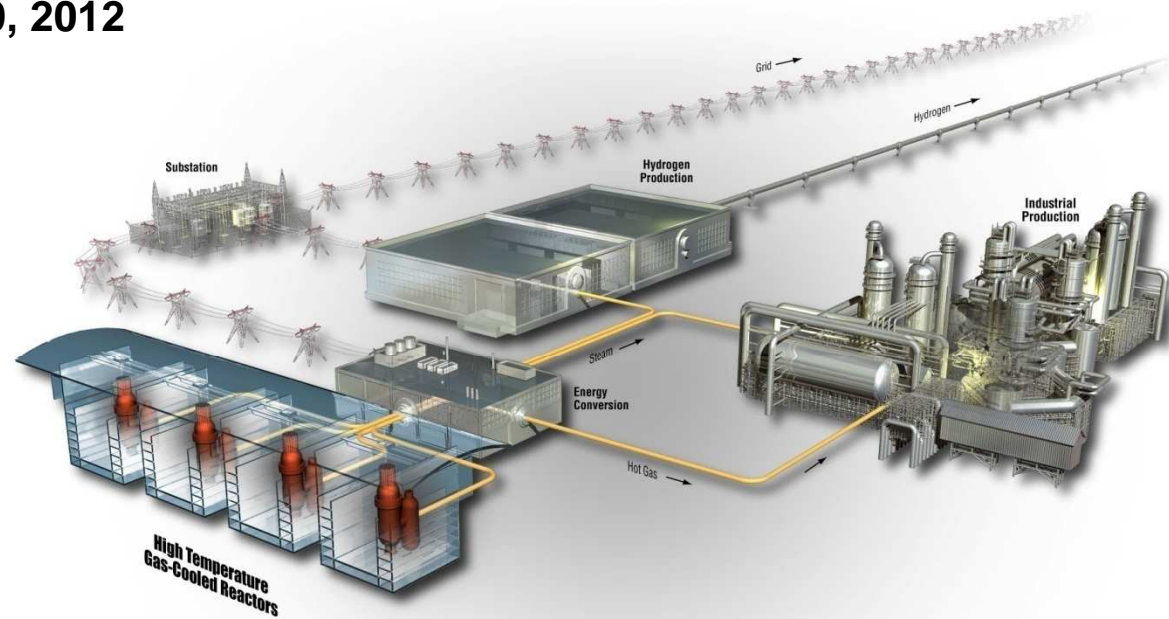


# ***Next Generation Nuclear Plant***

## ***Structures, Systems, and Components Safety Classification Discussions***

**July 10, 2012**

[www.inl.gov](http://www.inl.gov)



## ***Meeting Outline***

- Meeting Purpose
- SSC Safety Classification White Paper Objectives
- NGNP Approach for SSC Safety Classification
- SSC Safety Classification Examples
- Special Treatment
- Assessment Report Discussion
- Meeting Summary

## ***Today's Meeting***

- Achieve consensus on key issues related to the NGNP's proposed risk-informed performance-based licensing process related to SSC classification methodology
- Material to be discussed draws on:
  - Previous NGNP-NRC public meeting interactions
  - NRC documents
  - Insights based on NGNP review of the NRC Assessment Reports
  - NGNP responses to NRC RAIs
- Identify areas of consensus and establish next steps necessary for NRC development of staff positions

