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U.S. Nuclear Regulatory Commission
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Submittal of X Energy, LLC (X-energy) Xe-100 Principal Design Criteria Licensing Topical Report

REFERENCES:
1) Letter from T. Chapman to U.S. Nuclear Regulatory Commission (NRC) dated 13 July 2022, “Submission of X Energy, LLC (X-energy) Xe-100 Principal Design Criteria Licensing Topical Report” (ML22195A260)

2) Email from NRC to T. Chapman dated 17 November 2022, “U.S. NRC Preliminary Questions regarding X Energy LLC Topical Report: "Xe-100 Principal Design Criteria Licensing Topical Report"” (ML22322A176)

3) Letter from T. Chapman to NRC dated 30 December 2022, “X Energy, LLC (X-energy) Responses to "NRC Staff's Preliminary Questions on the NRC Assessment of the X Energy, LLC Xe-100 Principal Design Criteria Licensing Topical Report"” (ML22364A293)

4) Letter from NRC to T. Chapman dated 12 April 2023, “X ENERGY, LLC – REPORT ON THE REGULATORY AUDIT OF TOPICAL REPORT, “XE-100 PRINCIPAL DESIGN CRITERIA: LICENSING TOPICAL REPORT” (EPID NO. L-2022-TOP-0010) "” (ML23093A216)

The purpose of this letter is to submit Revision 2 of the subject licensing topical report (LTR) to the U.S. Nuclear Regulatory Commission (NRC) on behalf of X Energy, LLC (“X-energy”). This topical report describes the development of the principal design criteria (PDC) for the X-energy Xe-100 pebble-bed, high-temperature gas-cooled reactor (HTGR). The PDCs are developed using guidance from Regulatory Guide (RG) 1.232, “Guidance for Developing Principal Design Criteria for Advanced (Non-Light Water) Reactors,” NEI 21-07, “Technology Inclusive Guidance for Non-Light Water Reactor Safety Analysis Report: Content for Applicants Using the NEI 18-04 Methodology,” Revision 1, and Xe-100-specific safety functions and design requirements. This version supersedes Reference 1 above.

This letter contains no commitments. Should you have any questions or require additional information, please contact Stephen Vaughn at svaughn@x-energy.com.

Sincerely,

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Xe-100 Principal Design Criteria Licensing Topical Report

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Enclosure

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Xe-100 Principal Design Criteria Licensing Topical Report
Revision 2

Xe-100 Principal Design Criteria Licensing Topical Report

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SYNOPSIS

This topical report describes the development of the principal design criteria (PDC) for the X energy Xe 100 pebble bed, high-temperature gas cooled reactor (HTGR). The PDC are developed using guidance from Regulatory Guide (RG) 1.232, “Guidance for Developing Principal Design Criteria for Non-Light Water Reactors,” Nuclear Energy Institute (NEI) 21-07, “Technology Inclusive Guidance for Non-Light Water Reactor Safety Analysis Report: Content for Applicants Using the NEI 18 04 Methodology,” Revision 1, and Xe-100-specific safety functions and design requirements. The resulting PDC are specific to the Xe-100 design and support licensing bases development for future license applicants. X energy is requesting review and approval of these PDC by the U.S. Nuclear Regulatory Commission (NRC) for use by future applicants for permits, licenses, certifications, and/or approvals under Title 10 of the Code of Federal Regulations applicable regulations governing PDC development.

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This document is the property of X Energy LLC (X-energy) and was prepared for review by the U.S. Nuclear Regulatory Commission (NRC) and use by X-energy, its contractors, its customers, and other stakeholders as part of regulatory engagements for the Xe-100 reactor plant design. Other than by the NRC and its contractors as part of such regulatory reviews, the content herein may not be reproduced, disclosed, or used without prior written approval of X-energy. This report has been reviewed for proprietary and controlled information and determined to be available for unrestricted release.

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DEPARTMENT OF ENERGY ACKNOWLEDGEMENT AND DISCLAIMER

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1	08-Jul-2022	P Loza	Entirety	For Approval
2	30-Apr-2023	S Vaughn	Throughout the Document	Revised the licensing topical report to incorporate feedback from the NRC from both clarification questions provided in November 2022 (ML22322A175) and the audit held in February 2023 (ML230009B755) and edits based on updated NEI 18-04 implementation activities.

Table of Contents

Appendices

List of Tables

Abbreviations/Acronyms

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Short Form	Phrase
AOO	Anticipated Operational Occurrences (as defined in NEI 18-04)
ARDC	Advanced Reactor Design Criteria
ASME	American Society of Mechanical Engineers
BDBE	Beyond Design Basis Events (as defined in NEI 18-04)
CDC	Complementary Design Criteria
CFR	Code of Federal Regulations
COL	Combined License
CP	Construction Permit
DBA	Design Basis Accidents (as defined in NEI 18-04)
DBE	Design Basis Events (as defined in NEI 18-04)
DBHL	Design Basis Hazard Levels
DC	Design Certification
DID	Defense-in-Depth
DOE	U.S. Department of Energy
GDC	General Design Criteria
HPB	Helium Pressure Boundary
HTGR	High Temperature Gas-Cooled Reactor
IDP	Integrated Decision-Making Process
LBE	Licensing Basis Events (as defined in NEI 18-04)
LTR	Licensing Topical Report
LWA	Limited Work Authorization
LWR	Light Water Reactor
MHTGR	Modular High Temperature Gas Reactor
ML	Manufacturing License
NEI	Nuclear Energy Institute
NRC	U.S. Nuclear Regulatory Commission
NSRST	Non-Safety-Related with Special Treatments
OCDC	Owner Controlled Design Criteria

Short Form	Phrase
OL	Operating License
PDC	Principal Design Criteria
PRA	Probabilistic Risk Assessment
PSF	PRA Safety Function
RCCS	Reactor Cavity Cooling System
RFDC	Required Functional Design Criteria
RG	Regulatory Guide
RSF	Required Safety Function
SAR	Safety Analysis Report
SARRDL	Specified Acceptable System Radionuclide Release Design Limit
SDA	Standard Design Approval
SDC	Standard Design Certification
SR	Safety Related
SSC	Structures, Systems, and Components
X-energy	X Energy, LLC

1. Introduction

X energy, LLC (X energy) is designing the Xe-100, a pebble-bed high-temperature gas-cooled reactor, and has developed PDC to support both the design and licensing process and compliance with pertinent regulatory requirements of Title 10 of the Code of Federal Regulation (10 CFR) Parts 50 and 52. The PDC described in this report were developed using the guidance in RG 1.232, “Guidance for Developing Principal Design Criteria for Non Light Water Reactors” [4], NEI 21-07, “Technology Inclusive Guidance for Non Light Water Reactor Safety Analysis Report: Content for Applicants Using the NEI 18 04 Methodology” Revision 1 [3], and Xe 100-specific Probabilistic Risk Assessment (PRA) safety functions (PSFs) and design features.

X energy requests NRC review and approval of these PDCs to be used in applications based on the Xe 100 design for limited work authorizations (LWAs), construction permits (CPs), and operating licenses (OLs) under 10 CFR 50; or LWAs, standard design certifications (SDCs), combined licenses (COLs), standard design approvals (SDAs), and manufacturing licenses (MLs) under the applicable regulations in 10 CFR 52. The demonstration that the Xe 100 design bases satisfies these PDCs will be provided within the safety analysis reports (SARs) of each application. At the time this Licensing Topical Report (LTR) was written, the scope of the PRA and the NEI 18-04 implementation activities was limited to full power internal events. In accordance with NEI 21-07 expectations for a CP application, external hazards are addressed primarily from the Design Basis Hazard Level (DBHL) perspective via supplemental analyses. Lower modes, non-core sources and a programmatic review of Defense-in-Depth (DID) were not comprehensively assessed. As such, the PDC herein are expected to support the preliminary safety analysis report (PSAR), however, the PDC may require modification due to the iterative nature of the NEI 18-04 methodology and warrant an additional submittal, review, and approval.

1.1 Regulatory Analysis

The NRC provides rules for the design, licensing, construction, operation, and decommissioning of reactors in order to provide reasonable assurance of adequate protection of public health and safety and to provide for the common defense and security. The majority of regulations associated with reactors are found in 10 CFR Parts 1-199, with a principle set of requirements found in Parts 50 and 52. The NRC also provides guidance to prospective applicants in the form of RGs that provide acceptable methods and approaches to demonstrate compliance with the regulations. RGs may be stand-alone documents or issued as acceptance of a code, standard, or other non-NRC document as an acceptable means of demonstrating conformance. Prospective applicants are allowed to propose alternative approach to meeting regulatory requirements if appropriately justified. The following sections provide a brief analysis of requirements associated with the development of PDC for a reactor facility.

1.1.1 Title 10 of the Code of Federal Regulations, Parts 50 and 52

The regulations under 10 CFR Part 50, Appendix A, “General Design Criteria for Nuclear Power Plants,” provides general design criteria (GDC) for water-cooled nuclear power plants similar to those historically licensed by the NRC. Under the provisions of 10 CFR Parts 50 and 52, applicants for a CP, OL, design certification (DC), COL, SDA, or ML must submit PDCs for the proposed facility and described how the design bases for the facility conform to those PDC (typically in the associated application’s SAR).

The following NRC regulations pertain specifically to the development of PDCs:

- 10 CFR 50.34(a)(3)(i), which requires, in part, that applications for a CP include PDCs for the facility. An OL would reference a CP, which would include PDCs
- 10 CFR 52.47(a)(3)(i), which requires, in part, that applications for a DC include PDCs for the facility
- 10 CFR 52.79(a)(4)(i), which requires, in part, that applications for a COL include PDCs for the facility
- 10 CFR 52.137(a)(3)(i), which requires, in part, that applications for an SDA include PDCs for the facility
- 10 CFR 52.157(a), which requires, in part, that applications for an ML include PDCs for the reactor to be manufactured

The regulations under 10 CFR 50.34(a)(3)(i) state that 10 CFR Part 50, Appendix A, establishes the minimum requirements for the PDCs for water-cooled nuclear power plants similar in design and location to plants for which CPs have previously been issued by the Commission and provide guidance to applicants in establishing PDCs for other types of nuclear power plants. Because HTGRs are not water-cooled nuclear power plants, PDCs are required to be provided, but do not necessarily need to align with, the minimum requirements in the GDCs in 10 CFR Part 50, Appendix A.

1.1.2 RG 1.232, Revision 0

The GDC in 10 CFR 50, Appendix A, provide a minimum set of requirements to establish the PDC for a water-cooled nuclear power plant. These PDC establish necessary design, fabrication, construction, testing, and inspection requirements for structures, systems, and components (SSCs) that have a significant impact on public health and safety. The NRC and U.S. Department of Energy (DOE) implemented a joint initiative to review the GDC for applicability to non-light water reactor (LWR) designs and to propose amended and/or additional design criteria that address non LWR design features, resulting in the issuance of RG 1.232 [4], Revision 0 in 2018. While GDCs are not regulatory requirements for non LWR designs, they do provide guidance in establishing the PDC for non LWR designs and would not warrant the need for an exemption request from the GDC.

RG 1.232 provides a set of advanced reactor design criteria (ARDC) that serve the same purpose for non LWRs as the GDC serve for LWRs. In addition to the technology inclusive ARDC, RG 1.232 provides two sets of technology specific, non LWR design criteria, one of which is for the modular high-temperature gas-cooled reactor (MHTGR) and is described in Appendix C of the guide. The PDC provided for the MHTGR design are referred to as the MHTGR design criteria (MHTGR DC). Because RG 1.232 provides the necessary regulatory ties between the GDC, ARDC, and MHTGR-DC, the Xe-100 PDC are derived, in part, from the MHTGR-DC as described in Appendix C of the guide.

RG 1.232 determined that some of the GDC contained in 10 CFR Part 50 Appendix A were not applicable to HTGR technology and developed MHTGR-DCs as guidance for developing non-LWR PDCs. These GDCs are screened in Table 5 with the same basis described in RG 1.232.

1.1.3 NEI 21-07, Revision 1

NEI 21-07 provides guidance on developing safety analysis report content using the risk-informed and performance-based approach to design and licensing bases development described in NEI 18-04, "Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development" Revision 1 [3]. Chapter 5 of NEI 21-07, entitled "Safety Functions, Design Criteria, and SSC Classification" focuses on identifying the required safety functions (RSFs) and other PRA safety functions (PSFs) that support SSC classification and are associated with different types of PDC. For example, an SSC that is credited in fulfilling a particular RSF is classified as safety-related (SR) and the associated PDC is referred to as required functional design criteria (RFDC.) Likewise, an SSC that performs a PSF necessary for DID adequacy is classified as non-safety-related with special treatments (NSRST) and the associated PDC is referred to as complementary design criteria (CDC.)

Some proposed PDC based on the MHTGR-DC do not provide an RSF or PSF, as such, and are more akin to a special treatment as defined in both NEI 18-04 and NEI 21-07. For example, PDC that focus on monitoring, testing, inspection and/or surveillance do not perform an RSF or PSF, rather these types of PDC ensure that system designs account for the impacts from programmatic requirements during the system lifecycle. In addition, some proposed PDC focus specifically on normal operations, while both the NEI 18-04 and NEI 21-07 scope focuses mainly on Licensing Basis Events (LBEs.) As such, the set of Xe-100 PDC that is limited to normal operations is effectively outside the scope of the NEI 18-04 methodology and NEI 21-07 structure. However, PDC related to normal operations are necessary to demonstrate that the Xe-100 will provide reasonable assurance of adequate protection during normal operations.

1.2 Definitions

This report uses, but does not replicate herein, the definitions from both Section 6 "Glossary of Terms" of NEI 18-04 [1] and Appendix A "Glossary of Terms" of NEI 21-07 [3]. Given that NEI 21-07 is not currently endorsed by the NRC at the time of this publication, the Xe-100 PDC language may need to be reassessed after the NRC concludes the NEI 21-07 endorsement process. While developing the Xe-100 PDC and related NEI 18-04 implementation activities, an additional set of defined terms needed to be established to support effective communication. Below are four definitions and the rationale for creating them.

- <u>Risk-Significant Function</u>: A PRA Safety Function that is: a) required to keep one or more LBEs inside the F-C Target based on mean frequencies and consequences; or b) if the total frequency LBEs that involve failure of the SSC PRA Safety Function contributes at least 1% to any of the LMP cumulative risk targets. The LMP cumulative risk targets include: (i) maintaining the frequency of exceeding 100 mrem to less than 1/plant-year; (ii) meeting the NRC safety goal QHO for individual risk of early fatality; and (iii) meeting the NRC safety goal QHO for individual risk of latent cancer fatality.

The term "Risk-Significant SSC" is defined in NEI 18-04 and NEI 21-07, however the term "Risk-Significant Function" is not explicitly defined; rather it is a subset of "Risk-Significant SSC" definition. As such, the beginning phrase "An SSC that meets defined risk significance criteria. In the LMP framework, an SSC is regarded as risk-significant if its…" was removed from the "Risk-Significant SSC" in defining the term

"Risk-Significant Function." The purpose of defining risk-significant in terms of a function, instead of an SSC, is to ensure that it is SSC agnostic to support its use in the terms "NSRST PSF" and "NST PSF" below.

- Non-Safety-Related with Special Treatments PRA Safety Function (NSRST PSF) - A PRA safety function that is not an RSF but is either a risk significant function or necessary for DID adequacy.

The term "NSRST PSF" is not defined in NEI 18-04 nor NEI 21-07. However, there is a need to define a term analogous to an RSF that describes the category of PSFs that are performed by SSCs classified as NSRST. Without such a term there is not a clear way to communicate the connection between the PDC categorized as CDC to an appropriate PSF similar to the connection between RFDC and a particular RSF. As such, each CDC can be linked to an NSRST PSF to provide consistency in implementation.

- Non-Safety-Related with no Special Treatments PRA Safety Function (NST PSF) - A PRA safety function that is not an RSF, risk significant function, nor necessary for DID adequacy.

The term "NST PSF" is not defined in NEI 18-04 nor NEI 21-07. However, there is a need to define a term analogous to a NSRST PSF that describes the category of PSFs that are performed by SSCs classified as NST. Without such a term there is not a clear way to communicate the connection between the PDC categorized as owner-controlled design criteria (OCDC), which is defined directly below, to an appropriate PSF similar to the connection between CDC and a particular NSRST PSF. As such, each OCDC can be linked to an NST PSF to provide consistency in implementation.

- Owner Controlled Design Criteria (OCDC) - Design-specific design criteria that are necessary and sufficient to meet the NST PSFs.

