarchy described in NUREG/BR-0303, "Guidance for Performance-Based Regulation." Performance requirements (operations) addressed in Subpart F based on role of SSC in DBA and/or event sequences in PRA.

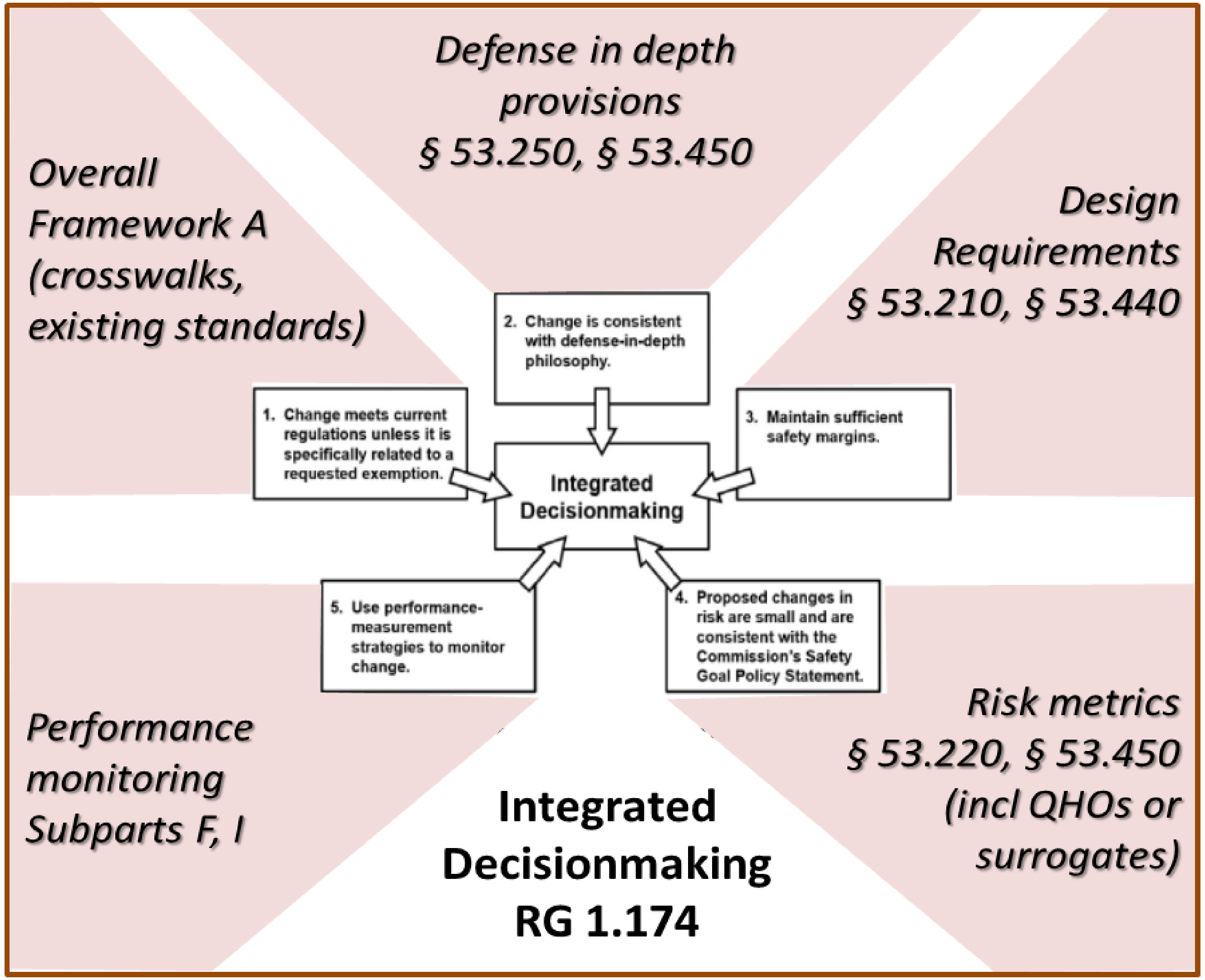




Framework A

Ensuring Comparable Level of Safety

Additional discussion in Preamble on how an integrated assessment like that in Regulatory Guide (RG) 1.174 can be used to support the comparisons to existing requirements and related regulatory findings.