## ***SSC White Paper Outcome Objectives***

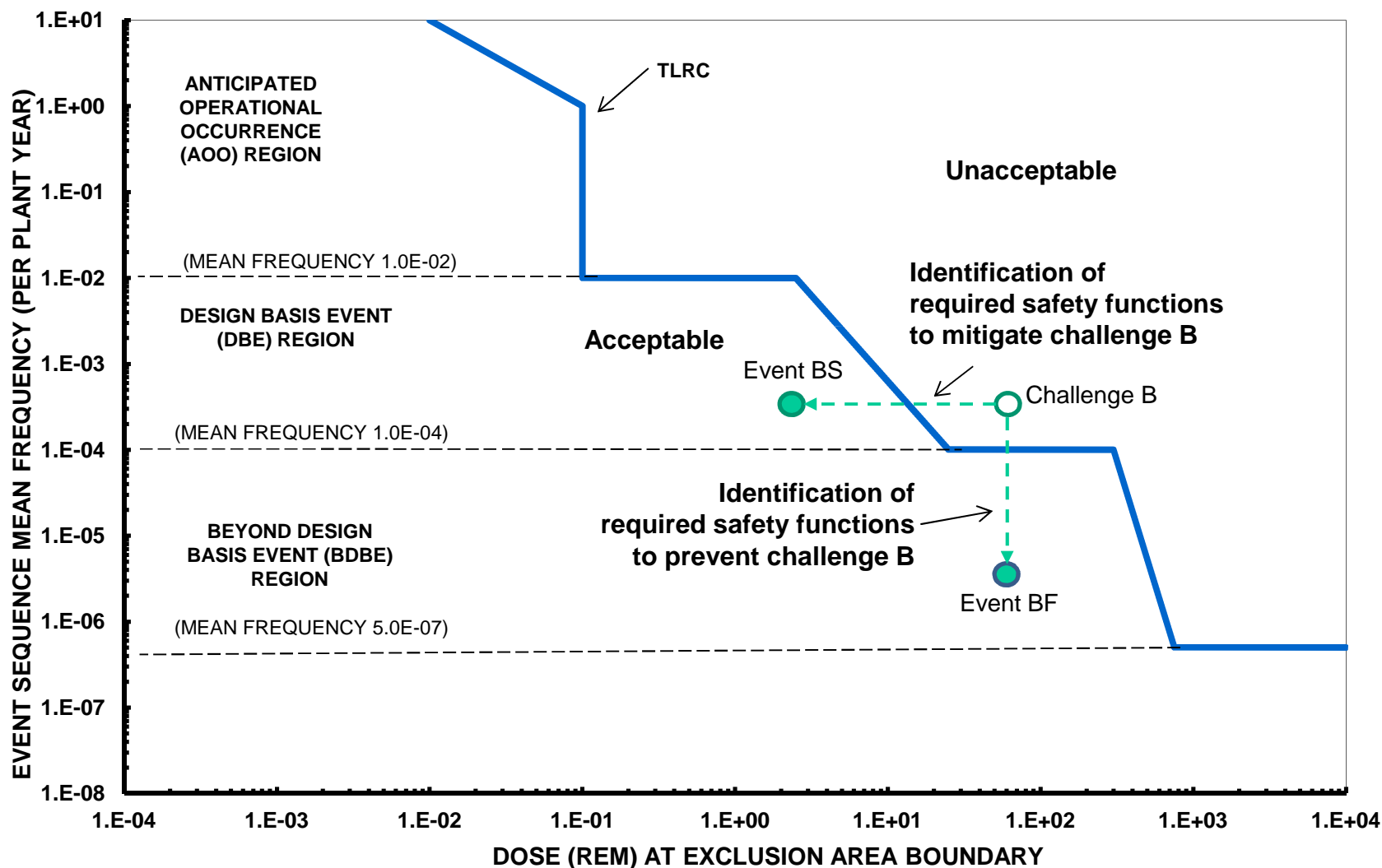
1. The NGNP approach to risk-informed safety classification and special treatment that blends the strengths of probabilistic and deterministic methods is acceptable
2. The NGNP risk-informed safety classification categories and the bases for SSC classification within each category are acceptable
3. The special treatment for the SR category of classification is commensurate with ensuring the SSCs ability to perform their safety function for DBEs and high consequence BDBEs
4. The special treatment for the NSRST category is commensurate with ensuring the SSCs ability to perform their safety function of providing significant DID

# ***NGNP Approach for SSC Safety Classification***

## ***NGNP SSC Safety Classifications***

- Safety-Related (SR)
- Non-Safety Related
  - Non-Safety Related with Special Treatment (NSRST)
- Safety classification is made in the context of specific, required safety functions performed by the SSC during LBEs to meet the TLRC
- Special treatments are specified to ensure that the SSCs classified as SR and NSRST have the capability and reliability, given the LBE environment and conditions under which the SSCs are relied on to perform their safety function