The term "OCDC" is not defined in NEI 18-04 nor NEI 21-07. However, there is a need to define a term analogous to a CDC that describes the category of design criteria that support meeting a particular NST PSF. The impetus in using the term OCDC is driven by the need to separate design criteria that support normal operations from the CDC and RFDC that support NSRST PSFs during AOOs and RSFs during DBEs and DBAs. In NEI 18-04, Section 4.1, Task 6 describes, "For those SSCs classified as NST, the reliability and capability targets are part of the non-regulatory owner design requirements" and Task 7 describes, "… owner design requirements for NST-classified SSCs." As such, NEI 18-04, as endorsed by RG 1.233, provides guidance to support the development of PDC categorized as OCDC to align with normal operations and NST SSCs.

2. Xe-100 PDC Development Process

PDC development for the Xe 100 design is a two-pronged approach. The MHTGR-DC from Appendix C of RG 1.232 [4] and Xe-100 RFDC and CDC identified from implementing the NEI 18-04 [1] and NEI 21-07 [3] guidance were both used to derive the Xe-100 PDC. While both of these approaches to develop PDC are different, they can be used in concert to develop a set of Xe-100 PDC that can be further categorized based on their alignment with three main objectives:

1. Perform RSFs and NSRST PSFs with supporting RFDC and CDC respectively
2. Support the identification and implementation of special treatments
3. Support normal operations

Starting with the MHTGR-DC in Appendix C of RG 1.232, each PDC is reviewed for applicability and alignment to the Xe-100 design. In cases where there is sufficient alignment between a particular MHTGR-DC and Xe-100 design, no suggested changes to the MHTGR-DC are provided. In cases where the Xe-100 design and implementation of NEI 18-04 does not align well with a particular MHTGR-DC, suggested changes to the MHTGR-DC and associated bases are provided. Each of the Xe-100 PDC are characterized further to describe any RFDC supporting an RSF, a CDC supporting an NSRST PSF, design criteria that support the identification and implementation of a special treatment, or an OCDC supporting a NST PSF or normal operations. In some cases, more than one of these characterizations could apply to a single PDC.

The Xe-100 PDC often use the term “safety-significant SSC” as defined in NEI 18-04, which is analogous to “important to safety SSC” used in the MHTGR-DC. NEI 18-04 also defines Licensing Basis Events (LBEs) including Anticipated Operational Occurrences (AOOs), Design Basis Events (DBEs), Design Basis Accidents (DBAs) and Beyond Design Basis Events (BDBEs). These LBE definitions are used, as appropriate, to replace terms like “postulated accident” and “accident conditions” in the MHTGR-DC. BDBEs were not included in the scope of the Xe-100 PDC to replace MHTGR-DC terms such as “postulated accidents” and “accident conditions” because those terms are characterized as DBAs. The Xe-100 PDC that align with RFDC assure that those RSFs and associated design limits are met during DBAs, which aligns with the historical precedent of the GDC. BDBEs are addressed in accordance with the NEI 18-04 process as endorsed in RG 1.233 and documented in accordance with NEI 21-07. One of the two criterion that describes the SR classification category from Section 4 of NEI 18-04, states “SSCs selected by the designer and relied on to perform RSFs to prevent the frequency of BDBE with consequences greater than the 10 CFR 50.34 dose limits from increasing into the DBE region and beyond the F-C Target.” By ensuring that the RFDC are met for all DBEs and DBAs, coupled with the fact that Xe-100 design and supporting analyses demonstrate that there are not any BDBEs with consequences greater than the 10 CFR 50.34 dose limits that could increase into the DBE region and beyond the F-C Target, the Xe-100 PDC scope does not require the phrase “during BDBEs” to assure that appropriate design limits are not exceeded.

3. Xe-100 PDC Structure

The structure of the Xe-100 PDC follows the seven-section layout below as described in RG 1.232, Appendix C [4] to facilitate the traceability from the MHTGR-DC to the Xe-100 PDC. As such, the Xe-100 PDC retains the MHTGR-DC numbering scheme for accounting purposes.

- Section I—Overall Requirements (Criteria 1–6[1])
- Section II—Multiple Barriers (Criteria 10–19)
- Section III—Reactivity Control (Criteria 20–29)
- Section IV—Heat Transport Systems (Criteria 30 46)
- Section V—Reactor Containment (Criteria 50–57)
- Section VI—Fuel and Radioactivity Control (Criteria 60–64)
- Section VII—Additional Xe-100 Design Criteria (Criteria 70–72)

The results of the Xe-100 PDC development are provided in Appendix A of this report. The detailed evaluation results are organized in a tabular form for each PDC as follows:

- **Title**: Provides the number and the title of the PDC. In most cases, the title is from Appendix C of RG 1.232, however, in some cases the title is changed to reflect relevant aspects of the Xe 100 design.
- **Xe 100 PDC**: Provides the Xe-100 PDC wording. Where RFDC and CDC are identified, the PDC is either split into RFDC and CDC if the wording is different or it is noted that the PDC language covers both RFDC and CDC.
- **Position**: Provides a determination of whether a given MHTGR-DC is adopted with or without changes. Where changes are determined necessary, this content identifies the modifications made to the underlying criteria to derive the Xe 100 PDC. Wording removed is shown in **red** text with a strikethrough and wording added is shown in **blue** text. If the changes are extensive only **blue** text is provided. The source MHTGR-DC is provided adjacent to any modifications for convenience.
- **Basis**: Provides any justification and rationale for the Xe 100 PDC and any additional characterizations as described in Section 2 of this report. Note: The basis does not explain how the Xe-100 meets the PDC; the demonstration that the Xe 100 design satisfies these PDC will be provided within the SARs of each plant application.
- **Source**: Provides the particular MHTGR-DC from Appendix C of RG 1.232.

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[1] A new criterion “PDC 6” is created to replace PDC within multiple sections regarding monitoring, inspection, and testing, which is the only deviation from the sections defined in RG 1.232

4. Cross References and References

4.1 Cross References and References

	Document Title Cross References: X-energy documents that <u>may</u> impact the content of this document. References: X-energy or other documents that <u>will not</u> impact the content of this document	**Document No.**	**Rev./ Date of Issuance**	**Cross Reference/ Reference**
[1]	Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development	NEI 18-04	Rev 1/ Aug 2018	Reference
[2]	Guidance for a Technology-Inclusive, Risk-Informed, and Performance-Based Methodology to Inform the Licensing Basis and Content of Applications For Licenses, Certifications, and Approvals For Non-Light-Water Reactors	Regulatory Guide 1.233	Rev 1/ Jun 2020	Reference
[3]	Technology Inclusive Guidance for Non-Light Water Reactor Safety Analysis Report: Content for Applicants Using the NEI 18-04 Methodology	NEI 21-07	Rev 1/ Feb 2022	Reference
[4]	Guidance for Developing Principal Design Criteria for Non-Light-Water Reactors	RG 1.232	Rev 0/ Apr 2018	Reference
[5]	Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs	SECY-94-084	Mar 1994	Reference

Appendix A Xe-100 Principal Design Criteria

Each of the Xe-100 PDC are described using the structure from Section 3 of this report. Table 1 and Table 2 briefly describe the RSFs and PSFs respectively and provide the associated PDC that they are aligned with. Table 3 and Table 4 describe which PDC are associated with normal operations and special treatments respectively. Tables 1-4 are summarized from data in this report and are provided as background information to assist the review process. Table 5 shows the gaps in the sequential numbering of the Xe-100 PDC. Table 6 provides the Xe-100 PDC.

Table 1:PDC Aligning with RSFs

RSF to PDC	
RSF #	**Addressed in PDC**
1 - Retain Radionuclides in Fuel Particles and Pebbles	RFDC 16
1.1 - Control Reactivity	RFDC 11, 13, 20, 26
1.1.1 - Control Reactivity with Inherent Reactivity Feedback	RFDC 11
1.1.2 - Control Reactivity with Moveable Poisons	RFDC 13, 20, 26
1.2.1 - Control Heat Removal through Passive Means	RFDC 34
1.3 - Control Water/Steam Ingress	RFDC 13, 20, 30
1.3.1 - Isolate Water/Steam Source	RFDC 13, 20, 30
1.4.1 - Maintain HPB and Core Geometry	RFDC 70
1.4.2 - Maintain Reactor Building Geometry	RFDC 71

Table 2: PDC Aligning with NSRST PSFs

NSRST PSF #	Addressed in PDC
1.1.2 - Control Reactivity with Moveable Poisons	CDC 13, 17, 26
1.2.2 - Control Heat Removal with Active Means	CDC 13, 17, 34, 44
1.3.2 - Remove Water/Steam Source	CDC 13, 17
2 - Retain Radionuclides in the HPB	CDC 16
2.5 - Maintain HPB Pressure Integrity During Transients	CDC 13, 17, 30
2.7 - Prevent Loss of HPB Integrity	CDC 15

Table 3: PDC Associated with Normal Operations

PDC
2
4
10
13
15
19
22
44
60
61
64

Table 4: PDC Associated with Special Treatments

PDC
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45
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72

Table 5: GDC and ARDC Screened as Not Applicable for MHTGRs based on RG 1.232

Criterion	Screening Rationale from RG 1.232 [4]
27	Combined reactivity control systems capability. Same as ARDC DELETED—Information incorporated into MHTGR-DC 26
33	The MHTGR does not require reactor coolant inventory maintenance for small leaks to meet the specified acceptable system radionuclide release design limits (SARRDLs), which replaces the concept of the specified acceptable fuel design limits, as discussed in GDC 10. Therefore, ARDC 33 is not applicable to the MHTGR design.
35	In the MHTGR design maintaining the helium inventory is not necessary to maintain effective cooling. Postulated accident heat removal is accomplished by the residual heat removal system described in MHTGR DC 34.
38	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a “pressure retaining reactor containment structure” but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR DC 16 rationale.
39	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a “pressure retaining reactor containment structure” but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR-DC 16 rationale.
40	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a “pressure retaining reactor containment structure” but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR-DC 16 rationale.
41	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a “pressure retaining reactor containment structure” but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR-DC 16 rationale.
42	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a “pressure retaining reactor containment structure” but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR-DC 16 rationale.
43	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a “pressure retaining reactor containment structure” but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR-DC 16 rationale.
50	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a “pressure retaining reactor containment structure” but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR-DC 16 rationale.
51	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a “pressure retaining reactor containment structure” but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR-DC 16 rationale.
52	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a “pressure retaining reactor containment structure” but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR-DC 16 rationale.
53	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a “pressure retaining reactor containment structure” but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR-DC 16 rationale.

Criterion	Screening Rationale from RG 1.232 [4]
54	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a "pressure retaining reactor containment structure" but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR-DC 16 rationale.
55	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a "pressure retaining reactor containment structure" but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR-DC 16 rationale.
56	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a "pressure retaining reactor containment structure" but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR-DC 16 rationale.
57	This criterion is not applicable to the MHTGR. The MHTGR designs do not have a "pressure retaining reactor containment structure" but instead rely on a multibarrier functional containment configuration to control the release of radionuclides. See the MHTGR-DC 16 rationale.

Table 6: Xe-100 Principal Design Criteria

<table>
<tr><th>Title:</th><th colspan="2">1. Quality standards and records</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Safety-significant structures, systems, and components shall be designed, fabricated, erected, and tested to quality standards commensurate with the safety significance of the functions to be performed. Where generally recognized codes and standards are used, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product in keeping with the safety-significant function. A quality assurance program shall be established and implemented in order to provide reasonable assurance that these structures, systems, and components will satisfactorily perform their safety-significant functions. Appropriate records of the design, fabrication, erection, and testing of safety-significant structures, systems, and components shall be maintained by or under the control of the nuclear power unit licensee for an appropriate period of time.</td></tr>
<tr><td>Position:</td><td colspan="2">PDC 1 of the Xe-100 design uses the language of MHTGR-DC 1 of RG 1.232 [4] with the following changes:</td></tr>
<tr><td></td><td>RG 1.232, Appendix C, Criterion 1</td><td>Xe-100 PDC 1</td></tr>
<tr><td></td><td>Structures, systems, and components important to safety shall be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed. Where generally recognized codes and standards are used, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product in keeping with the required safety function. A quality assurance program shall be established and implemented in order to provide adequate assurance that these structures, systems, and components will satisfactorily perform their safety functions. Appropriate records of the design, fabrication,erection, and testing of structures, systems, and components important to safety shall be maintained by or under the control of the nuclear power unit licensee throughout the life of the unit.</td><td>~~Structures~~ Safety-significant structures, systems, and components ~~important to safety~~ shall be designed, fabricated, erected, and tested to quality standards commensurate with the ~~importance~~ safety significance of the ~~safety~~ functions to be performed. Where generally recognized codes and standards are used, they shall be identified and evaluated to determine their applicability, adequacy, and sufficiency and shall be supplemented or modified as necessary to assure a quality product in keeping with the ~~required~~ safety-significant function. A quality assurance program shall be established and implemented in order to provide ~~adequate~~ reasonable assurance that these structures, systems, and components will satisfactorily perform their safety-significant functions. Appropriate records of the design, fabrication, erection, and testing of safety-significant structures, systems, and components ~~important to safety~~ shall be maintained by or under the control of the nuclear power unit licensee ~~throughout the life~~ for an appropriate period of ~~the unit~~ time.</td></tr>
<tr><td>Basis:</td><td colspan="2">Xe-100 PDC 1 is based on the language in NEI 21-07 [3], Revision 1, Section 5.3.1. The phrase “throughout the life” was changed to “for an appropriate period of time” to account for the application of quality assurance special treatments to NSRST SSCs. X-energy will reassess the PDC 1 language as appropriate based on the approved regulatory guidance.</td></tr>
</table>

Title:	***1. Quality standards and records***
	The phrase “important to safety” is changed to “safety-significant” to align with NEI 18-04 [1] terminology. Quality assurance measures are a special treatment in accordance with the NEI 18-04 methodology.
Source:	RG 1.232, Appendix C, Criterion 1

<table>
<tr><th>Title:</th><th colspan="2">2. Design bases for protection against natural phenomena.</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Safety-significant structures, systems, and components shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The design bases for these structures, systems, and components shall reflect: (1) Appropriate consideration of the severity of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) appropriate combinations of the effects of normal and licensing basis event conditions with the effects of the natural phenomena, (3) the safety- significance of the functions to be performed.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 2 of the Xe-100 design uses the language of MHTGR-DC 2 of RG 1.232 [4] with the following changes:</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 2</td><td>Xe-100 PDC RFDC 2</td></tr>
<tr><td>Structures, systems, and components important to safety shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The design bases for these structures, systems, and components shall reflect: (1) Appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) appropriate combinations of the effects of normal and accident conditions with the effects of the natural phenomena and (3) the importance of the safety functions to be performed</td><td>Safety-significant structures, systems, and components ~~important to safety~~ shall be designed to withstand the effects of natural phenomena such as earthquakes, tornadoes, hurricanes, floods, tsunami, and seiches without loss of capability to perform their safety functions. The design bases for these structures, systems, and components shall reflect: (1) Appropriate consideration of the ~~most severe~~ severity of the natural phenomena that have been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated, (2) appropriate combinations of the effects of normal and ~~accident~~ licensing basis event conditions with the effects of the natural phenomena and (3) the ~~importance~~ of the safety-significance of the functions to be performed.</td></tr>
<tr><td>Basis:</td><td colspan="2"><p>PDC 2 was modified because this design criterion is not a functional requirement, like those described in PDC 16, 26, and 34, it is not conducive to either an RFDC or CDC. As such, the design criterion was recombined into a single design criterion that can be applied to safety-significant SSCs. PDC 2 is structured to assure that the SSC capabilities in response to natural phenomena are consistent with the safety classification and safety functions to be performed.</p><p>The Xe-100 SSCs that are required to perform RSFs are designed to withstand the effects of Design Basis Hazard Levels (DBHLs) without loss of capability to perform their safety functions or are designed such that their response or failure will be in a safe condition. The SR SSC design bases reflect appropriate consideration of the most severe of the historical natural phenomena, and include sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated. These will be defined in Chapter 6.1 of the SAR as DBHLs.</p></td></tr>
</table>

Title:	***2. Design bases for protection against natural phenomena.***
	The PDC 2 identifies that the NSRST SSCs are not required to withstand DBHLs and their design against hazards will ensure their capability targets identified under the NEI 18-04 Integrated Decision-Making Process (IDP) [1] shall be met, thus “most severe” is changed to “severity” to allow for the appropriate consideration of the frequency and severity of the natural phenomena commensurate with the safety-significance of the functions performed. The phrase “important to safety” is changed to “safety-significant”. Replaced “accident” with “licensing basis event” to align with NEI 18-04 terminology. Capability targets identified through the IDP will include the hazard levels under which SSCs must perform their RSFs and NSRST PSFs. Hazard analysis will drive special treatments through the NEI 18-04 IDP.
Source:	RG 1.232, Appendix C, Criterion 2