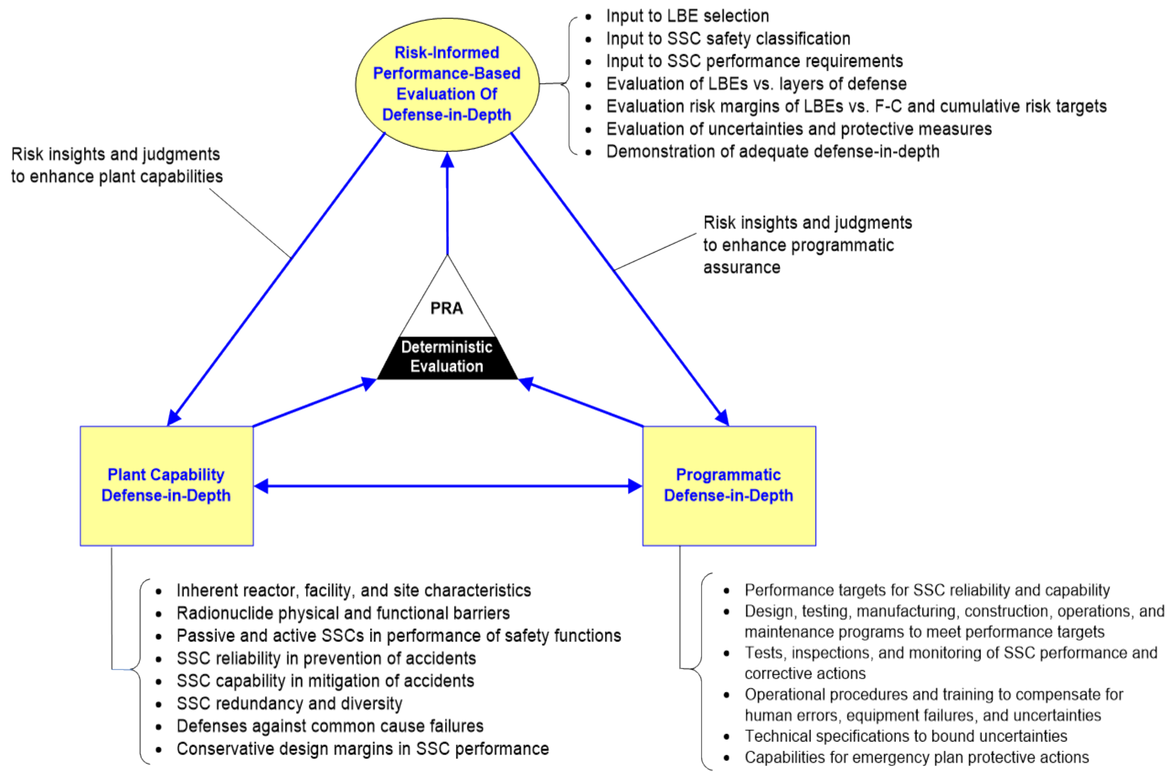


Safety Classification & Defense in Depth

Safety Classifications

- *Framework A*
  - Safety Related
  - Non-Safety Related but Safety Significant
  - Non-Safety Significant
- *Framework B*
  - Safety Related
  - Important to Safety
  - Alternative in § 53.4731, Risk-informed classification of SSCs

Defense in Depth (Integrated)



Manufacturing licenses

§ 53.620(d) / § 53.4120(d) Fuel loading

- A manufacturing license may include authorizing the loading of fuel into a manufactured reactor module
- Specify required protections to prevent criticality
    - At least two independent mechanisms that can prevent criticality should conditions result in the maximum reactivity being attained for the fissile material
- Commission finding that a manufactured reactor module in required configuration is not a utilization facility as defined in the Atomic Energy Act
- Manufactured reactor module becomes a utilization facility in its final place of use after the Commission makes required findings on inspections, tests, analyses and acceptance criteria

Framework B Safety Case

- Framework B provides a technology-inclusive approach to assessing safety of commercial nuclear plants under a more traditional framework
  - Safety Analysis Provisions in proposed § 53.4730(a) derived from Part 52

    (a)(1) – Site safety analysis (major accident)