# Identification of Required Safety Functions Leading to Safety-Related SSCs

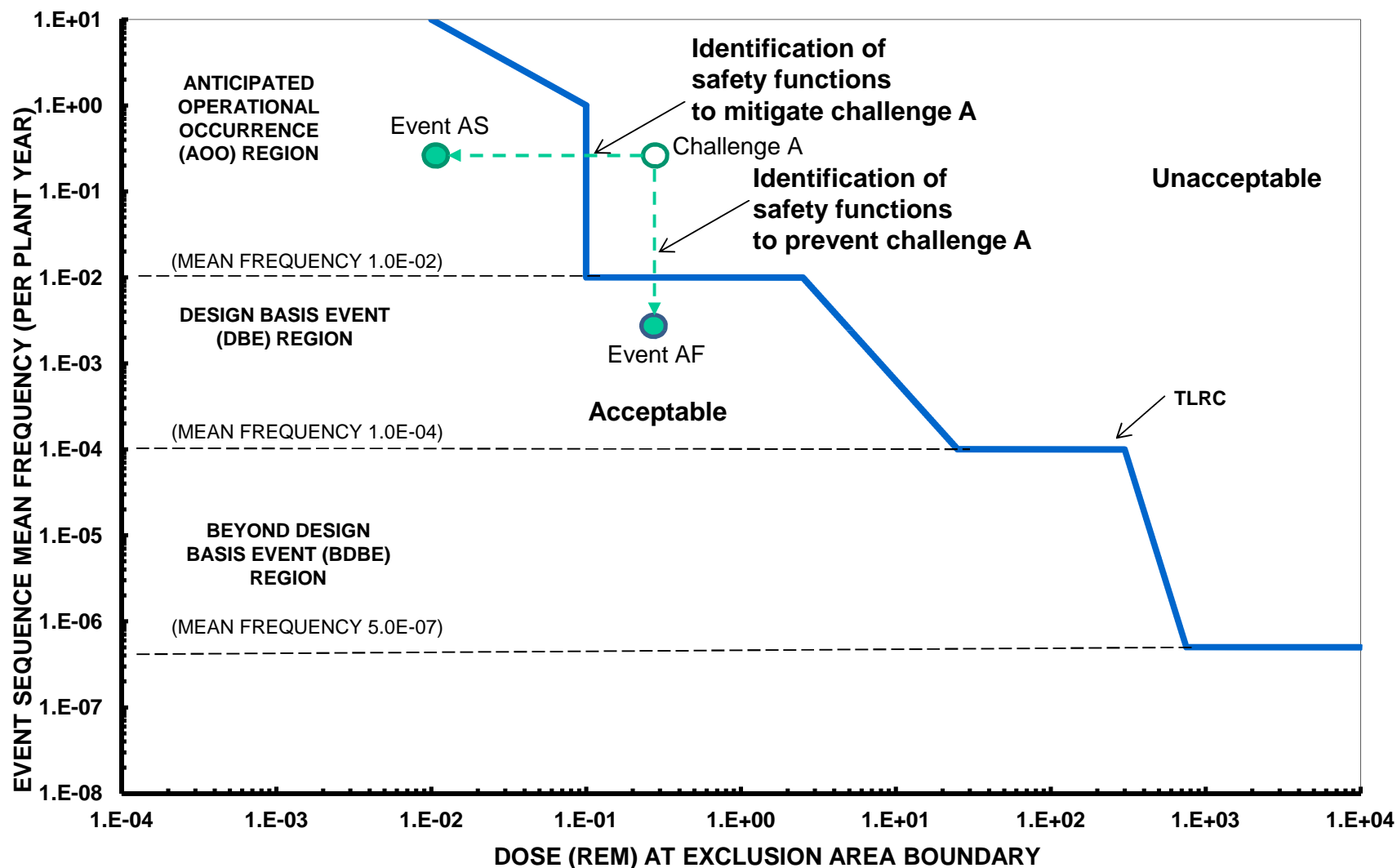


## ***Process for Classification as Safety-Related***

- The first step in the risk-informed process of classifying SSCs as safety-related is to determine the required safety functions for DBEs and BDBEs
  - For DBEs, the required safety functions are those functions that need to be performed during DBEs to meet the TLRC
  - For BDBEs with consequences above the DBE region's dose limits of 10 CFR 50.34 (10 CFR 52.79); the required safety functions are those that need to be performed to prevent them from increasing in frequency into the DBE region where their consequences would be unacceptable
- Next, for each required safety function, determine which SSCs are available and have sufficient capability and reliability to meet the required safety function
- From this review, a set of SSCs is classified as safety-related to assure that the required safety functions are accomplished