<table>
<tr><th>Title:</th><th colspan="2"><i>3. Fire protection</i></th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Safety-significant structures, systems, and components shall be designed and located to minimize, consistent with other safety requirements and the safety significance of the functions to be performed, the probability and effect of fires and explosions. Non-combustible and fire-resistant materials shall be used wherever practical throughout the unit, particularly in locations with safety-significant structures, systems, or components. Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on safety-significant structures, systems, and components commensurate with the safety significance of the functions to be performed. Firefighting systems shall be designed to ensure that their rupture or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components.</td></tr>
<tr><td>Position:</td><td colspan="2">PDC 3 of the Xe-100 design uses the language of MHTGR-DC 3 of RG 1.232 [4] with the following changes:</td></tr>
<tr><td></td><td>RG 1.232, Appendix C, Criterion 3</td><td>Xe-100 PDC 3</td></tr>
<tr><td></td><td>Structures, systems, and components important to safety shall be designed and located to minimize, consistent with other safety requirements, the probability and effect of fires and explosions. Non-combustible and fire-resistant materials shall be used wherever practical throughout the unit, particularly in locations with structures, systems, or components important to safety. Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on structures, systems, and components important to safety. Firefighting systems shall be designed to ensure that their rupture or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components.</td><td>Safety-significant structures, systems, and components ~~important to safety~~ shall be designed and located to minimize, consistent with other safety requirements and the safety significance of the functions to be performed, the probability and effect of fires and explosions. Noncombustible and fire-resistant materials shall be used wherever practical throughout the unit, particularly in locations with safety-significant structures, systems, or components ~~important to safety~~. Fire detection and fighting systems of appropriate capacity and capability shall be provided and designed to minimize the adverse effects of fires on safety-significant structures, systems, and components commensurate with the safety significance to ~~safety~~ be performed. Firefighting systems shall be designed to ensure that their rupture or inadvertent operation does not significantly impair the safety capability of these structures, systems, and components.</td></tr>
<tr><td>Basis:</td><td colspan="2">The phrase “Commensurate with the safety-significance of the functions to be performed” allows NSRST SSCs to have capability targets less than DBHLs but sufficient for DID adequacy as assessed by the IDP. SR SSCs will have design requirements to protect against DBHLs as described in NEI 18-04 [1] and NEI 21-07 [3].
The phrase “important to safety” is changed to “safety-significant” as described in the basis for PDC 1.
Capability targets identified through the IDP will include the hazard levels under which SSCs must perform their RSFs and NSRST PSFs. Hazard analysis will drive special treatments through the NEI 18-04 IDP.</td></tr>
</table>

Title:	***3. Fire protection***
Source:	RG 1.232, Appendix C, Criterion 3

<table>
<tr><th>Title:</th><th colspan="2">*4. Environmental and dynamic effects design bases*</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Safety-significant structures, systems, and components shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, anticipated operational occurrences, design basis events, and design basis accidents commensurate with the safety-significance of the functions to be performed. These structures, systems, and components shall be appropriately protected commensurate with the safety-significance of the functions to be performed against dynamic effects, including the effects of missiles originating both inside and outside the reactor helium pressure boundary, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit.

However, dynamic effects associated with postulated pipe ruptures in nuclear power units may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 4 of the Xe-100 design uses the language of MHTGR-DC 4 of RG 1.232 [4] with the following changes:</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 4</td><td>Xe-100 PDC 4</td></tr>
<tr><td>Structures, systems, and components important to safety shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and postulated accidents. These structures, systems, and components shall be appropriately protected against dynamic effects, including the effects of missiles originating both inside and outside the reactor helium pressure boundary, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit.

However, dynamic effects associated with postulated pipe ruptures in nuclear power units may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping.</td><td>Safety-significant structures, systems, and components ~~important to safety~~ shall be designed to accommodate the effects of and to be compatible with the environmental conditions associated with normal operation, maintenance, testing, and ~~postulated accidents~~ anticipated operational occurrences, design basis events, and design basis accidents commensurate with the safety-significance of the functions to be performed. These structures, systems, and components shall be appropriately protected commensurate with the safety-significance of the functions to be performed against dynamic effects, including the effects of missiles originating both inside and outside the reactor helium pressure boundary, pipe whipping, and discharging fluids, that may result from equipment failures and from events and conditions outside the nuclear power unit.

However, dynamic effects associated with postulated pipe ruptures in nuclear power units may be excluded from the design basis when analyses reviewed and approved by the Commission demonstrate that the probability of fluid system piping rupture is extremely low under conditions consistent with the design basis for the piping.</td></tr>
</table>

Title:	***4. Environmental and dynamic effects design bases***
Basis:	The phrase "Commensurate with the safety-significance of the functions to be performed" allows NSRST SSCs to have capability targets less than DBHLs but sufficient for DID adequacy as assessed by the IDP. SR SSCs will have design requirements to protect against DBHLs as described in NEI 18-04 [1] and NEI 21-07 [3]. The phrase "important to safety" is changed to "safety-significant" as described in the basis for PDC 1. Capability targets identified through the IDP will include the hazard levels under which SSCs must perform their RSFs and NSRST PSFs. Hazard analysis will drive special treatments through the NEI 18-04 IDP.
Source:	RG 1.232, Appendix C, Criterion 4

<table>
<tr><th>Title:</th><th colspan="2">5. Sharing of structures, systems, and components</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Safety-significant structures, systems, and components shall not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, commensurate with the safety-significance of the functions to be performed, including, in the event of an anticipated operational occurrence or design basis event or design basis accident in one unit, an orderly shutdown of the remaining units.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 5 of the Xe-100 design uses the language of MHTGR-DC 5 of RG 1.232 [4] with the following changes:</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 5</td><td>Xe-100 PDC 5</td></tr>
<tr><td>Structures, systems, and components important to safety shall not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, including, in the event of an accident in one unit, an orderly shutdown and cooldown of the remaining units.</td><td>Safety-significant structures, systems, and components ~~important to safety~~ shall not be shared among nuclear power units unless it can be shown that such sharing will not significantly impair their ability to perform their safety functions, commensurate with the safety-significance of the functions to be performed, including, in the event of an anticipated operational occurrence or design basis event or design basis accident in one unit, an orderly shutdown ~~and cooldown~~ of the remaining units.</td></tr>
<tr><td>Basis:</td><td colspan="2">Changed “accident” to “anticipated operational occurrence or design basis event or design basis” to align with NEI 18-04 [1] terminology and definitions from this report.
Added “commensurate with the safety-significance of the functions to be performed” given that safety-significant SSCs includes SSCs that support RSFs and SSCs that support NSRST PSFs and is similar to the approach described in the basis section of PDC 3 and PDC 4. As such, the previous PDC-RFDC was consolidated into a single PDC.
Removed “and cooldown” from PDC RFDC 5 and PDC CDC 5 to align with Appendix C of RG 1.232, in particular MHTGR-DC 26 “Reactivity Control Systems” and the column titled “NRC Rationale for Adaptions to GDC,” which states:
“SECY-94-084, “Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs”, describes the characteristics of a safe shutdown condition as reactor subcriticality, decay heat removal, and radioactive materials containment.”
“The fourth sentence of GDC 26 regarding the capability to reach cold shutdown has been generalized in MHTGR-DC 26 (4) to refer to activities which are performed at conditions below (less limiting than) those normally associated with safe shutdown.”
“SECY-94-084 describes staff positions on obtaining a cold shutdown and explains that the requirement to bring the plant to cold shutdown is driven by the need to inspect and repair a plant following an accident. In regards to safety class, the capability to bring the plant to a cold shutdown is not covered by the definition of safety-related SSCs in 10 CFR 50.2, and most operating pressurized-water reactors have not credited safety-related SSCs to satisfy this requirement of GDC 26. Based on the information provided above, the</td></tr>
</table>

Title:	***5. Sharing of structures, systems, and components***
	system credited for holding the reactor subcritical under conditions necessary for activities such as refueling, inspection and repair is identified as an important to safety system.” The phrase “important to safety” is changed to “safety-significant” as described in the basis for PDC 1. Reliability targets for safety-significant systems will demonstrate that “sharing will not significantly impair their ability to perform their safety functions.”
Source:	RG 1.232, Appendix C, Criterion 5

<table>
<tr><th>Title:</th><th colspan="2">6. Monitoring, Inspection, Testing, Surveillance</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Safety-significant structures, systems, and components shall be designed to permit appropriate monitoring, periodic inspection, testing, and/or surveillances to ensure functional capability commensurate with the safety significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, for anticipated operational occurrences, design basis events, and design basis accidents as appropriate.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 6 of the Xe-100 design uses language from MHTGR-DCs 18, 32, 36, 37, 45, 46, and 72 of RG 1.232 [4] into a single PDC for monitoring, inspection, testing, surveillance.</td></tr>
<tr><td>RG 1.232, Appendix C</td><td>Xe-100 PDC 6</td></tr>
<tr><td>No generic monitoring, inspection, testing and/or surveillance PDC in RG 1.232.</td><td>Safety-significant structures, systems, and components shall be designed to permit appropriate monitoring, periodic inspection, testing, and/or surveillances to ensure functional capability commensurate with the safety-significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, for anticipated operational occurrences, design basis events, and design basis accidents as appropriate.</td></tr>
<tr><td>Basis:</td><td colspan="2">Monitoring, periodic inspection, testing and/or surveillances will be established as special treatments in accordance with the NEI 18-04 [1] IDP and will meet the functional performance intent of the MHTGR-DC.
Added “as appropriate” after “design basis accidents” to clarify that the phrase “commensurate with the safety-significance of the functions performed” needs to align with the LBEs.
The phrase “important to safety” is changed to “safety-significant” as described in the basis for PDC 1.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criteria 18, 32, 36, 37, 45, 46 and 72</td></tr>
</table>

Title:	10. Reactor design	
Xe-100 PDC	The reactor system and associated heat removal, control, and protection systems shall be designed with appropriate margin to ensure that specified acceptable system radionuclide release design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.	
Position:	PDC 10 of the Xe-100 design uses the language of MHTGR-DC 10 of RG 1.232 [4] with the following changes.	
	RG 1.232, Appendix C, Criterion 10	Xe-100 PDC CDC 10
	The reactor system and associated heat removal, control, and protection systems shall be designed with appropriate margin to ensure that specified acceptable system radionuclide release design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.	The reactor system and associated heat removal, control, and protection systems shall be designed with appropriate margin to ensure that specified acceptable system radionuclide release design limits are not exceeded during any condition of normal operation, including the effects of anticipated operational occurrences.
Basis:	Because PDC 10 is not aligned with a particular RFDC nor CDC, the design criteria is not separated into those needed to provide support “during AOOs” and those needed to provide support “during normal operations.” However, the design criteria for heat removal and control systems will align with OCDC that provide NST PSFs during normal operations. Likewise, heat removal, control and protection systems will align with CDC that provide NSRST PSFs. PDC 10 is a higher-level requirement for other PDC covered elsewhere in this report, specifically PDC 11, 12, 17, 20, 25, 26, and 34. PDC 10 is not a functional requirement derived from NEI 18-04 implementation, rather a design limit that supports acceptance criteria for the design and analysis of systems. PDC RFDC 11/12 (RSF 1.1.1) describes the function provided by the reactor in meeting the SARRDL. PDC CDC 26 (PSF 1.1.2) describes the function provided by the reactivity control and shutdown system in meeting the SARRDL. PDC CDC 34 (PSF 1.2.2) describes the function provided by active heat removal in meeting the SARRDL. SARRDL is an initial condition for DBA dose calculations with acceptance criteria based on PDC 16.	
Source:	RG 1.232, Appendix C, Criterion 10	

<table>
<tr><th>Title:</th><th colspan="2">11. Reactor inherent protection</th></tr>
<tr><td>Xe-100 PDC RFDC</td><td colspan="2">The reactor core and associated systems shall be designed with sufficient negative reactivity feedback characteristics such that, in the power operating range, the net effect compensates for a rapid increase in reactivity, adequately controls heat generation, and ensures fuel performance and radionuclide release limits are not exceeded during design basis events or design basis accidents and that specified acceptable radionuclide release design limits are not exceeded during anticipated operational occurrences.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 11 of the Xe-100 design combines the language of MHTGR-DC 11 & 12 of RG 1.232 [4] with the following changes:</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 11</td><td>Xe-100 PDC-RFDC 11</td></tr>
<tr><td>The reactor core and associated systems that contribute to reactivity feedback shall be designed so that, in the power operating range, the net effect of the prompt inherent nuclear feedback characteristics tends to compensate for a rapid increase in reactivity.</td><td>The reactor core and associated systems ~~that contribute to reactivity feedback~~ shall be designed with sufficient negative reactivity feedback characteristics ~~so~~ such that, in the power operating range, the net effect ~~of the prompt inherent nuclear feedback characteristics~~ ~~tends~~ is to compensate for a rapid increase in reactivity, to adequately control heat generation, and ensures fuel performance and radionuclide release limits are not exceeded during design basis events and design basis accidents and that specified acceptable radionuclide release design limits are not exceeded during anticipated operational occurrences.</td></tr>
<tr><td>Basis:</td><td colspan="2">Modifications to Xe-100 PDC-RFDC 11 meets the intent of both MHTGR-DC 11 and MHTGR-DC 12 while providing one of the two means for meeting the intent of parts of MHTGR-DC 26. The intent of MHTGR-DC 11 is reflected in Xe-100 PDC-RFDC 11 with additional language incorporated from PDC 12 and 26. Inherent reactivity is one of the two means of controlling reactivity for the Xe-100 design, which is distributed into PDC-RFDC 11 for the inherent protection portion and PDC 26 for the insertion of moveable poisons.
The fuel performance and radionuclide release limits will be demonstrated with safety analysis showing that the fuel performance specifications discussed in the Xe-100 TRISO-X Pebble Fuel Qualification Methodology LTR and F-C Target radionuclide release limits are met. These analysis methodologies are not in the scope of this LTR but provided as information to substantiate the merging of MHTGR-DC 11 and 12 into a single Xe-100 PDC-RFDC 11.
PDC-RFDC 11 includes “specified acceptable radionuclide release design limits are not exceeded during anticipated operational occurrences” and aligns with a PDC-CDC not a PDC-RFDC. However, for simplicity the SARRDL AOO design criteria is added to the end of PDC-RFDC 11.
The modified PDC-RFDC 11 is aligned with RSF 1.1 “Control Reactivity” and RSF 1.1.1 “Control Reactivity with Inherent Reactivity Feedback.”</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 11</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2"><i>12. Suppression of reactor power oscillations (subsumed by Xe-100 PDC 11, Reactor inherent protection and restated here)</i></th></tr>
<tr><td>Xe-100 PDC RFDC</td><td colspan="2">The reactor core and associated systems shall be designed with sufficient negative reactivity feedback characteristics such that, in the power operating range, the net effect compensates for a rapid increase in reactivity, adequately controls heat generation, and ensures fuel performance and radionuclide release limits are not exceeded during design basis events or design basis accidents and that specified acceptable radionuclide release design limits are not exceeded during anticipated operational occurrences.</td></tr>
<tr><td>Position:</td><td colspan="2">PDC 11 of the Xe-100 design combines the language of MHTGR-DC 11 & 12 of RG 1.232 [4] with the following changes:</td></tr>
<tr><td></td><td>RG 1.232, Appendix C, Criterion 12</td><td>Xe-100 PDC RFDC 11</td></tr>
<tr><td></td><td>The reactor core and associated control and protection systems shall be designed to ensure that power oscillations that can result in conditions exceeding specified acceptable system radionuclide release design limits are not possible or can be reliably and readily detected and suppressed.</td><td>The reactor core and associated systems ~~that contribute to reactivity feedback~~ shall be designed with sufficient negative reactivity feedback characteristics ~~so~~ such that, in the power operating range, the net effect ~~of the prompt inherent nuclear feedback characteristics tends~~ is to compensate for a rapid increase in reactivity, to adequately control heat generation, and ensures fuel performance and radionuclide release limits are not exceeded during design basis events and design basis accidents and that specified acceptable radionuclide release design limits are not exceeded during anticipated operational occurrences.</td></tr>
<tr><td>Basis:</td><td colspan="2">Modifications to Xe-100 PDC RFDC 11 meets the intent of both MHTGR-DC 11 and MHTGR-DC 12 while providing one of the two means for meeting the intent of parts of MHTGR-DC 26. The intent of MHTGR-DC 11 is reflected in Xe-100 PDC RFDC 11 with additional language incorporated from PDC 12 and 26. Inherent reactivity is one of the two means of controlling reactivity for the Xe-100 design, which is distributed into PDC RFDC 11 for the inherent protection portion and PDC 26 for the insertion of moveable poisons.
The fuel performance and radionuclide release limits will be demonstrated with safety analyses showing that the fuel performance specifications discussed in the Xe-100 TRISO-X Pebble Fuel Qualification Methodology LTR and the F-C Target radionuclide release limits are met. These analysis methodologies are not in the scope of this LTR but provided as information to substantiate the merging of MHTGR-DC 11 and 12 into a single Xe-100 PDC RFDC 11.
PDC-RFDC 11 includes “specified acceptable radionuclide release design limits are not exceeded during anticipated operational occurrences” and aligns with a PDC-CDC not a PDC-RFDC. However, for simplicity the SARRDL AOO design criteria is added to the end of PDC-RFDC 11.
The modified PDC-RFDC 11 aligns with RSF 1.1.1 “Control Reactivity with Inherent Reactivity Feedback.”</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 12</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2">*13. Instrumentation and control*</th></tr>
<tr><td>Xe-100 PDC
RFDC
CDC</td><td colspan="2">Instrumentation shall be designed to monitor variables and systems over their anticipated ranges during anticipated operational occurrences, design basis events, and design basis accidents, as appropriate, to ensure functions that safety-significant structures, systems, and components are provided, including those variables and systems that can affect the fission process and the integrity of the reactor core, reactor helium pressure boundary, and functional containment. Appropriate controls shall be designed to maintain these variables and systems within prescribed operating ranges.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 13 of the Xe-100 design uses the language of MHTGR-DC 13 of RG 1.232 [4] with the following changes.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 13</td><td>Xe-100 PDC 13 RFDC and CDC</td></tr>
<tr><td>Instrumentation shall be provided to monitor variables and systems over their anticipated ranges for normal operation, for anticipated operational occurrences, and for accident conditions, as appropriate, to ensure adequate safety, including those variables and systems that can affect the fission process and the integrity of the reactor core, reactor helium pressure boundary, and functional containment. Appropriate controls shall be provided to maintain these variables and systems within prescribed operating ranges.</td><td>Instrumentation shall be designed ~~provided~~ to monitor variables and systems over their anticipated ranges ~~for normal operation and for accident conditions~~ during anticipated operational occurrences, design basis events, and design basis accidents, as appropriate, to ensure functions that ~~adequate~~ safety-significant structures, systems, and components perform are provided, including those variables and systems that can affect the fission process and the integrity of the reactor core, reactor helium pressure boundary, and functional containment. Appropriate controls shall be designed ~~provided~~ to maintain these variables and systems within prescribed operating ranges.</td></tr>
<tr><td>Basis:</td><td colspan="2">For PDC 13 RFDC-CDC changed “anticipated operational occurrences and accident conditions” to “anticipated operational occurrences, design basis events, and design basis accidents” and changed “adequate safety” to “functions that safety-significant systems, structures, and components perform are provided” to align with the NEI 18-04 [1] terminology. The term “provided” was replaced by “designed” to limit the criteria to the design of safety-significant instrumentation and control SSCs. The term “provided” could construe other activities beyond design criteria.
The modified PDC 13 RFDC-CDC aligns with RSF 1.1 “Control Reactivity”, RSF 1.1.2 “Control Reactivity with Moveable Poisons,” RSF 1.3 “Control Water/Steam Ingress.” and RSF 1.3.1 “Isolate Water/Steam Ingress.”
The modified PDC 13 RFDC-CDC also aligns with NSRST PSF 1.1.2 “Control Reactivity with Moveable Poisons”, NSRST PSF 1.2.2 “Control Heat Removal with Active Means”, NSRST PSF 1.3.2 “Remove Water/Steam Source”, and NSRST PSF 2.5 “Maintain HPB Pressure Integrity During Transients.”
The phrase “for normal operation” was removed because the instrumentation and controls and associated systems to maintain the Xe-100 within its normal operating envelope does not provide any RSFs, nor NSRST PSFs, nor any associated RFDC and CDC respectively. Design for instrumentation and control and associated systems will align with OCDC that provide NST PSFs during normal operations.</td></tr>
</table>