    (a)(5) – Initiating events and accident analysis
      - Analysis and Evaluation
      - Design Basis Accidents
      - Anticipated Operational Occurrences
      - Additional Licensing Basis Events
      - Severe Accidents
      - Chemical Hazards

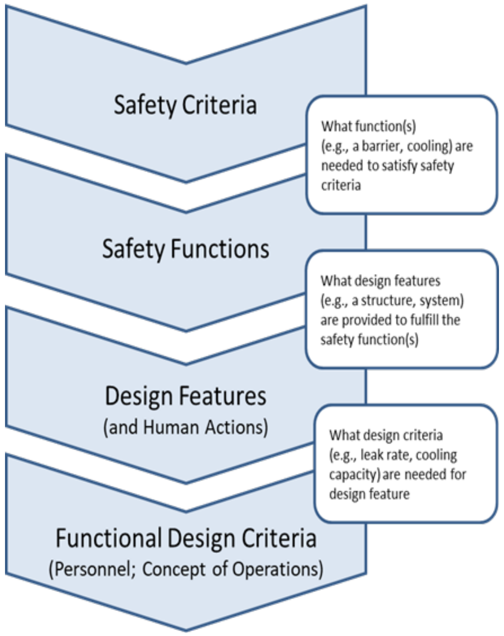
    (a)(36) – Containments
      - Essentially Leak Tight (LWRs)
      - Functional Containment Barriers

Some flexibility via technology-inclusive nature of requirements (less prescriptive)

Also note that existing RIPB requirements (e.g., maintenance rule) in Parts 50/52 incorporated into Part 53

General staffing, training, personnel qualifications, and human factors requirements.

- Defining, fulfilling, and maintaining the role of personnel in ensuring safe operations (§ 53.730)
  - (a) Human factors engineering design requirements.
  - (b) Human system interface design requirements.
  - (c) Concept of operations
  - (d) Functional requirements analysis and function allocation
  - (e) Programmatic requirements
  - (f) Staffing plan
- § 53.800 Facility licensees for self-reliant- mitigation facilities
  - *Generally licensed reactor operators (GLROs)*
- Maintains requirements for systems approach to training.



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Framework B
Alternate Evaluation of Risk Insights (AERI)

§ 53.4730 General technical requirements

(a)(34) … The risk evaluation must be based on:

(i) A PRA; or

(ii) An alternative evaluation for risk insights (AERI), provided that:

A. Limited offsite dose for bounding event
B. Bounding event systematically considers radionuclide inventories, internal and external hazards, roles of SSCs (active/passive), and human errors

- Guidance documents prepared include DG-1413 (Licensing events) and DG-1414 (AERI)

Key Guidance Development

Under Development

Existing

- LMP (RG 1.233)
- Siting Criteria (RG 4.7)
- Fuel Qualification Framework (NUREG-2246)
- Developing Principal Design Criteria for Non-LWR (RG 1.232)

Near-Term

- TICAP (NEI 21-07) / ARCAP ISGs
- ASME/ANS Non-LWR PRA Standard
- Non-LWR PRA Standard Applicability ISG
- High Temp Materials (ASME III-5)
- Reliability & Integrity Mgt (ASME XI-2)
- Molten Salt Reactor Fuel Qualification
- Seismic Design / Isolators
- Emergency Planning (50.160)
- Change Evaluation (SNC-led)
- QA Alternatives (NEI-led)
- Facility Training Programs ISG
- Materials Compatibility ISG
- Treatment of Consequence Uncertainty

Part 53

- *DG-1413, Identification of Licensing Events*
- *DG-1414, AERI Methodology*
- *DRO-ISG-2023-01, Operator Licensing Program Review ISG*
- *DRO-ISG-2023-02, Staffing Plan Review ISG Augmenting NUREG-1791*
- *DRO-ISG-2023-03, Scalable Human Factors Engineering Review ISG*
- Part 26, Fitness for Duty
- Part 26, Fatigue Management
- Part 73, Access Authorization
- Part 73, Cyber Security
- Part 73, Security Programs

Future

- Analytical Margin
- Chemical Hazards
- Manufacturing
- Technical Specifications
- Facility Safety Program
- Framework B Content of Applications

Questions ?