# Identification of Safety Functions Leading to NSRST SSCs

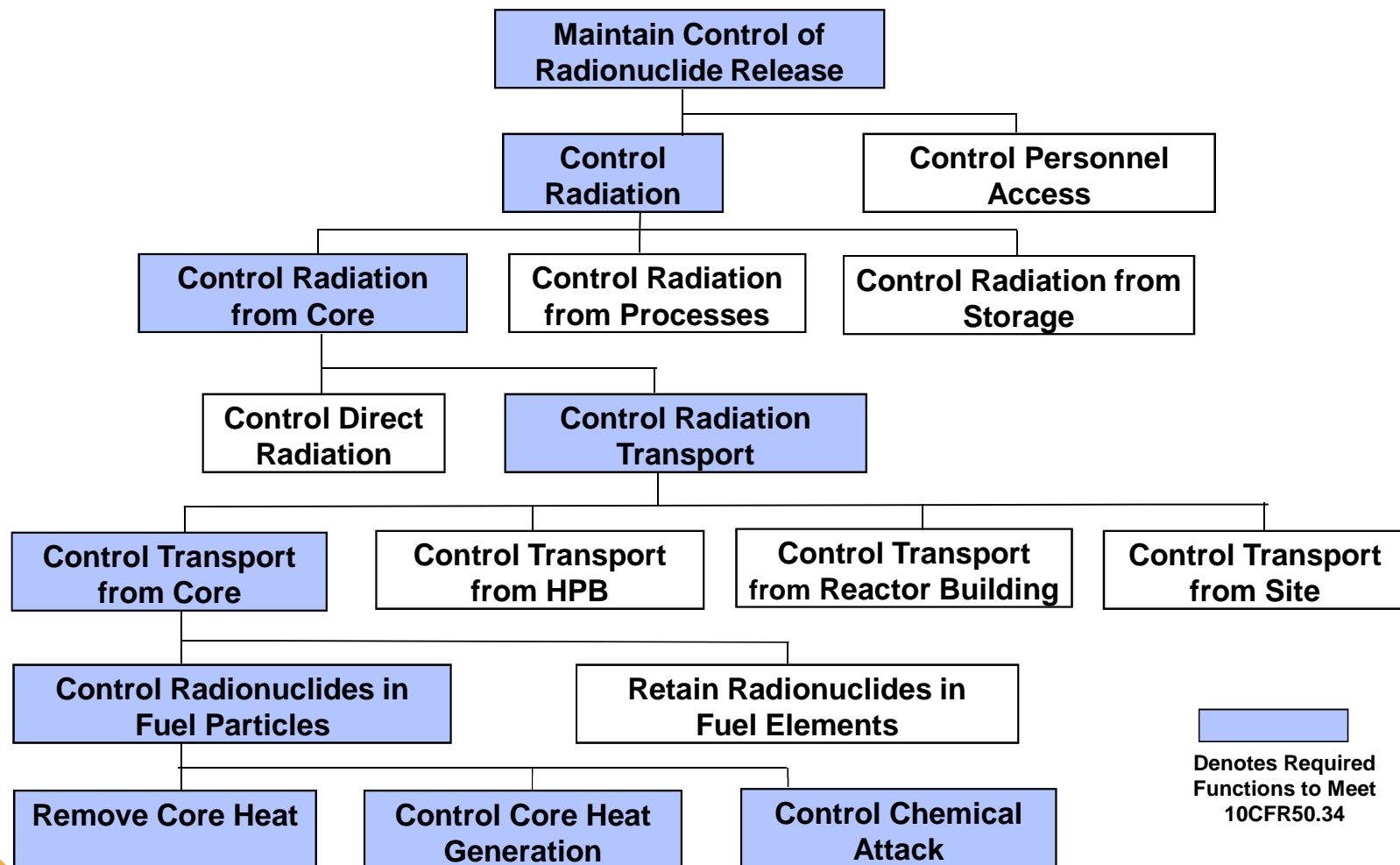


## ***SSCs Classified as Non-Safety-Related with Special Treatment***

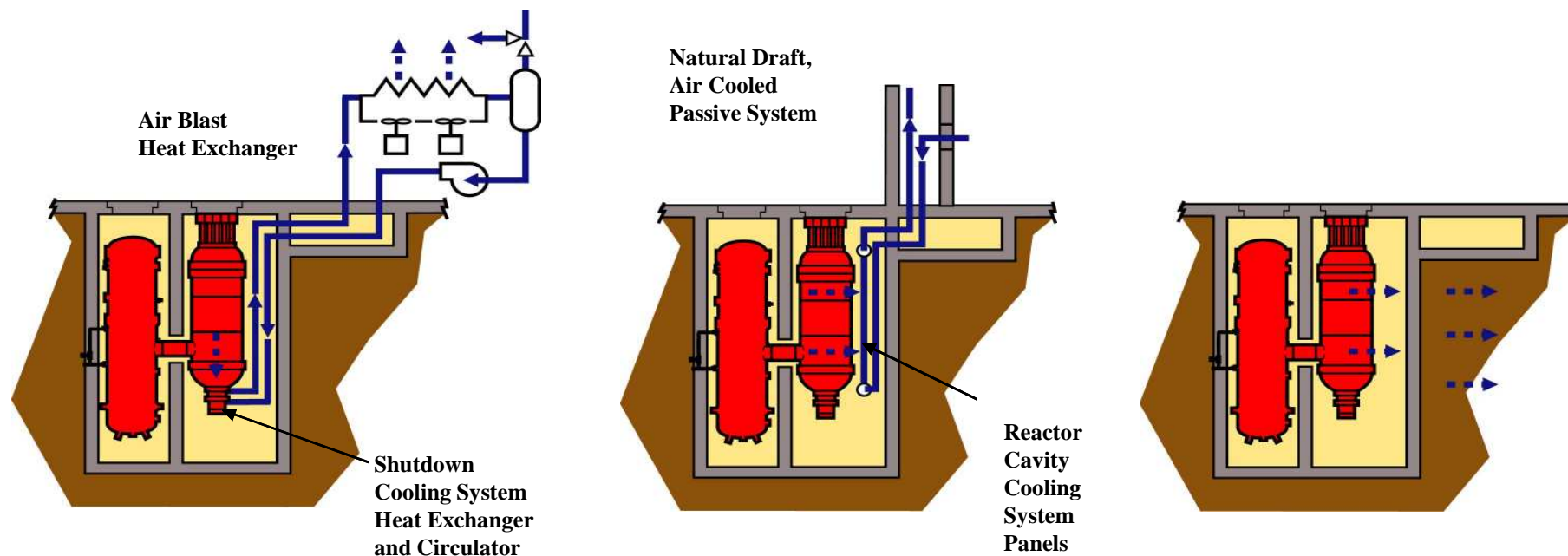
- SSCs classified as non-safety-related with special treatment are those relied on:
  - To perform safety functions to mitigate the consequences of AOOs to comply with the TLRC
  - To perform safety functions to prevent the frequency of DBEs with consequences greater than the 10 CFR 20 offsite dose limits from increasing into the AOO region
- Analogous to the selection of SR SSCs, the functions that are needed to meet the TLRC for AOO events are determined from a review of the PRA
- Since DBEs can have consequences above those acceptable for AOOs, assurance must be provided that the frequency of events with consequences greater than the 10 CFR 20 dose limits for the AOO region are lower than the cut off for AOO events
- The SSCs available to perform these safety functions are reviewed to select a set to receive greater attention from a risk, safety margin, and defense-in-depth perspective and are classified as NSRST