Title:	***13. Instrumentation and control***
Source:	RG 1.232, Appendix C, Criterion 13

<table>
<tr><th>Title:</th><th colspan="2"><i>14. Reactor helium pressure boundary</i></th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">The reactor helium pressure boundary shall be designed to have an extremely low probability of abnormal leakage and unacceptable moisture ingress.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 14 of the Xe-100 design uses some of the language of MHTGR-DC 14 of RG 1.232 [4] with the following changes:</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 14</td><td>Xe-100 PDC 14</td></tr>
<tr><td>The reactor helium pressure boundary shall be designed, fabricated, erected, and tested so as to have an extremely low probability of abnormal leakage, of rapidly propagating failure, of gross rupture, and of unacceptable ingress of moisture, air, secondary coolant, or other fluids.</td><td>The reactor helium pressure boundary shall be designed<s>, fabricated, erected, and tested so as</s> to have an extremely low probability of abnormal leakage<s>, of rapidly propagating failure, of gross rupture, and of</s> and unacceptable <s>ingress of</s> moisture ingress<s> air, secondary coolant, or other fluids</s>.</td></tr>
<tr><td>Basis:</td><td colspan="2">Deleted “rapidly propagating failure” and “gross rupture” given that the phenomena are sufficiently addressed in PDC 70 in the context of maintaining core geometry.
Monitoring, inspection, testing and/or surveillances will be established as special treatments in accordance with the NEI 18-04 [1] IDP and PDC 6. Therefore, “tested” is removed from PDC 14.
The terms “fabricated” and “erected” were deleted given that they are sufficiently covered by PDC 1.
No risk significant AOOs, DBEs, or DBAs were identified with unacceptable ingress of air or other fluids. “Secondary coolant” for the Xe-100 design is water, which is already addressed by “moisture”.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 14</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2">15. Reactor helium pressure boundary design</th></tr>
<tr><td>Xe-100 PDC CDC</td><td colspan="2">Safety-significant structures, systems, and components that are part of the reactor helium pressure boundary shall be designed with sufficient margin to ensure that the design conditions of the reactor helium pressure boundary are not exceeded during normal operations and anticipated operational occurrences.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 15 of the Xe-100 design uses the language of MHTGR-DC 15 of RG 1.232 [4] with the following changes:</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 15</td><td>Xe-100 PDC-CDC 15</td></tr>
<tr><td>All systems that are part of the reactor helium pressure boundary, such as the reactor system, vessel system, and heat removal systems, and the associated auxiliary, control, and protection systems, shall be designed with sufficient margin to ensure that the design conditions of the reactor helium pressure boundary are not exceeded during any condition of normal operation, including anticipated operational occurrences.</td><td>~~All~~ Safety-significant structure, systems, and components that are part of the reactor helium pressure boundary~~, such as the reactor system, vessel system, and heat removal systems, and the associated auxiliary, control, and protection systems,~~ shall be designed with sufficient margin to ensure that the design conditions of the reactor helium pressure boundary are not exceeded during ~~any condition of~~ normal operations~~, including~~ and anticipated operational occurrences.</td></tr>
<tr><td>Basis:</td><td colspan="2">Changed “All systems” to “Safety-significant SSCs” to align with NEI 18-04. Replaced “any condition of normal operation, including anticipated operational occurrences” with “normal operations and anticipated operational occurrences”
Removed the phrase “such as the reactor system, vessel system, and heat removal systems, and the associated auxiliary, control, and protection systems” because those structures, systems, and components that are not reflective of Xe-100 nomenclature and design of the Xe-100 helium pressure boundary.
The modified PDC-CDC 15 aligns with NSRST PSF 2.7 “Prevent Loss of HPB Integrity”</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 15</td></tr>
</table>

Title:	***16. Functional containment design***	
Xe-100 PDC RFDC	The design of the reactor fuel particles and pebbles shall provide barriers as part of the reactor functional containment and control the release of radioactivity to the environment to ensure that the functional containment design limit is not exceeded during design basis events and design basis accidents.	
Xe-100 PDC CDC	The design of the helium pressure boundary shall provide a barrier as part of the reactor functional containment and control the release of radioactivity to the environment to ensure that the functional containment design limit is not exceeded during anticipated operational occurrences.	
Position:	PDC 16 of the Xe-100 design uses the language of MHTGR-DC 16 of RG 1.232 [4] with the following changes:	
	RG 1.232, Appendix C, Criterion 16	Xe-100 PDC RFDC 16
	A reactor functional containment, consisting of multiple barriers internal and/or external to the reactor and its cooling system, shall be provided to control the release of radioactivity to the environment and to ensure that the functional containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.	The design of the reactor fuel particles and pebbles shall provide barriers as part of the reactor functional containment and control the release of radioactivity to the environment to ensure that the functional containment design limit is not exceeded during design basis events and design basis accidents.
	RG 1.232, Appendix C, Criterion 16	Xe-100 PDC CDC 16
	A reactor functional containment, consisting of multiple barriers internal and/or external to the reactor and its cooling system, shall be provided to control the release of radioactivity to the environment and to ensure that the functional containment design conditions important to safety are not exceeded for as long as postulated accident conditions require.	The design of the helium pressure boundary shall provide a barrier as part of the reactor functional containment and control the release of radioactivity to the environment to ensure that the functional containment design limit is not exceeded during anticipated operational occurrences.
Basis:	PDC 16 was separated into PDC-RFDC and PDC-CDC to effectively allocate design criteria, functions, and design limits to the appropriate LBEs. For PDC RFDC-16 changed “postulated accident” to “DBEs and DBAs” and for PDC-CDC 16 changed “postulated accident” to “AOOs” to align with NEI 18-04 [1] terminology. Changed “design conditions” to “design limits” to clearly state that there is a limit of the functional containment that cannot be exceeded. Design conditions are the conditions under which RSFs and NSRST PSFs are needed to be performed. For PDC-RFDC 16, the phrase “consisting of multiple barriers internal and/or external to the reactor and its cooling system” was changed to “fuel particles and pebbles” to clearly articulate the barrier. For PDC-CDC 16, the phrase “consisting of multiple barriers internal and/or external to the reactor and its cooling system” was changed to “helium pressure boundary” to clearly articulate the barrier.	

Title:	***16. Functional containment design***
	The modified PDC-RFDC 16 aligns with RSF 1 “Retain Radionuclides in Fuel Particles and Pebbles”, and PDC-CDC 16 aligns with PSF 2 “Retain Radionuclides in the HPB”. The phrase “important to safety” was deleted and is not changed to “safety-significant” as described in the basis for PDC 1 because the separation into RFDC and CDC effectively captures the safety significance of the design criteria.
Source:	RG 1.232, Appendix C, Criterion 16

<table>
<tr><th>Title:</th><th colspan="2">17. Electric power systems</th></tr>
<tr><td>Xe-100 PDC CDC</td><td colspan="2">Electric power systems shall be designed to provide sufficient capacity and capability, when required, to safety-significant structures, systems, and components commensurate with the safety significance of the functions to be performed to ensure that the specified acceptable system radionuclide release design limits and the reactor helium pressure boundary design limits are not exceeded during anticipated operational occurrences.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 17 of the Xe-100 design uses the language of MHTGR-DC 17 of RG 1.232 [8] with the following changes:</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 17</td><td>Xe-100 PDC CDC 17</td></tr>
<tr><td>Electric power systems shall be provided when required to permit functioning of structures, systems, and components. The safety function for each power system shall be to provide sufficient capacity and capability to ensure that (1) that the specified acceptable system radionuclide release design limits and the reactor helium pressure boundary design limits are not exceeded as a result of anticipated operational occurrences and (2) safety functions that rely on electric power are maintained in the event of postulated accidents.
The electric power systems shall include an onsite power system and an additional power system. The onsite electric power system shall have sufficient independence, redundancy, and testability to perform its safety functions, assuming a single failure. An additional power system shall have sufficient independence and testability to perform its safety function.
If electric power is not needed for anticipated operational occurrences or postulated accidents, the design shall demonstrate that power for important to safety functions is provided.</td><td>Electric power systems shall be designed to ~~provided when required to permit functioning of structures, systems, and components. The safety function for each power system shall be to~~ provide sufficient capacity and capability, when required, to safety-significant structures, systems, and components commensurate with the safety significance of the functions to be performed to ensure~~ that (1)~~ that the specified acceptable system radionuclide release design limits and the reactor helium pressure boundary design limits are not exceeded during ~~as a result of~~ anticipated operational occurrences. ~~and (2) safety functions that rely on electric power are maintained in the event of postulated accidents.~~
~~The electric power systems shall include an onsite power system and an additional power system. The onsite electric power system shall have sufficient independence, redundancy, and testability to perform its safety functions, assuming a single failure. An additional power system shall have sufficient independence and testability to perform its safety function.~~
~~If electric power is not needed for anticipated operational occurrences or postulated accidents, the design shall demonstrate that power for important to safety functions is provided.~~</td></tr>
<tr><td>Basis:</td><td colspan="2">The Xe-100 design does not have any risk-significant functions or required safety functions that rely on a supply of electrical power. Portions of the MHTGR-DC that are applicable to the NSRST PSFs and the associated design criteria in PDC-CDC 17 that electric power supports have been retained.
Removed “An additional power system shall have sufficient independence and testability to perform its safety function” because the requirement for redundancy and independence is not needed to meet the</td></tr>
</table>

Title:	***17. Electric power systems***
	reliability and capability targets for NSRST PSFs and testability is covered in PDC 6, which replaces PDC 18. The single failure criterion language is deleted consistent with the guidance in NEI 18-04 [1] as endorsed by RG 1.233 [2]. The modified PDC CDC 17 supports NSRST PSFs 1.1.2 Control Reactivity with Movable Poisons, NSRST PSF 1.2.2 “Control Heat Removal with Active Means,” NSRST PSF 1.3.2 “Remove Water/Steam Source,” and NSRST PSF 2.5 “Maintain HPB Pressure Integrity During Transients”.
Source:	RG 1.232, Appendix C, Criterion 17

<table>
<tr><th>Title:</th><th colspan="2"><i>18. Inspection and testing of electric power systems (replaced by Xe-100 PDC 6, Monitoring Inspection Testing Surveillance and restated here)</i></th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Safety-significant structures, systems, and components shall be designed to permit monitoring, periodic inspection, testing, and/or surveillances to ensure functional capability commensurate with the safety-significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, for anticipated operational occurrences, design basis events, and design basis accidents as appropriate.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 6 of the Xe-100 design uses language from MHTGR-DCs 18, 32, 36, 37, 45, 46, and 72 of RG 1.232 [4] into a single PDC for monitoring, inspection, testing, surveillance.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 18</td><td>Xe-100 PDC 6</td></tr>
<tr><td>Electric power systems important to safety shall be designed to permit appropriate periodic inspection and testing of important areas and features, such as wiring, insulation, connections, and switchboards, to assess the continuity of the systems and the condition of their components. The systems shall be designed with a capability to test periodically (1) the operability and functional performance of the components of the systems, such as onsite power sources, relays, switches, and buses, and (2) the operability of the systems as a whole and, under conditions as close to design as practical, the full operation sequence that brings the systems into operation, including operation of applicable portions of the protection system, and the transfer of power among systems.</td><td>~~Electric power~~ Safety-significant structures, systems ~~important to safety~~, and components shall be designed to permit ~~appropriate~~ monitoring, periodic inspection, testing, and/or surveillances ~~of important areas and features, such as wiring, insulation, connections, and switchboards, to assess the continuity of the systems and the condition of their components. The systems shall be designed with a capability to test periodically (1)~~ to ensure functional capability commensurate with the safety-significance of the functions to be performed. Functional testing shall ensure the operability and ~~functional~~ performance of the ~~systems, such as onsite power sources, relays, switches, and buses,~~ system components, and ~~(2)~~ the operability of the systems as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, for anticipated operational occurrences, design basis events, and design basis accidents as appropriate ~~operation of applicable portions of the protection system, and the transfer of power among systems~~.</td></tr>
<tr><td>Basis:</td><td colspan="2">The phrase “of important areas and features, such as wiring, insulation, connections, and switchboards, to assess the continuity of the systems and the condition of their components” is addressed by “functional capability” to be clearly defined as capability targets under NEI 18-04 [1] through the IDP. Monitoring, periodic inspection, testing and/or surveillance will be established as special treatments in accordance with the NEI 18-04 IDP and will meet the functional performance intent of the MHTGR-DC.
The phrase “important to safety” is changed to “safety-significant” as described in the basis for PDC 1.</td></tr>
</table>

