Xe-100 Graphite Engagement: Preliminary Safety Analysis Report Content

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Agenda & Objectives

Agenda:

- Meeting Objectives
- Introduction & Background
- Graphite in the Xe-100 Safety Case
- Construction Permit Application Content
- Supporting Documents for the Application
- Conclusion | Next Steps

Closed Portion:

- Discussion of Supporting Analysis Plans

Objectives:

- Present scope and level of detail to be provided in the ARDP/Dow Construction Permit application's PSAR for graphite-related analyses and SSC design information for NRC staff awareness
- Receive feedback on approach to organize graphite-related content in future submittals

Introduction & Background

- In October 2022, X-energy provided a Graphite Qualification Program topical report for NRC review
- Withdrawn in January 2023 based on NRC feedback to expand level of detail and scope for several key methods and approaches
- Open meeting April 24, 2023 better aligned NRC and X-energy staff on areas to expand level of detail
- X-energy approach: Preapplication engagements via open / partially closed meetings to present technical bases in key subject areas, followed by submittal of (2) Technical Reports with the ARDP/Dow Construction Permit application and Preliminary Safety Analysis Report (PSAR)
- Graphite Regulatory Engagement Plan (REP) sent 7/31 to provide proposed topic schedule
- This is the first engagement of this series. Feedback will be used to inform scope and timing of future engagements

Graphite in the Xe-100 Safety Case

- Graphite, like all Safety-Significant SSCs for the Xe-100, derives design criteria principally from NEI 18-04 as endorsed in RG 1.233
- The level of detail for SSC content (including SR-SSCs such as key parts of the Xe-100 graphite reflectors) at the CP stage is provided in NEI 21-07 being endorsed by DG-1404
  - 50.35 also provides generic direction "*When an applicant has not supplied initially all of the technical information*" that has informed the PSAR Content scope selection
- Additional Guidance for Graphite is found in ASME Section III Division 5 as endorsed in RG 1.87 Rev. 2
  - Following the code as endorsed is a key special treatment for graphite in the Xe-100 design
- Further content guidance is provided in DANU-ISG-2023-01 that informs level of detail/scope in the PSAR

Approach to Provide Graphite-Related Safety Case

Objective: Provide a "Complete Picture" enabling thorough NRC evaluation of design criteria and preliminary analyses at the Construction Permit stage of review.

- Graphite Design Details → Graphite Material Qualification and Modeling Technical Report
  - Graphite system preliminary design description, principal design criteria (PDC) aligned to Chapter 6 of the PSAR
  - Reference in PSAR SR-SSCs
- Irradiated Graphite Analysis Software (IGNIS) Technical Details → Graphite Structural Analysis Technical Report
  - Ties graphite material data already presented to our FEA approach and associated V&V
  - Reference in PSAR methodologies
- Analysis Methodologies → Graphite Structural Analysis Technical Report
  - Conveys plans for how all degradation mechanisms identified in the ASME Section III Division 5 Graphite code will be modeled
  - Reference in PSAR methodologies
- Testing Definitions → Graphite Structural Analysis Technical Report
  - Define the scope of ongoing / planned test activities
  - Reference in PSAR
- Preliminary Analysis Results → PSAR Chapter 3.8
  - Share preliminary stage analytical results to demonstrate confidence
- Approach to Meet General ASME Code Requirements – High-level description in PSAR
  - Code compliance and screening for exceptions – how we either comply or need exceptions to the Code, the technical basis, and any requirements that deviate from the NRC's endorsement

Graphite Safety Case – Required Functional Design Criteria

- Graphite supports conformance with the following Principal Design Criteria – Required Functional Design Criteria (PDC – RFDC)
  - PDC – RFDC 11: *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*.
  - PDC – RFDC 26: *The reactor shall be designed to provide movable poisons that can insert and maintain safe shutdown during design basis events and design basis accidents.*
  - PDC – RFDC 34: *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.*
  - [SRDC] 70: *The core reflector graphite shall be designed to ensure acceptable geometry is maintained to control reactivity and heat removal during DBEs and DBAs.**

*Note SRDC development for graphite identified a gap in PDC 70 as defined in the Xe-100 Principal Design Criteria Development topical report (ML23181A172), which will be addressed in future submittals.

Graphite Safety Case: PDC-CDC & Other PDC Support

- PDC-CDC 34: *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.*
- PDC-CDC 26: *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.*
- PDC 28: *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.*
- PDC 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.*

Quality Assurance (PSAR Chapter 8)

- X-energy is currently pursuing the ASME G and GC certificates
  - ASME BPVC Section III Division 5 Article HAB
  - Selected authorized nuclear inspector (ANI) to support certification effort
- PSAR Chapter 8 (Plant Programs) will provide an overview of various programs that support special treatment application and other requirements
  - Reliability and Integrity Management (RIM) – ASME BPVC Section XI
  - Graphite Quality System – ASME BPVC Section III Division 5 Article HAB
  - G and GC Certification plan – ASME BPVC Section III Division 5 Article HAB
  - X-energy's QAPD describing NQA-1 conformance

Conclusion / Next Steps

For the Construction Permit application for ARDP/Dow, the PSAR will address:

- Graphite SSCs and associated PDCs
- Development of design/safety analysis methods
- Criteria for analysis results or design basis information

For the Operating License application that follows, X-energy will address:

- ASME Section III Div. 5 design and analysis
- Graphite component specifications
- Maturation of graphite-related material datasets

Next meetings will address:

- Methods development
- Design criteria and capability target establishment
- PSAR Ch. 6 graphite-related content
- Loading conditions and evaluation

Closed Portion

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Supporting Documentation (Undocketed)

X-energy Document Title	Supporting Information	Application Content Alignment
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Irradiated Graphite Analysis Software Technical Details

X-energy Document Title	Supporting Information	Application Content Alignment
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Design Loading Conditions Analysis Methods

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Evaluation of Other Loading Conditions & Degradation Mechanisms

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