## ***Examples of Safety-Related SSC Classification***

# HTGR Safety Functions (Example)



## Representative Residual Heat Removal Paths When Heat Transport System Is Unavailable



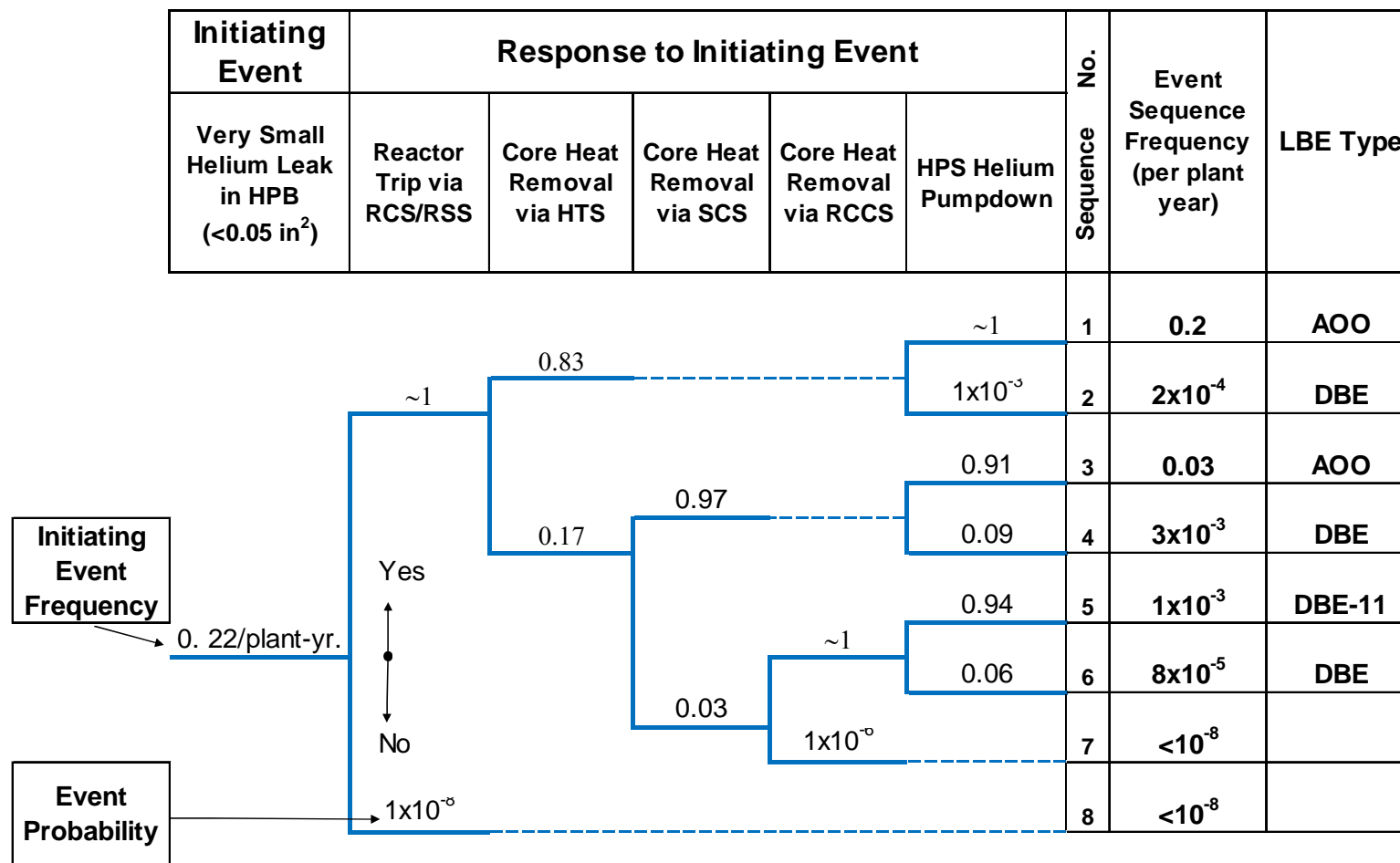
**A) Active Shutdown Cooling System**

**B) Passive Reactor Cavity Cooling System**

**C) Passive radiation and conduction of residual heat to reactor building (Beyond Design Basis Event)**

**Defense-in-Depth buttressed by inherent characteristics**

## DBE-11 from Small HPB Leak Initiating Event



## MHTGR Example of Safety Classification for Core Heat Removal Function (1/3)

Are SSCs Available and Sufficient to Remove Core Heat in the DBE?	
Alternative Sets of SSCs	DBE 11
Initiating Event	HPB small leak
Reactor HTS ECA	No
Reactor SCS SCWS	No
Reactor RV RCCS	Yes
Reactor RV RB	Yes

## MHTGR Example of Safety Classification for Core Heat Removal Function (2/3)

### Are SSCs Available and Sufficient to Remove Core Heat in the DBE?

Alt. Sets of SSCs	DBE 1	DBE 2	DBE 3	DBE 4	DBE 5	DBE 6/7	DBE 8/9	DBE 10	DBE 11
IE	Transt, (LOSP +TT)	ATWS	Control rod withdwl	Control rod withdwl	SSE	SG tube rupture	SG tube leak	HPB moderate leak	HPB small leak
Reactor HTS ECA	No	No	No	No	No	No	No	No	No
Reactor SCS SCWS	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No
Reactor RV RCCS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Reactor RV RB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