Title:	***18. Inspection and testing of electric power systems (replaced by Xe-100 PDC 6, Monitoring Inspection Testing Surveillance and restated here)***
Source:	RG 1.232, Appendix C, Criterion 18

<table>
<tr><th>Title:</th><th colspan="2">19. Control room</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">A control room shall be provided from which actions can be taken to operate the nuclear power unit safely during normal conditions and to maintain it in a safe condition during anticipated operational occurrences and design basis events. Adequate radiation protection shall be provided to permit access and occupancy of the control room during anticipated operational occurrences and design basis events without personnel receiving radiation exposures in excess of 5 rem total effective dose equivalent as defined in § 50.2.
Adequate habitability measures shall be provided to permit access and occupancy of the control room during normal operations, anticipated operational occurrences, and design basis events. Equipment at appropriate locations outside the control room shall be provided with a design capability for prompt safe shutdown of the reactor, including any necessary instrumentation and controls to maintain the unit in a safe shutdown condition.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 19 of the Xe-100 design uses the language of ARDC 19 of RG 1.232 [4] with the following changes.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 19</td><td>Xe-100 PDC CFDC 19</td></tr>
<tr><td>A control room shall be provided from which actions can be taken to operate the nuclear power unit safely under normal conditions and to maintain it in a safe condition under accident conditions. Adequate radiation protection shall be provided to permit access and occupancy of the control room under accident conditions without personnel receiving radiation exposures in excess of 5 rem total effective dose equivalent as defined in § 50.2 for the duration of the accident.
Adequate habitability measures shall be provided to permit access and occupancy of the control room during normal operations and under accident conditions. Equipment at appropriate locations outside the control room shall be provided (1) with a design capability for prompt hot shutdown of the reactor, including necessary instrumentation and controls to maintain the unit in a safe condition during hot shutdown, and (2) with a potential capability for subsequent cold shutdown of the reactor through the use of suitable procedures.</td><td>A control room shall be provided from which actions can be taken to operate the nuclear power unit safely ~~under~~ during normal conditions and to maintain it in a safe condition ~~under~~ during anticipated operational occurrences and design basis events ~~accident conditions~~. Adequate radiation protection shall be provided to permit access and occupancy of the control room ~~under~~ during anticipated operational occurrences and design basis events ~~accident conditions~~ without personnel receiving radiation exposures in excess of 5 rem total effective dose equivalent as defined in § 50.2 ~~for the duration of the accident~~.
Adequate habitability measures shall be provided to permit access and occupancy of the control room during normal operations, ~~and under~~ anticipated operational occurrences, and design basis events ~~accident conditions~~. Equipment at appropriate locations outside the control room shall be provided ~~(1)~~ with a design capability for prompt ~~hot~~ safe shutdown of the reactor, including any necessary instrumentation and controls to maintain the unit in a safe shutdown condition. ~~during hot shutdown, and (2) with a potential capability for subsequent cold safe shutdown of the reactor through the use of suitable procedures.~~</td></tr>
</table>

Title:	***19. Control room***
Basis:	Changed “hot shutdown” and “cold safe shutdown” to “safe shutdown” to align with Appendix C of RG 1.232, in particular MHTGR-DC 26 “Reactivity Control Systems” and the column titled “NRC Rationale for Adaptions to GDC.” See basis section in PDC 5 for more detail. Replaced “accident conditions” with “anticipated operational occurrences and design basis events” as defined in NEI 18-04 as the operators and control room equipment are not necessary to reach prompt safe shutdown conditions and do not perform any required safety functions. Certain accidents in the Beyond Design Basis Event (BDBE) range as well as the DBA earthquake may result in evacuation of the operators as the Xe-100 can safely shutdown with indefinite heat removal without operator action. X-energy intends to calculate control room dose to show that no AOOs nor DBEs result in more than 5 rem in the control room. While operators will be available to perform actions during many DBEs and BDBEs, no operator actions have been identified as requiring operator support to meet the NEI 18-04 safety goals. PDC 19 is retained to support occupational safety and potential operator actions that may be identified through the iterative NEI 18-04 process. Added the word “any” to “including any necessary instrumentation and controls to maintain the unit in a safe shutdown condition” and deleted “through the use of suitable procedures” given that the only operator action outside of the control room is to support prompt safe shutdown of the reactor. The modified PDC 19 aligns with NSRST PSFs 1.1.2 Control Reactivity with Insertion of Moveable Poisons, NSRST PSF 1.2.2 Control Heat Removal with Active Means, and NSRST PSF 2.6 Maintain HPB activity to acceptable levels.
Source:	RG 1.232, Appendix C, Criterion 19

Title:	***20. Protection system functions***	
Xe-100 PDC RFDC	The protection system shall be designed to sense conditions and initiate the operation of necessary systems and components to perform required safety functions.	
Xe-100 PDC	The protection system shall be designed to automatically initiate the operation of appropriate systems, including the reactivity control systems, to ensure that the specified acceptable system radionuclide release design limits are not exceeded during anticipated operational occurrences.	
Position:	PDC 20 of the Xe-100 design uses the language of MHTGR-DC 20 of RG 1.232 [4] with the following changes:	
	RG 1.232, Appendix C, Criterion 20	Xe-100 PDC RFDC 20
	The protection system shall be designed (1) to initiate automatically the operation of appropriate systems, including the reactivity control systems, to ensure that the specified acceptable system radionuclide release design limits is not exceeded as a result of anticipated operational occurrences and (2) to sense accident conditions and to initiate the operation of systems and components important to safety.	The protection system shall be designed (1) to ~~initiate automatically~~ automatically initiate the operation of appropriate systems, including the reactivity control systems, to ensure that the specified acceptable system radionuclide release design limits are not exceeded ~~as a result of~~ during anticipated operational occurrences and (2) to sense ~~accident~~ conditions and ~~to~~ initiate the operation of necessary systems and components to perform required safety functions ~~important to safety~~.
	RG 1.232, Appendix C, Criterion 20	Xe-100 PDC 20
	The protection system shall be designed (1) to initiate automatically the operation of appropriate systems, including the reactivity control systems, to ensure that the specified acceptable system radionuclide release design limits is not exceeded as a result of anticipated operational occurrences and (2) to sense accident conditions and to initiate the operation of systems and components important to safety.	The protection system shall be designed ~~(1)~~ to ~~initiate~~ automatically initiate the operation of appropriate systems, including the reactivity control systems, to ensure that the specified acceptable system radionuclide release design limits is not exceeded as a result of anticipated operational occurrences ~~and (2) to sense accident conditions and to initiate the operation of systems and components important to safety~~.
Basis:	PDC 20 was separated into PDC-RFDC 20 and PDC 20 because the first part of PDC 20, designated as (1), is focused on how the protection system is designed to ensure that the specified acceptable system radionuclide release design limits is not exceeded as a result of anticipated operational occurrences. As generally described in PDC 10, and more specifically in PDC 25 and PDC-CDC 26, ensuring that SARRDL is met during AOOs aligns with CDC as opposed to RFDC. In PDC-RFDC 20 deleted “accident” and added “to perform required safety functions” to clarify that the conditions that need to be sensed are those that support RSFs. Added the word “necessary” because the RPS does not need to initiate all systems to perform RSFs. For example, PDC-RFDC 34 is provided by a	

Title:	***20. Protection system functions***
	passive means and does not require RPS to sense nor initiate residual heat removal. The phrase "important to safety" is changed to "to perform required safety functions" because the protection system function aligns with the RSFs mentioned above. The modified PDC-RFDC 20 aligns with RSF 1.1 "Control Reactivity", RSF 1.1.2 "Control Reactivity with Movable Poisons", RSF 1.3 "Control Water/Steam Ingress", and RSF 1.3.1 "Isolate Water/Steam Source". The modified PDC 20 replaced "as a result of" with "during" to be consistent with other PDC. Changed "initiate automatically" to "automatically initiate" to align with proper grammar.
Source:	RG 1.232, Appendix C, Criterion 20

<table>
<tr><th>Title:</th><th colspan="2">21. Protection system reliability and testability</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">The protection system shall be designed for high functional reliability and in-service testability commensurate with the safety functions to be performed. Redundancy and independence designed into the protection system shall be sufficient to assure that (1) the protection function high functional reliability and (2) removal from service of any component or channel does not result in loss of the required minimum redundancy unless the acceptable reliability of operation of the protection system can be otherwise demonstrated. The protection system shall be designed to permit periodic testing of its functioning when the reactor is in operation, including a capability to test channels independently to determine failures and losses of redundancy that may have occurred.</td></tr>
<tr><td>Position:</td><td colspan="2">PDC 21 of the Xe-100 design uses the language of MHTGR-DC 21 of RG 1.232 [4] with the following changes.</td></tr>
<tr><td></td><td>RG 1.232, Appendix C, Criterion 21</td><td>Xe-100 PDC 21</td></tr>
<tr><td></td><td>The protection system shall be designed for high functional reliability and in-service testability commensurate with the safety functions to be performed. Redundancy and independence designed into the protection system shall be sufficient to assure that (1) no single failure results in loss of the protection function and (2) removal from service of any component or channel does not result in loss of the required minimum redundancy unless the acceptable reliability of operation of the protection system can be otherwise demonstrated. The protection system shall be designed to permit periodic testing of its functioning when the reactor is in operation, including a capability to test channels independently to determine failures and losses of redundancy that may have occurred.</td><td>The protection system shall be designed for high functional reliability and in-service testability commensurate with the safety functions to be performed. Redundancy and independence designed into the protection system shall be sufficient to assure that (1) ~~no single failure results in loss of~~ the protection function maintains high functional reliability and (2) removal from service of any component or channel does not result in loss of the required minimum redundancy unless the acceptable reliability of operation of the protection system can be otherwise demonstrated. The protection system shall be designed to permit periodic testing of its functioning when the reactor is in operation, including a capability to test channels independently to determine failures and losses of redundancy that may have occurred.</td></tr>
<tr><td>Basis:</td><td colspan="2">PDC 21 is a special treatment in accordance with the NEI 18-04 methodology and is not a functional requirement analogous to a RFDC or CDC.
The phrase “no single failure results in the loss of” was replaced by “maintains high functional reliability” consistent with the guidance in NEI 18-04 as endorsed by RG 1.233 [2]. Reliability targets will be set for safety significant SSCs and special treatments will be applied to ensure those reliability targets are met.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 21</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2"><i>22. Protection system independence</i></th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">The protection system shall be designed to assure that the effects of natural phenomena, and of normal operating, maintenance, testing, and design basis accident conditions on redundant channels do not result in loss of the protection function or shall be demonstrated to be acceptable on some other defined basis. Design techniques, such as functional diversity or diversity in component design and principles of operation, shall be used to the extent practical to prevent loss of the protection function.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 22 of the Xe-100 design uses the language of MHTGR-DC 22 with minor changes.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 22</td><td>Xe-100 PDC 22</td></tr>
<tr><td>The protection system shall be designed to assure that the effects of natural phenomena, and of normal operating, maintenance, testing, and postulated accident conditions on redundant channels do not result in loss of the protection function or shall be demonstrated to be acceptable on some other defined basis. Design techniques, such as functional diversity or diversity in component design and principles of operation, shall be used to the extent practical to prevent loss of the protection function.</td><td>The protection system shall be designed to assure that the effects of natural phenomena, and of normal operating, maintenance, testing, and design basis ~~postulated~~ accident conditions on redundant channels do not result in loss of the protection function or shall be demonstrated to be acceptable on some other defined basis. Design techniques, such as functional diversity or diversity in component design and principles of operation, shall be used to the extent practical to prevent loss of the protection function.</td></tr>
<tr><td>Basis:</td><td colspan="2">PDC 22 is a special treatment in accordance with the NEI 18-04 methodology and is not a functional requirement analogous to a RFDC or CDC.
Changed “postulated accident” to “design basis accident” to align with NEI 18-04 [1] terminology.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 22</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2">23. Protection system failure modes</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">The protection system shall be designed to fail into a safe state or into a state demonstrated to be acceptable on some other defined basis if conditions such as disconnection of the system, loss of energy (e.g., electric power, instrument air), or postulated adverse environments (e.g., extreme heat or cold, fire, pressure, steam, water, and radiation) are experienced.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 23 of the Xe-100 design uses the language of MHTGR-DC 23 of RG 1.232 [4] with no changes.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 23</td><td>Xe-100 PDC 23</td></tr>
<tr><td>The protection system shall be designed to fail into a safe state or into a state demonstrated to be acceptable on some other defined basis if conditions such as disconnection of the system, loss of energy (e.g., electric power, instrument air), or postulated adverse environments (e.g., extreme heat or cold, fire, pressure, steam, water, and radiation) are experienced.</td><td>The protection system shall be designed to fail into a safe state or into a state demonstrated to be acceptable on some other defined basis if conditions such as disconnection of the system, loss of energy (e.g., electric power, instrument air), or postulated adverse environments (e.g., extreme heat or cold, fire, pressure, steam, water, and radiation) are experienced.</td></tr>
<tr><td>Basis:</td><td colspan="2">No changes are proposed to the existing MHTGR-DC 23 language.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 23</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2"><i>24. Separation of protection and control systems</i></th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">The protection system shall be separated from control systems to the extent that failure of any single control system component or channel, or failure or removal from service of any single protection system component or channel which is common to the control and protection systems leaves intact a system satisfying all reliability, redundancy, and independence requirements of the protection system. Interconnection of the protection and control systems shall be limited so as to assure that safety is not significantly impaired.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 24 of the Xe-100 design uses the language of MHTGR-DC 24 of RG 1.232 [4] with no changes.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 24</td><td>Xe-100 PDC 24</td></tr>
<tr><td>The protection system shall be separated from control systems to the extent that failure of any single control system component or channel, or failure or removal from service of any single protection system component or channel which is common to the control and protection systems leaves intact a system satisfying all reliability, redundancy, and independence requirements of the protection system. Interconnection of the protection and control systems shall be limited so as to assure that safety is not significantly impaired.</td><td>The protection system shall be separated from control systems to the extent that failure of any single control system component or channel, or failure or removal from service of any single protection system component or channel which is common to the control and protection systems leaves intact a system satisfying all reliability, redundancy, and independence requirements of the protection system. Interconnection of the protection and control systems shall be limited so as to assure that safety is not significantly impaired.</td></tr>
<tr><td>Basis:</td><td colspan="2">No changes are proposed to the existing MHTGR-DC 24 language.
The phrases “any single control system component or channel” and “any single protection system component or channel which is common to the control and protection systems” do not imply the single failure criterion.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 24</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2">25. Protection system requirements for reactivity control malfunctions</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">The protection system shall be designed to ensure that specified acceptable system radionuclide release design limits are not exceeded during any anticipated operational occurrence, accounting for a single malfunction of the reactivity control systems.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 25 of the Xe-100 design uses the language of MHTGR-DC 25 of RG 1.232 [4] with no changes.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 25</td><td>Xe-100 PDC 25</td></tr>
<tr><td>The protection system shall be designed to ensure that specified acceptable system radionuclide release design limits are not exceeded during any anticipated operational occurrence, accounting for a single malfunction of the reactivity control systems.</td><td>The protection system shall be designed to ensure that specified acceptable system radionuclide release design limits are not exceeded during any anticipated operational occurrence, accounting for a single malfunction of the reactivity control systems.</td></tr>
<tr><td>Basis:</td><td colspan="2">No changes are proposed to the existing MHTGR-DC 25 language.
The phrase “a single malfunction” does not imply the single failure criterion.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 25</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2"><i>26. Reactivity control systems</i></th></tr>
<tr><td>Xe-100 PDC
CDC</td><td colspan="2">The reactor shall be designed, which is independent and diverse from the reactivity control systems required functional design criteria, to insert negative reactivity at a sufficient rate and amount to assure, with appropriate margin for malfunctions, that the specified acceptable system radionuclide release design limits and the helium pressure boundary design limits are not exceeded, and safe shutdown is achieved and maintained during anticipated operational occurrences.</td></tr>
<tr><td>Xe-100 PDC
RFDC</td><td colspan="2">The reactor shall be designed to provide movable poisons that can insert and maintain safe shutdown during design basis events and design basis accidents.</td></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">A means for holding the reactor shutdown under conditions that allow for interventions such as fuel loading, inspection, and repair shall be provided.</td></tr>
<tr><td rowspan="5">Position:</td><td colspan="2">PDC 26 of the Xe-100 design covers the intent of MHTGR-DC 26 of RG 1.232 [4] with a PDC-CDC, PDC-RFDC and PDC with the following changes:</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 26</td><td>Xe-100 PDC CDC 26</td></tr>
<tr><td rowspan="3">A minimum of two reactivity control systems or means shall provide:
(1) A means of inserting negative reactivity at a sufficient rate and amount to assure, with appropriate margin for malfunctions, that the specified acceptable system radionuclide release design limits and the reactor helium pressure boundary design limits are not exceeded, and safe shutdown is achieved and maintained during normal operation, including anticipated operational occurrences.
(2) A means which is independent and diverse from the other(s), shall be capable of controlling the rate of reactivity changes resulting from planned, normal power changes to assure that the specified acceptable system radionuclide release design limits and the reactor helium pressure boundary design limits are not exceeded.
(3) A means of inserting negative reactivity at a sufficient rate and amount to assure, with appropriate margin for malfunctions, that the capability to cool the core is maintained and a means of shutting down the reactor and maintaining, at a minimum, a safe shutdown condition following a postulated accident.</td><td>~~(1) A means~~ The reactor shall be designed ~~provided~~, independent and diverse from the required functional design criteria, to insert negative reactivity at a sufficient rate and amount to assure, with appropriate margin for malfunctions, that the specified acceptable system radionuclide release design limits and the reactor helium pressure boundary design limits are not exceeded and safe shutdown is achieved and maintained during ~~normal operation, including~~ anticipated operational occurrences.
~~(2) A means which is independent and diverse from the other(s), shall be capable of controlling the rate of reactivity changes resulting from planned, normal power changes to assure that the specified acceptable system radionuclide release design limits and the reactor helium pressure boundary design limits are not exceeded.~~</td></tr>
<tr><td>Xe-100 PDC RFDC 26</td></tr>
<tr><td>~~A minimum of two reactivity control systems or means~~ The reactor shall be designed to provide movable poisons that can ~~provide:~~
~~A means of~~ insert~~ing negative reactivity at a sufficient rate and amount to assure, with appropriate margin for malfunctions, that the~~</td></tr>
</table>