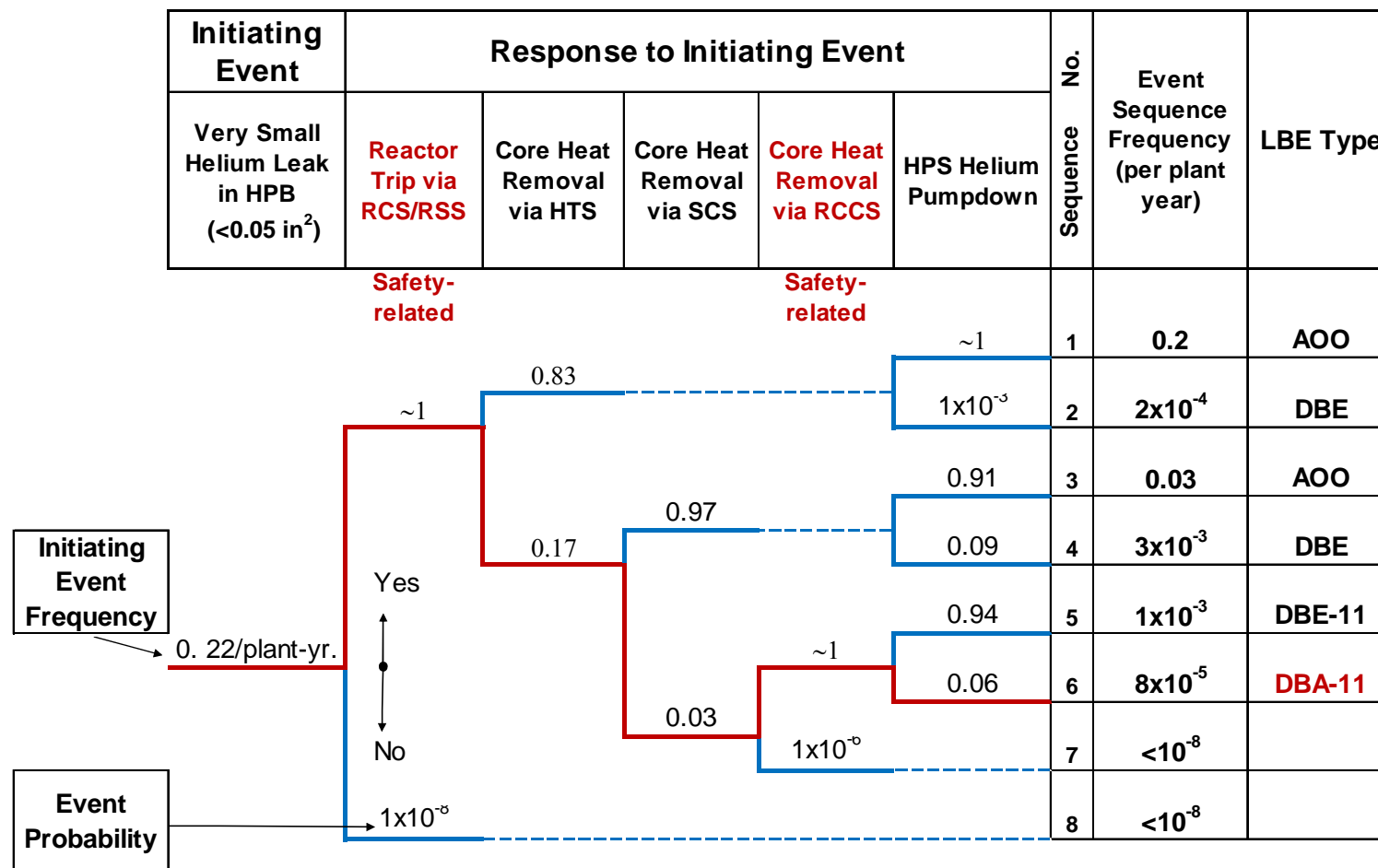


## MHTGR Example of Safety Classification for Core Heat Removal Function (3/3)

### Are SSCs Available and Sufficient to Remove Core Heat in the DBE?

Alt. Sets of SSCs	DBE 1	DBE 2	DBE 3	DBE 4	DBE 5	DBE 6/7	DBE 8/9	DBE 10	DBE 11	SSCs Classified as SR?
IE	Transt, (LOSP +TT)	ATWS	Control rod withdwl	Control rod withdwl	SSE	SG tube rupture	SG tube leak	HPB moderate leak	HPB small leak	
Reactor HTS ECA	No	No	No	No	No	No	No	No	No	
Reactor SCS SCWS	No	Yes	Yes	No	Yes	Yes	Yes	Yes	No	
Reactor RV RCCS	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes, optimum selection to achieve capability & reliability
Reactor RV RB	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	

## DBA-11 Derived from DBE-11 by Relying Only on Safety-Related SSCs



## ***SSC Special Treatment***

## ***Special Treatment for Safety-Related SSCs***

- Special treatment for safety-related SSCs is commensurate with that needed for the SSCs to achieve their capability and reliability requirements during select LBEs to meet the TLRC
- Capability requirements are derived from accident mitigation considerations, for DBEs
- Reliability requirements are derived from accident prevention considerations, for DBEs and BDBEs
- Safety-related SSCs may have more than one required safety function; special treatments must be tailored to ensure capability and reliability to meet both required safety functions

## ***Special Treatment for NSRST SSCs***

- Special treatment for the non-safety-related with special treatment category of SSCs is commensurate with that needed for the SSCs to perform their capability and reliability requirements during AOOs
- Capability requirements are derived from accident mitigation considerations, for AOOs
- Reliability requirements are derived from accident prevention considerations, for AOOs and (low consequence) DBEs
  - Special treatment may be applied to implement assumptions made in the PRA about the characteristics of SSCs that are modeled as well as those that may be screened out due to a low frequency of occurrence

# ***Representative Special Treatment Options***

Special treatment considerations
Design requirements for SSC capabilities to mitigate specific LBE challenges
Numerical targets for SSC reliability and availability to perform safety functions
Design requirements for independence, redundancy, and diversity
Design requirements for safety margins and design conservatism
Codes and Standards for design, material procurement, fabrication, construction, and operation
Seismic design basis
Seismic qualification testing
Equipment qualification testing
Quality assurance and quality control
Operational performance monitoring
Operational controls
Technical specifications
Materials surveillance testing
Pre-service and in-service inspection
Pre-service and in-service testing

# ***Assessment Report Discussion***

## ***Assessment Report Consensus Areas***

- The NRC's assessment report is generally supportive of a risk-informed approach to classifying SSCs and determining appropriate levels of treatment for the SSCs under different Classifications
- The working group finds that the categories proposed for the NGNP project are reasonable
- The working group concludes that the special treatment described for safety-related SSCs is reasonable
- The working group finds the clarification to RAI SSC-09 to be adequate
  - Regarding LBE definition to include the loading conditions and environmental conditions under which the SSC must fulfill its safety function(s), and this will facilitate a full definition of the special treatment requirements
- RAI SSC-13 clarification is adequate with respect to conformance with future codes developed for HTGR plants



## Assessment Report Discussion Items

- SSC-03: Reference to 10 CFR 50.2

*The NGNP criteria for determining safety-related SSCs should be stated in a fashion similar to the definition of safety-related structures, systems and components in 10 CFR 50.2 and should be equivalent, in principal, to this definition. In this regard, **the working group notes that the NRC staff and current reactor licensees have considered the term design basis events referred to in 10 CFR 50.2 to include Anticipated Operational Occurrences.***

(Assessment Report section 2.3.1, item #2, p. 33)

## Assessment Report Discussion Items *(continued)*

- SSC-04: Incomplete Means for Incorporating DID

*NGNP's specification of treatment for select non-safety-related SSCs to assure a measured degree of reliability and capability as a means of incorporating defense-in-depth is incomplete, as discussed below in section 2.3.2 and 2.3.4.*

(Assessment Report Section 2.3.1, item #3, p. 33)

- SSC-13: AOO Classification – Reference to Exelon/PBMR Letter

*The NGNP further states that SSCs relied upon to perform safety functions to prevent the frequency of DBEs with consequences greater than 10 CFR Part 20 offsite dose limits from increasing into the AOO region are to be classified as NSRST. The NRC staff stated in its review of the proposed risk-informed licensing approach for the Pebble Bed Modular Reactor (PBMR) that SSCs which are relied upon to prevent the frequency of an LBE from increasing from a lower event category (e.g., DBE ) to a higher event category (e.g., AOO) should be categorized as SR. The working group believes that this previous position is also applicable to the NGNP risk-informed licensing approach.*

(Assessment Report Section 2.3.2, p.36)

## Assessment Report Discussion Items *(continued)*

- SSC-12: AOO Classification

*The definition of “design basis events” set forth in 10 CFR 50.49(b), as conditions of normal operation, including anticipated operational occurrences, design basis accidents, external events and natural phenomena, and the historical interpretation of the term “design basis events” in 10 CFR 50.2 are broader than the definition of “design basis events” proposed by the NGNP Project. As such, 10 CFR 50.49(b) would require that SSCs involved in the prevention and mitigation of AOOs should also be safety-related, which is regulatory practice for LWRs. However, the NGNP project proposes that SSCs that are relied upon to perform safety-functions to mitigate the consequences of AOOs to meet the associated TLRC, be classified as NSRST. SSCs involved in the prevention and mitigation of AOOs are also expected to include SR SSCs such as the fuel and the HPB. NSR SSCs involved in the mitigation of AOOs are anticipated to include operational SSCs such as operational core cooling systems and operational waste treatment systems (e.g., clean-up and filtration systems).*

*It is regulatory practice for LWRs that those SSCs credited with prevention and mitigation of AOOs are designated (using deterministic judgment) as SR to ensure the integrity of the principle fission product barriers (e.g., fuel barrier, and RCPB barrier) rather than to ensure that 10 CFR Part 20 limits are met. The NRC Standard Review Plans for AOOs do not include a review of radiological consequences because events designated as AOOs are not expected, by design, to result in release of radioactivity that might challenge regulatory limits. NGNP has not provided an adequate rationale for their proposal to treat AOOs differently (i.e., be subject to event-based dose limits). As noted in Section 2.1.4 above, the working group considers AOO dose acceptance criteria to be a potential Commission policy issue.*