Title:	*26. Reactivity control systems*	
	(4) A means for holding the reactor shutdown under conditions which allow for interventions such as fuel loading, inspection and repair shall be provided.	~~capability to cool the core is maintained and a means of shutting down the reactor~~ and maintain~~ing, at a minimum, a~~ safe shutdown ~~condition following~~ during design basis events and design basis accidents ~~a postulated accident~~.
		Xe-100 PDC 26
		~~(4)~~ A means for holding the reactor shutdown under conditions that allow for interventions such as fuel loading, inspection, and repair shall be provided.
Basis:	PDC 26 requires two reactivity control systems or means to perform the required safety function of “Control reactivity”, which does not align with NEI 18-04 methodology that establishes a functional basis for establishing RFDC and CDC. As such, the scope and intent of PDC-RFDC 26 is collectively covered by PDC-RFDC 26 and PDC-RFDC 11 “Reactor inherent protection.” Because inherent reactivity feedback is one of the means by which the Xe-100 design controls reactivity, PDC-RFDC 26 covers the second means of controlling reactivity, which are the moveable poisons. For PDC-RFDC 26 changed “postulated accident” to “design basis events and design basis accidents” to align with NEI 18-04 [1] terminology. Removed “normal operations” because the OCDC associated with the reactivity control system that maintains normal operations supports an NST PSF not a NSRST PSF or RSF. SARRDL and certain HPB design limits will not be exceeded during normal operations as described in PDC 10. Xe-100 PDC-CDC 26 aligns with NSRST PSF 1.1.2, “Control Reactivity with Movable Poisons”, and meets Criterion (1) & (2) of MHTGR-DC 26. Xe-100 PDC-RFDC 26 aligns with RSF 1.1 “Control Reactivity” and RSF 1.1.2, “Control Reactivity with Movable Poisons”, and meets Criterion (3) of MHTGR-DC 26. As noted above, PDC-RFDC 11, which aligns with RSF 1.1.1 “Ensure Inherent Reactivity Feedback” supports meeting Criterion (3) of MHTGR-DC 26. Xe-100 PDC 26 meets Criterion (4) of MHTGR-DC 26.	
Source:	RG 1.232, Appendix C, Criterion 26	

<table>
<tr><th>Title:</th><th colspan="2">28. Reactivity limits</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">The reactor core, including the reactivity control systems, shall be designed with appropriate limits on the potential amount and rate of reactivity increase to ensure that design basis events and design basis accidents can neither (1) result in damage to the reactor helium pressure boundary greater than limited local yielding, nor (2) sufficiently disturb the core, its support structures, or other reactor vessel internals to impair significantly the capability to cool the core.</td></tr>
<tr><td>Position:</td><td colspan="2">PDC 28 of the Xe-100 design uses the language of MHTGR-DC 28 of RG 1.232 [4] with the following changes.</td></tr>
<tr><td></td><td>RG 1.232, Appendix C, Criterion 28</td><td>Xe-100 PDC RFDC 28</td></tr>
<tr><td></td><td>The reactor core, including the reactivity control systems, shall be designed with appropriate limits on the potential amount and rate of reactivity increase to ensure that the effects of postulated reactivity accidents can neither (1) result in damage to the reactor helium pressure boundary greater than limited local yielding, nor (2) sufficiently disturb the core, its support structures, or other reactor vessel internals to impair significantly the capability to cool the core.</td><td>The reactor core, including the reactivity control systems, shall be designed with appropriate limits on the potential amount and rate of reactivity increase to ensure that design basis events and design basis accidents ~~the effects of postulated reactivity accidents~~ can neither (1) result in damage to the reactor helium pressure boundary greater than limited local yielding, nor (2) sufficiently disturb the core, its support structures, or other reactor vessel internals to impair significantly the capability to cool the core.</td></tr>
<tr><td>Basis:</td><td colspan="2">Replaced “the effect of postulated reactivity accidents” with “design basis events and design basis accidents” to align with NEI 18-04 [1] terminology.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 28</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2"><i>~~29. Protection against anticipated operational occurrences~~</i></th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">~~The protection and reactivity control systems shall be designed to assure an extremely high probability of accomplishing their safety functions in the event of anticipated operational occurrences.~~</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">MHTGR-DC 29 does not provide any additional design criteria not already covered by other Xe-100 PDC and is therefore deleted.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 29</td><td>Xe-100 PDC 29</td></tr>
<tr><td>The protection and reactivity control systems shall be designed to assure an extremely high probability of accomplishing their safety functions in the event of anticipated operational occurrences.</td><td>~~The protection and reactivity control systems shall be designed to assure an extremely high probability of accomplishing their safety functions in the event of anticipated operational occurrences.~~</td></tr>
<tr><td>Basis:</td><td colspan="2">MHTGR-DC 29 is effectively subsumed by the collection of design criteria described in PDC-RFDC 20, PDC 21, PDC 25, and PDC-CDC 26.
PDC-RFDC 20 states “The protection system shall be designed (1) to initiate automatically the operation of appropriate systems, including the reactivity control systems, to assure that the specified acceptable system radionuclide release design limits are not exceeded as a result of anticipated operational occurrences…”
PDC 21 states “The protection system shall be designed for high functional reliability and in-service testability commensurate with the safety functions to be performed.”
PDC 25 states “The protection system shall be designed to assure that specified acceptable system radionuclide release design limits are not exceeded during any anticipated operational occurrence, accounting for a single malfunction of the reactivity control systems."
PDC-CDC 26 states “The reactor shall be designed, which is independent and diverse from the required functional design criteria, of inserting negative reactivity at a sufficient rate and amount to assure, with appropriate margin for malfunctions, that the specified acceptable system radionuclide release design limits and the helium pressure boundary design limits are not exceeded, and safe shutdown is achieved and maintained during anticipated operational occurrences.”</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 29</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2">30. Integrity of reactor helium pressure boundary</th></tr>
<tr><td>Xe-100 PDC
RFDC</td><td colspan="2">The reactor shall be designed to detect moisture ingress within the helium pressure boundary and automatically isolate the source of moisture ingress during design basis events and design basis accidents.</td></tr>
<tr><td>Xe-100 PDC
CDC</td><td colspan="2">The reactor shall be designed to detect and, to the extent practical, identify and isolate the source of reactor helium leakage during anticipated operational occurrences.</td></tr>
<tr><td rowspan="5">Position:</td><td colspan="2">PDC 30 of the Xe-100 design uses the language of MHTGR-DC 30 of RG 1.232 [4] with the following changes.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 30</td><td>Xe-100 PDC RFDC 30</td></tr>
<tr><td>Components that are part of the reactor helium pressure boundary shall be designed, fabricated, erected, and tested to the highest quality standards practical. Means shall be provided for detecting and, to the extent practical, identifying the location of the source of reactor helium leakage. Means shall be provided for detecting ingress of moisture, air, secondary coolant, or other fluids to within the reactor helium pressure boundary.</td><td>~~Components that are part of~~ The reactor ~~helium pressure boundary~~ shall be designed~~, fabricated, erected, and tested to the highest quality standards practical~~. ~~Means shall be provided for detecting and, to the extent practical, identifying the location of the source of reactor helium leakage. Means shall be provided for~~ to detect~~ing~~ ~~ingress of~~ moisture ingress~~, air, secondary coolant, or other fluids to~~ within the ~~reactor~~ helium pressure boundary and automatically isolate the source of moisture ingress during design basis events and design basis accidents.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 30</td><td>Xe-100 PDC CDC 30</td></tr>
<tr><td>Components that are part of the reactor helium pressure boundary shall be designed, fabricated, erected, and tested to the highest quality standards practical. Means shall be provided for detecting and, to the extent practical, identifying the location of the source of reactor helium leakage. Means shall be provided for detecting ingress of moisture, air, secondary coolant, or other fluids to within the reactor helium pressure boundary.</td><td>~~Components that are part of~~ The reactor ~~helium pressure boundary~~ shall be designed~~, fabricated, erected, and tested to the highest quality standards practical. Means shall be provided for~~ to detect~~ing~~ and, to the extent practical, identify~~ing~~ and isolate ~~the location of~~ the source of reactor helium leakage during anticipated operational occurrences. ~~Means shall be provided for detecting ingress of moisture, air, secondary coolant, or other fluids to within the reactor helium pressure boundary.~~</td></tr>
<tr><td>Basis:</td><td colspan="2">PDC 30 is separated into a PDC-RFDC for isolating to prevent excessive moisture ingress during DBEs and DBAs and a PDC-CDC to prevent helium leakage during AOOs. Added “assure that the helium pressure boundary design limit is not exceeded” for both PDC-RFDC and PDC-CDC.
Because PDC 1 addresses quality assurance characteristics for all safety significant SSCs, the phrase “fabricated, erected” was removed. In addition, PDC 6 addresses monitoring and testing, therefore “tested”</td></tr>
</table>

Title:	***30. Integrity of reactor helium pressure boundary***
	was removed. As such, the term “Quality” was replaced with “Integrity” in the title of PDC 30 to better align with updated design criteria. The PDC-RFDC 30 aligns with RSF 1.3 “Control Water/Steam/Ingress” and RSF1.3.1, “Isolate Water/Steam Source” The PDC-CDC 30 aligns with NSRST PSF 2.5, “Maintain HPB Pressure Integrity During Transients”. Preventing helium leakage is identified as an NSRST PSF at the point where the leakage is beyond the normal makeup capability.
Source:	RG 1.232, Appendix C, Criterion 30

<table>
<tr><th>Title:</th><th colspan="2">31. Fracture prevention of reactor helium pressure boundary</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">The reactor helium pressure boundary design shall reflect consideration of service temperatures, service degradation of material properties, creep, fatigue, stress rupture, and other conditions of the boundary material under operating, maintenance, testing, anticipated operational occurrences, design basis events, and design basis accidents and the uncertainties in determining (1) material properties, (2) the effects of irradiation and helium composition, including contaminants and reaction products, on material properties, (3) residual, steady-state, and transient stresses, and (4) size of flaws.</td></tr>
<tr><td>Position:</td><td colspan="2">PDC 31 of the Xe-100 design uses the language of MHTGR-DC 31 of RG 1.232 [4] with the changes below.</td></tr>
<tr><td></td><td>RG 1.232, Appendix C, Criterion 31</td><td>Xe-100 PDC 31</td></tr>
<tr><td></td><td>The reactor helium pressure boundary shall be designed with sufficient margin to ensure that, when stressed under operating, maintenance, testing, and postulated accident conditions, (1) the boundary behaves in a nonbrittle manner and (2) the probability of rapidly propagating fracture is minimized. The design shall reflect consideration of service temperatures, service degradation of material properties, creep, fatigue, stress rupture, and other conditions of the boundary material under operating, maintenance, testing, and postulated accident conditions and the uncertainties in determining (1) material properties, (2) the effects of irradiation and helium composition, including contaminants and reaction products, on material properties, (3) residual, steady-state, and transient stresses, and (4) size of flaws.</td><td>The reactor helium pressure boundary ~~shall be designed with sufficient margin to ensure that, when stressed under operating, maintenance, testing, and postulated accident conditions, (1) the boundary behaves in a nonbrittle manner and (2) the probability of rapidly propagating fracture is minimized. The~~ design shall reflect consideration of service temperatures, service degradation of material properties, creep, fatigue, stress rupture, and other conditions of the boundary material under operating, maintenance, testing, ~~and postulated accident conditions~~ anticipated operational occurrences, design basis events, and design basis accidents and the uncertainties in determining (1) material properties, (2) the effects of irradiation and helium composition, including contaminants and reaction products, on material properties, (3) residual, steady-state, and transient stresses, and (4) size of flaws.</td></tr>
<tr><td>Basis:</td><td colspan="2">Changed the existing MHTGR-DC 31 phrase “postulated accident conditions” to “anticipated operational occurrences, design basis events, and design basis accidents” to align with NEI 18-04 [1] terminology.
Removed the phrases “shall be designed with sufficient margin to ensure that, when stressed” and “(1) the boundary behaves in a nonbrittle manner and (2) the probability of rapidly propagating fracture is minimized” because the phenomena are adequately captured in PDC-RFDC 70, “Reactor vessel and reactor system structural design basis,” which states “The helium pressure boundary shall be designed such that the reactor vessel and reactor system integrity is maintained during anticipated operational occurrences, design basis events, and design basis accidents and that there is a low probability of rapidly propagating failure”
Xe-100 PDC 31 is aligned with the capability targets, reliability targets, and special treatments established in accordance with the NEI 18-04 [1] methodology and will meet the intent of the MHTGR-DC 31.</td></tr>
</table>

Title:	***31. Fracture prevention of reactor helium pressure boundary***
Source:	RG 1.232, Appendix C, Criterion 31

<table>
<tr><th>Title:</th><th colspan="2"><i>32. Inspection of reactor helium pressure boundary (replaced by Xe-100 PDC 6, Monitoring Inspection Testing Surveillance and restated here)</i></th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Safety-significant structures, systems, and components shall be designed to permit monitoring, periodic inspection, testing, and/or surveillance to ensure functional capability commensurate with the safety significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, during anticipated operational occurrences, design basis events, and design basis accidents as appropriate.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 6 of the Xe-100 design uses language from MHTGR-DCs 18, 32, 36, 37, 45, 46, and 72 of RG 1.232 [4] into a single PDC for monitoring, inspection, testing, surveillance.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 32</td><td>Xe-100 PDC 6</td></tr>
<tr><td>Components that are part of the reactor helium pressure boundary shall be designed to permit (1) periodic inspection and functional testing of important areas and features to assess their structural and leak-tight integrity, and (2) an appropriate material surveillance program for the reactor vessel.</td><td>Safety-significant structures, systems, and components ~~that are part of the reactor helium pressure boundary~~ shall be designed to permit ~~(1)~~ monitoring, periodic inspection, testing, and/or ~~functional of important areas and features to assess their structural and leaktight integrity, and (2) an appropriate material~~ surveillances~~ program for the reactor vessel.~~ to ensure functional capability commensurate with the safety significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, during anticipated operational occurrences, design basis events, and design basis accidents as appropriate.</td></tr>
<tr><td>Basis:</td><td colspan="2">Adding the phrase “structural and leak-tight integrity” of the HPB to PDC 6 was not deemed necessary given that the concepts would be addressed, as applicable, in the phrase “to ensure functional capability commensurate with the safety significance of the functions to be performed”. Structural integrity is also already a requirement in PDC-RFDC 70 for the HPB and aligns with PDC-RFDC 14. Leak-tight is addressed in PDC CDC 15, 16, and 30.
The phrase “of important areas and features to assess their structural and leak-tight integrity, and (2) an appropriate material surveillance program for the reactor vessel” is addressed by “functional capability” to be clearly defined as capability targets under NEI 18-04 [1] through the IDP. Monitoring, periodic inspection, testing and/or surveillances will be established as special treatments in accordance with the NEI 18-04 IDP.</td></tr>
</table>