*(Assessment Report section 2.3.2, p. 36)*

## Regulatory Basis Discussion

### SSC Assessment Report (Sec. 2.3.2)

*“The NRC staff stated in its review of the proposed risk-informed licensing approach for the Pebble Bed Modular Reactor (PBMR) that SSCs which are relied upon to prevent the frequency of an LBE from increasing from a lower event category (e.g., DBE ) to a higher event category (e.g., AOO) should be categorized as SR. The working group believes that this previous position is also applicable to the NGNP risk-informed licensing approach.”*

### Letter to Exelon/PBMR (03/26/2002)

*“Also, while Exelon has stated that it does not anticipate the need for special treatment of SSCs solely for the purpose of preventing or mitigating EPBEs, the staff emphasizes that SSCs relied on to avoid exceeding TLRC, or to keep the frequencies of similar event sequences within the acceptable range (e.g., within the AOO, DBE, or EPBE range) should be classified as safety-related.”*

## Assessment Report Discussion Items *(continued)*

- SSC-16: NSRST Special Treatment

*Table 1 of the SSC white paper suggests that special treatment requirements for design reliability, i.e., independence, redundancy and diversity, do not apply to SSCs categorized as NSRST. The staff's position is that NSR SSCs that perform important safety functions should be highly reliable, which includes reliability in design. The working group considers a graded approach to the required level of design reliability to be reasonable. However, eliminating this element of special treatment is, in the working group's view, inconsistent with the NRC's philosophy of defense-in-depth.*

(Assessment Report Section 2.3.4, p. 40)

# White Paper Table 1 – Elements of Special Treatment

Special treatment requirements	Safety-related SSCs	Nonsafety-related with special treatment SSCs
Design requirements for SSC capabilities to mitigate specific LBE challenges	√	√
Numerical targets for SSC reliability and availability to perform safety functions	√	√
Design requirements for independence, redundancy, and diversity	√	
Design requirements for safety margins and design conservatism	√	
Codes and Standards for design, material procurement, fabrication, construction, and operation	√	
Seismic design basis	√	√
Seismic qualification testing	√	
Equipment qualification testing	√	
Quality assurance and quality control	√	√
Operational performance monitoring	√	√
Operational controls	√	√
Technical specifications	√	
Materials surveillance testing	√	
Pre-service and in-service inspection	√	√
Pre-service and in-service testing	√	

√ Indicates a level of special treatment for safety-related SSCs or consideration of the need for special treatment for NSRST.

## Assessment Report Discussion Items *(continued)*

- SSC-02: Fission Product Barriers

*A major feature of defense-in-depth philosophy is maintaining multiple barriers to the release of fission products. Therefore, the NGNP criteria for determining safety-related SSCs should address all of the barriers included in the design to prevent or limit the release of radioactivity to the environment, not just the fuel as described in the SSC white paper. In addition, the definition of safety-related SSCs should make clear that SSCs required to assure that the primary barriers are intact are designated as safety-related.*

(Assessment Report section 2.3.1, p. 33)

## Assessment Report Discussion Items *(continued)*

- SSC-08: Helium Pressure Boundary

*Although not explicitly stated by the NGNP Project, it is the working group's view that the SSCs which comprise the NGNP primary helium pressure boundary (HPB) (e.g., primary vessel system, connected piping, valve bodies, etc.) **should be classified as safety-related, and have sufficient capability and reliability to perform the required radionuclide containment safety function.** The working group believes that for DBEs, this approach is consistent with requirements that the NGNP primary helium pressure boundary be highly reliable in both preventing the initiation of DBE sequences, and to be highly reliable in mitigating the dose consequences of DBE sequences so that the DBE dose consequences meet the TLRC. The classification of the primary HPB SSCs as safety-related is also viewed as an outcome of the proposed process described by the NGNP Project for the selection of safety-related SSCs. The working group also believes that requiring the NGNP primary helium pressure boundary SSCs to be safety-related is consistent with the staff's earlier views documented in a March 26, 2002, letter from NRC to Exelon (ADAMS accession number ML020860097) in which the staff stated that SSCs relied on to avoid exceeding TLRC or to keep the frequencies of similar event sequences within the acceptable range (e.g., within the AOO, DBE, or EPBE ranges) should be classified as safety-related.*

(Assessment Report section 2.3.2, p. 35)



## Assessment Report Discussion Items *(continued)*

- SSC-09: Reactor Building

*Similarly, SSCs associated with the NGNP reactor building containment should be classified as safety-related with special treatment **if the SSCs are relied on to avoid exceeding TLRC for a DBE, or if the SSCs are relied on to prevent the frequency of a BDBE with a dose consequence greater than the dose limits of 10 CFR 50.34 from increasing into the DBE region.** The working group agrees that special treatment requirements for the safety-related SSCs should address the need to ensure that the safety-related SSC's are capable of performing their safety functions under the safety-related design conditions (i.e., limiting service conditions under which the SSCs are required to perform their safety-related functions).*

(Assessment Report section 2.3.2, p. 35)

## ***Meeting Summary***

- Summarize Areas of Agreement
- Summarize Action Items
- Discuss Need for Additional Information
- Future Topics and Meetings