Source:	RG 1.232, Appendix C, Criterion 32

<table>
<tr><th>Title:</th><th colspan="2"><i>34. Residual heat removal</i></th></tr>
<tr><td>Xe-100 PDC RFDC</td><td colspan="2">A passive means to remove residual heat shall be designed to provide effective heat removal to ensure that fuel and radionuclide release limits are not exceeded during design basis events and design basis accidents.</td></tr>
<tr><td>Xe-100 PDC CDC</td><td colspan="2">An active means shall be designed to transfer fission product decay heat and other residual heat from the reactor core to an ultimate heat sink at a rate such that specified acceptable system radionuclide release design limits are not exceeded during anticipated operational occurrences.</td></tr>
<tr><td rowspan="5">Position:</td><td colspan="2">PDC 34 of the Xe-100 design addresses the intent of MHTGR-DC 34 of RG 1.232 [4] with both a PDC-RFDC and a PDC-CDC.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 34</td><td>Xe-100 PDC RFDC 34</td></tr>
<tr><td>A passive system to remove residual heat shall be provided. For normal operations and anticipated operational occurrences, the system safety function shall be to transfer fission product decay heat and other residual heat from the reactor core to an ultimate heat sink at a rate such that specified acceptable system radionuclide release design limits and the design conditions of the reactor helium pressure boundary are not exceeded.
During postulated accidents, the system safety function shall provide effective cooling.
Suitable redundancy in components and features and suitable interconnections, leak detection, and isolation capabilities shall be provided to ensure the system safety function can be accomplished, assuming a single failure.</td><td>A passive system to remove residual heat shall be designed to provide~~. For normal operations and anticipated operational occurrences, the system safety function shall be to transfer fission product decay heat and other residual heat from the reactor core to an ultimate heat sink at a rate such that specified acceptable system radionuclide release design limits and the design conditions of the reactor helium pressure boundary are not exceeded. During postulated accidents, the passive system safety function shall provide~~ effective ~~cooling~~ heat removal to ensure that fuel and radionuclide release limits are not exceeded during design basis events and design basis accidents.
~~Suitable redundancy in components and features and suitable interconnections, leak detection, and isolation capabilities shall be provided to ensure the system safety function can be accomplished, assuming a single failure.~~</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 34</td><td>Xe-100 PDC CDC 34</td></tr>
<tr><td>A passive system to remove residual heat shall be provided. For normal operations and anticipated operational occurrences, the system safety function shall be to transfer fission product decay heat and other residual heat from the reactor core to an ultimate heat sink at a rate such that specified acceptable system radionuclide release design</td><td>~~A passive system to remove residual heat shall be provided. For normal operations and anticipated operational occurrences, the system safety function~~ An active means shall be designed to transfer fission product decay heat and other residual heat from the reactor core to an ultimate heat sink at a rate such that specified acceptable system radionuclide release design limits are not exceeded</td></tr>
</table>

Title:	***34. Residual heat removal***	
	limits and the design conditions of the reactor helium pressure boundary are not exceeded. During postulated accidents, the system safety function shall provide effective cooling. Suitable redundancy in components and features and suitable interconnections, leak detection, and isolation capabilities shall be provided to ensure the system safety function can be accomplished, assuming a single failure.	during anticipated operational occurrences. ~~and the design conditions of the reactor helium pressure boundary are not exceeded~~ ~~During postulated accidents, the system safety function shall provide effective cooling.~~ ~~Suitable redundancy in components and features and suitable interconnections, leak detection, and isolation capabilities shall be provided to ensure the system safety function can be accomplished, assuming a single failure.~~
Basis:	The title of PDC 34 was changed from “Passive residual heat removal” to “Residual heat removal” given the passive heat removal capability supports the RFDC and the active heat removal capability supports the CDC. The MHTGR-DC 34 wording was split into a PDC-RFDC for DBEs and DBAs as defined in NEI 18-04 and a PDC-CDC for AOOs. In line with the DID guidelines from NEI 18-04 [1], challenges to SR SSCs should be minimized during normal operation and AOOs. The phrase “for normal operations” was removed because design criteria for active heat to support normal operations will align with OCDC that provide NST PSFs. The single failure criterion language is deleted consistent with the guidance in NEI 18-04 as endorsed by RG 1.233 [2]. Reliability targets will be set for safety significant SSCs and special treatments will be applied to ensure those reliability targets are met in line with NEI 18-04 and RG 1.233. Language around suitable redundancy was deleted as the intent will be met with special treatments. The stated PDC-RFDC 34 “fuel performance limits” are considered the same as the previously used “fuel design limits” discussed in the PDC 10 NRC rationale in RG 1.232 [4]. The PDC-RFDC 34 aligns with RSF 1.2.1, “Control Heat Removal Through Passive Means.” The phrase “effective cooling” is defined in the capability targets based on LBE success criteria. The PDC-CDC 34 aligns with NSRST PSF 1.2.2, “Control Heat Removal with Active Means.” The phrase “and the design conditions of the reactor helium pressure boundary are not exceeded” was not included in PDC-CDC 34 because maintaining the helium pressure boundary is not a required safety function for the Xe-100 design. The function of the HPB to maintain core geometry is covered in PDC 70.	
Source:	RG 1.232, Appendix C, Criterion 34	

<table>
<tr><th>Title:</th><th colspan="2">36. Inspection of passive residual heat removal system (replaced by Xe-100 PDC 6, Monitoring Inspection Testing Surveillance and restated here)</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Safety-significant structures, systems, and components shall be designed to permit monitoring, periodic inspection, testing, and/or surveillance to ensure functional capability commensurate with the safety significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, during anticipated operational occurrences, design basis events, and design basis accidents as appropriate.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 6 of the Xe-100 design uses language from MHTGR-DCs 18, 32, 36, 37, 45, 46, and 72 of RG 1.232 [4] into a single PDC for monitoring, inspection, testing, surveillance.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 36</td><td>Xe-100 PDC 6</td></tr>
<tr><td>The passive residual heat removal system shall be designed to permit appropriate periodic inspection of important components to ensure the integrity and capability of the system.</td><td>~~The passive residual heat removal~~ Safety-significant structures, systems, and components shall be designed to permit ~~appropriate~~ monitoring, periodic inspection, ~~of important components to ensure the integrity and capability of the system.~~ testing, and/or surveillance to ensure functional capability commensurate with the safety significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, during anticipated operational occurrences, design basis events, and design basis accidents as appropriate.</td></tr>
<tr><td>Basis:</td><td colspan="2">“Integrity and capability” will be addressed by functional capability to be clearly defined as capability targets under NEI 18-04 [1] through the IDP. Monitoring, periodic inspection, testing, and/or surveillance will be established as special treatments in accordance with the NEI 18-04 IDP. Capability is defined based on PDC 34, providing effective cooling to meet dose targets in NEI 18-04 for DBEs and DBAs and to meet SARRDL for AOOs. The passive heat removal system provides the capability to perform periodic pressure and functional testing that along with online monitoring ensures operability and performance of system components and the operability and performance of the system as a whole.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 36</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2">37. Testing of passive residual heat removal system (replaced by Xe-100 PDC 6, Monitoring Inspection Testing Surveillance and restated here)</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Safety-significant structures, systems, and components shall be designed to permit monitoring, periodic inspection, testing, and/or surveillance to ensure functional capability commensurate with the safety significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, during anticipated operational occurrences, design basis events, and design basis accidents.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 6 of the Xe-100 design uses language from MHTGR-DCs 18, 32, 36, 37, 45, 46, and 72 of RG 1.232 [4] into a single PDC for monitoring, inspection, testing, surveillance.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 37</td><td>Xe-100 PDC 6</td></tr>
<tr><td>The passive residual heat removal system shall be designed to permit appropriate periodic functional testing to ensure (1) the structural and leak tight integrity of its components, (2) the operability and performance of the system components, and (3) the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, for AOO or postulated accident decay heat removal to the ultimate heat sink and, if applicable, any system(s) necessary to transition from active normal operation to passive mode.</td><td>~~The passive residual heat removal~~ Safety-significant structures, systems, and components shall be designed to permit ~~appropriate~~ monitoring, periodic inspection, testing, and/or surveillance to ensure ~~(1) the structural and leaktight integrity of its components, (2)~~ functional capability commensurate with the safety significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and ~~(3)~~ the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, during ~~AOO or postulated accident decay heat removal to the ultimate heat sink and, if applicable, any system(s) necessary to transition from active normal operation to passive mode.~~ anticipated operational occurrences, design basis events, and design basis accidents as appropriate.</td></tr>
<tr><td>Basis:</td><td colspan="2">The passive heat removal system provides the capability to perform periodic pressure and functional testing that along with online monitoring ensures operability and performance of system components and the operability and performance of the system as a whole.
“(1) the structural and leak tight integrity of its components, (2)” and “AOO or postulated accident decay heat removal to the ultimate heat sink and, if applicable, any system(s) necessary to transition from active normal operation to passive mode.” are covered by functional capability to be clearly defined as capability targets under NEI 18-04 [1] through the IDP. Monitoring, periodic inspection, testing, and/or surveillance will be established as special treatments in accordance with the NEI 18-04 IDP.</td></tr>
</table>

Title:	***37. Testing of passive residual heat removal system (replaced by Xe-100 PDC 6, Monitoring Inspection Testing Surveillance and restated here)***
Source:	RG 1.232, Appendix C, Criterion 37

<table>
<tr><th>Title:</th><th colspan="2">44. Structural and equipment cooling</th></tr>
<tr><td>Xe-100 PDC CDC</td><td colspan="2">In addition to the heat rejection capability of the passive residual heat removal system, a means shall be designed to transfer heat from safety-significant structures, systems, and components to a heat sink, as necessary, to transfer the combined heat load of these safety-significant structures, systems, and components during normal operations and anticipated operational occurrences.</td></tr>
<tr><td>Position:</td><td colspan="2">PDC 44 of the Xe-100 design uses the language of MHTGR-DC 44 of RG 1.232 [4] with the changes below.</td></tr>
<tr><td></td><td>RG 1.232, Appendix C, Criterion 44</td><td>Xe-100 PDC CDC 44</td></tr>
<tr><td></td><td>In addition to the heat rejection capability of the passive residual heat removal system, systems to transfer heat from structures, systems, and components important to safety to an ultimate heat sink shall be provided, as necessary, to transfer the combined heat load of these structures, systems, and components under normal operating and accident conditions.
Suitable redundancy in components and features and suitable interconnections, leak detection, and isolation capabilities shall be provided to ensure that the system safety function can be accomplished, assuming a single failure.</td><td>In addition to the heat rejection capability of the passive residual heat removal system, ~~systems~~ a means shall be designed to transfer heat from ~~important to safety~~ safety-significant structures, systems, and components to a heat sink ~~shall be provided~~, as necessary, to transfer the combined heat load of these structures, systems, and components ~~under~~ during ~~normal operating and accident conditions~~ anticipated operational occurrences.
~~Suitable redundancy in components and features and suitable interconnections, leak detection, and isolation capabilities shall be provided to ensure that the system safety function can be accomplished, assuming a single failure.~~</td></tr>
<tr><td>Basis:</td><td colspan="2">PDC-RFDC 34 of the Xe-100 design addresses the intent of MHTGR-DC 44 by providing adequate cooling for structures that support meeting the required safety functions. PDC-CDC 44 is retained because safety-significant, but not risk-significant, SSCs require cooling that is not covered by PDC-RFDC 34. The passive residual heat removal system provides indefinite core cooling capability as described in PDC-RFDC 34. Structural and equipment cooling systems are only required for DID adequacy.
Replaced the phrase “shall be provided” with “shall be designed” to limit the criteria to the design of safety-significant instrumentation and control SSCs. The term “provided” could construe other activities beyond design criteria.
Replaced “under” with “during” to be consistent with other PDC.
Replaced “accident conditions” with “anticipated operational occurrences” to align with the NEI 18-04 methodology. PDC-CDC 44 is not required to assure that any design limits are not exceeded during DBEs nor DBAs.
The phrase “important to safety” is changed to “safety-significant” as described in the basis for PDC 1.
The modified PDC-CDC 44 aligns with the NSRST PSF 1.2.2 “Control Heat Removal with Active Means.”</td></tr>
</table>

Title:	*44. Structural and equipment cooling*
	Removed the phrase “under normal operating conditions” from PDC-CDC 44 because design criteria for structural and equipment cooling to support normal operations will align with OCDC that provide NST PSFs. The single failure criterion language is deleted consistent with the guidance in NEI 18-04 [1] as endorsed by RG 1.233 [2]. Reliability targets will be set for safety significant SSCs and special treatments will be applied to ensure those reliability targets are met in line with NEI 18-04 and RG 1.233.
Source:	RG 1.232, Appendix C, Criterion 44

<table>
<tr><th>Title:</th><th colspan="2">45. Inspection of structural and equipment cooling systems (replaced by Xe-100 PDC 6, Monitoring Inspection Testing Surveillance and restated here)</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Safety-significant structures, systems, and components shall be designed to permit monitoring, periodic inspection, testing, and/or surveillance to ensure functional capability commensurate with the safety significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, during anticipated operational occurrences, design basis events, and design basis accidents as appropriate.</td></tr>
<tr><td>Position:</td><td colspan="2">PDC 6 of the Xe-100 design uses language from MHTGR-DCs 18, 32, 36, 37, 45, 46, and 72 of RG 1.232 [4] into a single PDC for monitoring, inspection, testing, surveillance.</td></tr>
<tr><td></td><td>RG 1.232, Appendix C, Criterion 45</td><td>Xe-100 PDC 6</td></tr>
<tr><td></td><td>The structural and equipment cooling systems shall be designed to permit appropriate periodic inspection of important components, such as heat exchangers and piping, to assure the integrity and capability of the systems.</td><td>Safety-significant structures, ~~The structural and equipment cooling~~ systems, and components shall be designed to permit ~~appropriate~~ monitoring, periodic inspection, testing ~~of important components, such as heat exchangers and piping, to assure the integrity and capability of the systems.~~ and/or surveillance to ensure functional capability commensurate with the safety significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, during anticipated operational occurrences, design basis events, and design basis accidents.</td></tr>
<tr><td>Basis:</td><td colspan="2">The passive heat removal system provides indefinite core cooling capability (see PDC 34), therefore PDC 44 is only required for DID cooling and the testing and inspection of equipment to support PDC 44 will be special treatments for those NSRST SSCs. PDC 6 covers the intent of MHTGR-DC 36 and 37 for structural cooling to support RSFs as well as MHTGR-DC 45 and 46 for structural cooling to support NSRST PSFs.
"Integrity and capability of the systems” is covered by “capability commensurate with the safety significance of the functions to be performed.”
Monitoring, periodic inspection, testing, and/or surveillance of SSC cooling to support safety-significant active cooling will be established as special treatments in accordance with the NEI 18-04 [1] IDP.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 45</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2">46. Testing of structural and equipment cooling systems (replaced by Xe-100 PDC 6, Monitoring Inspection Testing Surveillance and restated here)</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Safety-significant structures, systems, and components shall be designed to permit monitoring, periodic inspection, testing, and/or surveillance to ensure functional capability commensurate with the safety significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, during anticipated operational occurrences, design basis events, and design basis accidents as appropriate.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 6 of the Xe-100 design uses language from MHTGR-DCs 18, 32, 36, 37, 45, 46, and 72 of RG 1.232 [4] into a single PDC for monitoring, inspection, testing, surveillance.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 46</td><td>Xe-100 PDC 6</td></tr>
<tr><td>The structural and equipment cooling systems shall be designed to permit appropriate periodic functional testing to assure (1) the structural and leak tight integrity of their components, (2) the operability and the performance of the system components, and (3) the operability of the systems as a whole and, under conditions as close to design as practical, the performance of the full operational sequences that bring the systems into operation for reactor shutdown and postulated accidents, including operation of associated systems.</td><td>~~The structural and equipment cooling~~ Safety-significant structures, systems, and components shall be designed to permit ~~appropriate~~ monitoring, periodic inspection, testing, and/or surveillance to ensure ~~assure (1) the structural and leaktight integrity of their components, (2)~~ functional capability commensurate with the safety significance of the functions to be performed. ~~f~~Functional testing shall ensure the operability and ~~the~~ performance of the system components, and ~~(3)~~ the operability of the system~~s~~ as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system~~s~~ into operation ~~for reactor shutdown and postulated accidents,~~ including ~~operation of~~ associated systems, during anticipated operational occurrences, design basis events, and design basis accidents as appropriate.</td></tr>
<tr><td>Basis:</td><td colspan="2">The passive heat removal system provides indefinite core cooling capability (see PDC 34), therefore PDC 44 is only required for DID cooling and the testing and inspection of equipment to support PDC 44 will be special treatments for those NSRST SSCs. PDC 6 covers the intent of MHTGR DC 36 and 37 for structural cooling to support RSFs as well as MHTGR DCs 45 and 46 for structural cooling to support safety significant PSFs.
“Structural and leak tight integrity” is covered in the capabilities required to meet PDC 15, 16, and 30 and effective cooling is provided by PDC-RFDC 34. SSCs required for “reactor shutdown” fail in the safe position on loss of cooling, justifying the removal of this language from PDC 46.
Monitoring, periodic inspection, testing, and/or surveillance of SSC cooling to support safety-significant active cooling will be established as special treatments in accordance with the NEI 18-04 [1] IDP.</td></tr>
</table>

Title:	***46. Testing of structural and equipment cooling systems (replaced by Xe-100 PDC 6, Monitoring Inspection Testing Surveillance and restated here)***
Source:	RG 1.232, Appendix C, Criterion 46

Title:	***60. Control of releases of radioactive materials to the environment***	
Xe-100 PDC	The nuclear power unit design shall include means to control suitably the release of radioactive materials in gaseous and liquid effluents and to handle radioactive solid wastes produced during normal operations and anticipated operational occurrences. Sufficient holdup capacity, or other means necessary, shall be provided for retention, or other controlling measure, of gaseous and liquid effluents containing radioactive materials, particularly where unfavorable site environmental conditions can be expected to impose unusual operational limitations upon the release of such effluents to the environment.	
Position:	PDC 60 of the Xe-100 design uses the language of MHTGR-DC 60 of RG 1.232 [4] with minor changes.	
	RG 1.232, Appendix C, Criterion 60	Xe-100 PDC 60
	The nuclear power unit design shall include means to control suitably the release of radioactive materials in gaseous and liquid effluents and to handle radioactive solid wastes produced during normal reactor operation, including anticipated operational occurrences. Sufficient holdup capacity shall be provided for retention of gaseous and liquid effluents containing radioactive materials, particularly where unfavorable site environmental conditions can be expected to impose unusual operational limitations upon the release of such effluents to the environment.	The nuclear power unit design shall include means to control suitably the release of radioactive materials in gaseous and liquid effluents and to handle radioactive solid wastes produced during normal ~~reactor~~ operations and ~~including~~ anticipated operational occurrences. Sufficient holdup capacity, or other means necessary, shall be provided for retention, or other controlling measure, of gaseous and liquid effluents containing radioactive materials, particularly where unfavorable site environmental conditions can be expected to impose unusual operational limitations upon the release of such effluents to the environment.
Basis:	Removed “reactor” and “including” to simplify the phrase to read “during normal operations and anticipated operational occurrences.” Added “or other means necessary” and “or other controlling measure” to allow for alternative design solutions beyond “sufficient holdup capacity” and “retention” to effectively control the release of radioactive materials to the environment when unfavorable site environmental conditions are expected.	
Source:	RG 1.232, Appendix C, Criterion 60	

Title:	***61. Fuel storage and handling and radioactivity control***	
Xe-100 PDC	The fuel, storage and handling systems that interface with the fuel, radioactive waste systems, and other systems that may contain radioactivity shall be designed to assure adequate safety, commensurate with the safety-significance of the functions to be performed, during normal operations, anticipated operational occurrences, design basis events, and design basis accidents as appropriate. These systems shall be designed (1) with suitable shielding for radiation protection, (2) with appropriate containment, confinement, and/or filtering systems, (3) with sufficient residual heat removal, and (4) to prevent significant reduction in fuel storage cooling during anticipated operational occurrences, design basis events, and design basis accidents as appropriate.	
Position:	PDC 61 of the Xe-100 design uses the language of MHTGR-DC 61 of RG 1.232 [4] with the following changes:	
	RG 1.232, Appendix C, Criterion 61	Xe-100 PDC 61
	The fuel storage and handling, radioactive waste, and other systems which may contain radioactivity shall be designed to assure adequate safety under normal and postulated accident conditions. These systems shall be designed (1) with a capability to permit appropriate periodic inspection and testing of components important to safety, (2) with suitable shielding for radiation protection, (3) with appropriate containment, confinement, and filtering systems, (4) with a residual heat removal capability having reliability and testability that reflects the importance to safety of decay heat and other residual heat removal, and (5) to prevent significant reduction in fuel storage cooling under accident conditions.	The fuel, storage and handling systems that interface with the fuel, radioactive waste systems, and other systems which may contain radioactivity shall be designed to assure adequate safety, commensurate with the safety-significance of the functions to be performed, ~~under~~ during normal operations, ~~and postulated accident conditions~~ anticipated operational occurrences, design basis events, and design basis accidents as appropriate. These systems shall be designed ~~(1) with a capability to permit appropriate periodic inspection and testing of components important to safety, (2)~~ (1) with suitable shielding for radiation protection, ~~(3)~~ (2) with appropriate containment, confinement, and/or filtering systems, ~~(4)~~ (3) with ~~a~~ sufficient residual heat removal ~~capability having reliability and testability that reflects the importance to safety of decay heat and other residual heat removal~~, and (4) ~~(5)~~ to prevent significant reduction in fuel storage cooling during anticipated operational occurrences, design basis events, and design basis accidents as appropriate. ~~under postulated accident conditions~~
Basis:	The "fuel" was separated from the "storage and handling systems" because the fuel, as a system, has different design criteria and associated limits than the systems that the fuel interfaces with outside of the core. As such, the phrase "storage and handling systems that interface with the fuel" was added to "fuel" to create the distinction. Changed "accident conditions" to "anticipated operational occurrences, design basis events, and design basis accidents" to align with NEI 18-04 [1] terminology.	

Title:	***61. Fuel storage and handling and radioactivity control***
	Added “commensurate with the safety-significance of the functions to be performed” because the various systems described in PDC-RFDC-CDC-OCDC are applicable during normal operations, AOOs, DBEs, and DBAs, therefore the design criteria must be commensurate with the safety-significance of the functions and associated safety classification of the SSCs. The phrase “as appropriate” was added to the end of “AOOs, DBEs, and DBAs” to reiterate that the design criteria for the various systems is commensurate with the LBEs they are required to withstand. Removed “capability to permit appropriate periodic inspection and testing of components” and “and testability” because periodic inspection and testing is sufficiently covered by PDC 6. Added the “and/or” to provide optionality in design solutions. Replaced “capability having reliability and testability that reflects the importance to safety of decay heat and other residual heat removal” with “sufficient” to simplify the language such that the phrase states “(3) with sufficient residual heat removal.” Replaced “under accident conditions” with “during “anticipated operational occurrences, design basis events, and design basis accidents as appropriate” to align with the NEI 18-04 methodology.
Source:	RG 1.232, Appendix C, Criterion 61

<table>
<tr><th>Title:</th><th colspan="2">62. Prevention of criticality in fuel storage and handling</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Criticality in the fuel storage and handling system shall be prevented by physical systems or processes, preferably by use of geometrically safe configurations.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 62 of the Xe-100 design uses the language of MHTGR-DC 62 of RG 1.232 [4] with no changes.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 62</td><td>Xe-100 PDC 62</td></tr>
<tr><td>Criticality in the fuel storage and handling system shall be prevented by physical systems or processes, preferably by use of geometrically safe configurations.</td><td>Criticality in the fuel storage and handling system shall be prevented by physical systems or processes, preferably by use of geometrically safe configurations.</td></tr>
<tr><td>Basis:</td><td colspan="2">No changes are proposed to the existing MHTGR-DC 62 language.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 62</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2">*63. Monitoring fuel and waste storage*</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Appropriate systems shall be provided in fuel storage and radioactive waste systems and associated handling areas (1) to detect conditions that may result in loss of residual heat removal capability and excessive radiation levels and (2) to initiate appropriate safety actions.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 63 of the Xe-100 design uses the language of MHTGR-DC 63 of RG 1.232 [4] with no changes.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 63</td><td>Xe-100 PDC 63</td></tr>
<tr><td>Appropriate systems shall be provided in fuel storage and radioactive waste systems and associated handling areas (1) to detect conditions that may result in loss of residual heat removal capability and excessive radiation levels and (2) to initiate appropriate safety actions.</td><td>Appropriate systems shall be provided in fuel storage and radioactive waste systems and associated handling areas (1) to detect conditions that may result in loss of residual heat removal capability and excessive radiation levels and (2) to initiate appropriate safety actions.</td></tr>
<tr><td>Basis:</td><td colspan="2">No changes are proposed to the existing MHTGR-DC 63 language.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 63</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2">64. Monitoring radioactivity releases</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Means shall be provided for monitoring the reactor building atmosphere, effluent discharge paths, and plant environs for radioactivity that may be released during normal operations, anticipated operational occurrences, and design basis events.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 64 of the Xe-100 design uses the language of MHTGR-DC 64 of RG 1.232 [4] with the changes below.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 64</td><td>Xe-100 PDC 64</td></tr>
<tr><td>Means shall be provided for monitoring the reactor building atmosphere, effluent discharge paths, and plant environs for radioactivity that may be released from normal operations, including anticipated operational occurrences, and from postulated accidents.</td><td>Means shall be provided for monitoring the reactor building atmosphere, effluent discharge paths, and plant environs for radioactivity that may be released ~~from~~ during normal operations, ~~including~~ anticipated operational occurrences, and ~~from postulated accidents~~ design basis events.</td></tr>
<tr><td>Basis:</td><td colspan="2">MHTGR-DC 64 was modified to align with NEI 18-04 [1] terminology. Monitoring is required only for DID and no operator actions have been identified that would require any response during DBAs, therefore the phrase “postulated accidents” was replaced with “design basis events.”
Because PDC 64 is applicable to normal operations, AOOs, and DBEs, the design criteria associated with monitoring radioactive releases is commensurate with the plant state.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 64</td></tr>
</table>

<table>
<tr><th>Title:</th><th colspan="2">70. Reactor vessel and reactor system structural design basis</th></tr>
<tr><td>Xe-100 PDC RFDC</td><td colspan="2">The helium pressure boundary shall be designed such that the reactor vessel and reactor system integrity is maintained and that there is a low probability of rapidly propagating failure during design basis events and design basis accidents to (1) ensure the geometry for passive removal of residual heat from the reactor core to the ultimate heat sink and (2) permit sufficient insertion of the neutron absorbers and maintain reactor inherent protection to provide for reactor shutdown.</td></tr>
<tr><td>Position:</td><td colspan="2">PDC 70 of the Xe-100 design uses the language of MHTGR-DC 70 of RG 1.232 [4] with the changes below.</td></tr>
<tr><td></td><td>RG 1.232, Appendix C, Criterion 70</td><td>Xe-100 PDC 70</td></tr>
<tr><td></td><td>The design of the reactor vessel and reactor system shall be such that their integrity is maintained during postulated accidents (1) to ensure the geometry for passive removal of residual heat from the reactor core to the ultimate heat sink and (2) to permit sufficient insertion of the neutron absorbers to provide for reactor shutdown.</td><td>The helium pressure boundary shall be designed such that the reactor vessel and reactor system ~~shall be such that their~~ integrity is maintained ~~during postulated accidents~~ and that there is a low probability of rapidly propagating failure during design basis events and design basis accidents to (1) ~~to~~ ensure the geometry for passive removal of residual heat from the reactor core to the ultimate heat sink and (2) ~~to~~ permit sufficient insertion of the neutron absorbers and maintain reactor inherent protection to provide for reactor shutdown.</td></tr>
<tr><td>Basis:</td><td colspan="2">Changed “postulated accidents” to “DBEs and DBAs” to align with NEI 18-04 [1] terminology.
Added the phrase “low probability of rapidly propagating failure” from MHTGR-DC 14 because it was more focused on the core geometry function not controlling moisture ingress. Preventing the HPB from a rapidly propagating failure is part of the RFDC only if it challenged conditions (1) and (2).
Added “maintain reactor inherent protection” because by maintaining core geometry the inherent negative reactivity feedback supports safe shutdown as described in PDC-RFDC 11, “Reactor inherent protection”.
Xe-100 PDC RFDC 70 aligns with RSF 1.4.1, “Maintain HPB and Core Geometry,” which meets the intent of MHTGR-DC 70 and the “low probability of rapidly propagating failure” portion of MHTGR-DC 14.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 70</td></tr>
</table>

Title:	***71. Reactor building design basis***	
Xe-100 PDC RFDC	The reactor building shall be designed such that it structurally protects the reactor vessel and reactor system geometry during design basis events and design basis accidents to ensure passive removal of residual heat from the reactor core to the ultimate heat sink and permit sufficient insertion of the neutron absorbers and maintain reactor inherent protection to provide for reactor shutdown.	
Position:	PDC 71 of the Xe-100 design uses the language of MHTGR-DC 71 of RG 1.232 [4] with the changes below.	
	RG 1.232, Appendix C, Criterion 71	Xe-100 PDC 71
	The design of the reactor building shall be such that, during postulated accidents, it structurally protects the geometry for passive removal of residual heat from the reactor core to the ultimate heat sink and provides a pathway for the release of reactor helium from the building in the event of depressurization accidents.	The ~~design of the~~ reactor building shall be designed such that~~, during postulated accidents,~~ it structurally protects the reactor vessel and reactor system geometry during design basis events and design basis accidents ~~for~~ to ensure passive removal of residual heat from the reactor core to the ultimate heat sink and ~~provides a pathway for the release of reactor helium from the building in the event of depressurization accidents~~ permit sufficient insertion of the neutron absorbers and maintain reactor inherent protection to provide for reactor shutdown.
Basis:	Replaced “postulated accidents” with “DBEs and DBAs” to align with NEI 18-04 [1] terminology. Added “reactor vessel and reactor system” to specify the geometry that the reactor building is structurally protecting. Removed “provides a pathway for the release of reactor helium from the building in the event of depressurization accidents” because that capability is sufficiently addressed by assuring that the reactor building design structurally protects the core geometry. Added “permit sufficient insertion of the neutron absorbers and maintain reactor inherent protection to provide for reactor shutdown” to align with PDC-RFDC 70. PDC RFDC 71 aligns with RSF 1.4.2, “Maintain Reactor Building Geometry”.	
Source:	RG 1.232, Appendix C, Criterion 71	

<table>
<tr><th>Title:</th><th colspan="2">72. Provisions for periodic reactor building inspection (replaced by Xe-100 PDC 6, Monitoring Inspection Testing Surveillance and restated here)</th></tr>
<tr><td>Xe-100 PDC</td><td colspan="2">Safety-significant structures, systems, and components shall be designed to permit monitoring, periodic inspection, testing, and/or surveillance to ensure functional capability commensurate with the safety significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, during anticipated operational occurrences, design basis events and design basis accidents as appropriate.</td></tr>
<tr><td rowspan="3">Position:</td><td colspan="2">PDC 6 of the Xe-100 design uses language from MHTGR-DCs 18, 32, 36, 37, 45, 46, and 72 of RG 1.232 [4] into a single PDC for monitoring, inspection, testing, surveillance.</td></tr>
<tr><td>RG 1.232, Appendix C, Criterion 72</td><td>Xe-100 PDC 72</td></tr>
<tr><td>The reactor building shall be designed to permit (1) appropriate periodic inspection of all important structural areas and the depressurization pathway, and (2) an appropriate surveillance program.</td><td>~~The reactor building~~ Safety-significant structures, systems, and components shall be designed to permit monitoring, ~~(1) appropriate~~ periodic inspection ~~of all important structural areas and the depressurization pathway, and (2) an appropriate surveillance program.,~~ testing and/or surveillance to ensure functional capability commensurate with the safety significance of the functions to be performed. Functional testing shall ensure the operability and performance of the system components, and the operability of the system as a whole and, under conditions as close to design as practical, the performance of the full operational sequence that brings the system into operation, including associated systems, during anticipated operational occurrences, design basis events and design basis accidents as appropriate.</td></tr>
<tr><td>Basis:</td><td colspan="2">The intent of MHTGR-DC 72 is met by PDC 6. “Important structural areas and the depressurization pathway” in MHTGR-DC 72 aligns with the PDC 71 functional language which will be ensured via special treatments and capability targets. “An appropriate surveillance program” is intended to be among the special treatments for the reactor building.
Monitoring, periodic inspection, testing, and/or surveillance of reactor building performance will be established as special treatments in accordance with the NEI 18-04 [1] IDP.</td></tr>
<tr><td>Source:</td><td colspan="2">RG 1.232, Appendix C, Criterion 72</td></tr>
</table>