



UNITED STATES
NUCLEAR REGULATORY COMMISSION
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OFFICE OF NUCLEAR REACTOR REGULATION

REGULATORY AUDIT REPORT

XENITH™ PRINCIPAL DESIGN CRITERIA TOPICAL REPORT

X ENERGY, LLC.

DOCKET NO.: 99902118

1.0 BACKGROUND

By letters dated April 26, 2024, December 16, 2024, April 4, 2025, and May 7, 2025 (Agencywide Documents Access and Management System (ADAMS) Accession Nos. ML24117A262, ML24351A228, ML25094A192, and ML25127A342, respectively), X Energy, LLC., (X-energy), submitted Revisions 1, 2, 3, and 4 of the topical report (TR) titled, "XENITH™ Principal Design Criteria Licensing Topical Report," for the U.S. Nuclear Regulatory Commission (NRC) staff's review and safety evaluation. The TR describes the development of the principal design criteria (PDC) for X-energy's Next-Generation Integrated Transportable High-Temperature (XENITH™) microreactor.

The NRC staff provided its audit plan to X-energy on September 13, 2024, (ML24248A241), to support an audit using X-energy's electronic reading room (eRR). At the conclusion of the audit on April 25, 2025, the NRC staff held an audit exit meeting with X-energy to discuss the audit results, conclusions, proposed limitations and conditions, as well as the next steps for the TR review.

2.0 AUDIT REGULATORY BASES

The basis for the audit is the regulations in Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities," and Part 52, "Licenses, Certifications, and Approvals for Nuclear Power Plants." The applicants for a construction permit (CP), operating license (OL), standard design certification (DC), combined license (COL), standard design approval (SDA), or manufacturing license (ML) must submit PDCs for the proposed facility.

The following regulations relate to the PDCs:

- Regulation 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.
- Regulation 10 CFR 52.47(a)(3)(i), which requires, in part, that applications for a standard DC include PDCs for the facility.

Enclosure

- Regulation 10 CFR 52.79(a)(4)(i), which requires, in part, that applications for a COL include PDCs for the facility.
- Regulation 10 CFR 52.137(a)(3)(i), which requires, in part, that applications for an SDA include PDCs for the facility.
- Regulation 10 CFR 52.157(a), which requires, in part, that applications for an ML include PDCs for the reactor to be manufactured.

The regulations as required by 10 CFR 50.34(a)(3)(i), 10 CFR 52.47(a)(3)(i), 10 CFR 52.79(a)(4)(i), 10 CFR 52.137(a)(3)(i), and 10 CFR 52.157(a) state the General Design Criteria (GDCs) in 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," establish the minimum requirements for the PDCs for water-cooled nuclear powerplants similar in design and location to plants for which CPs have previously been issued by the Commission and provides guidance to the applicants in establishing PDCs for other types of nuclear power units. Since the XENITH™ is not a water-cooled nuclear powerplant design, its PDCs are not required to align with the minimum requirements in the GDCs in 10 CFR Part 50, Appendix A. Recognizing the GDCs in 10 CFR Part 50, Appendix A may not be appropriate for non-light-water reactors (non-LWRs). The NRC issued Regulatory Guide (RG) 1.232, "Guidance for Developing Principal Design Criteria for Non-Light Water Reactors," (ML17325A611), which provides a general set of advanced reactor design criteria (ARDCs) and includes design criteria for two specific non-LWR designs designated as sodium-cooled fast reactor design criteria (SFR-DC) in appendix B and modular high-temperature gas-cooled reactor design criteria (MHTGR-DC) in appendix C, respectively.

The PDCs establish the necessary design, fabrication, construction, testing, and performance requirements for structures, systems, and components (SSCs), important to safety, that provide reasonable assurance that the facility can be operated without undue risk to the health and safety of the public.

3.0 AUDIT PURPOSE AND OBJECTIVES

The purpose of the audit was to enable the NRC staff to: (1) efficiently gain an understanding of the detailed information supporting the TR, (2) verify information, and (3) identify information that needs to be docketed to support the development of the safety evaluation.

4.0 SCOPE OF THE AUDIT AND AUDIT ACTIVITIES

During the review of the initial submission of the TR on April 26, 2024, the NRC staff shared with X-energy a list of topics of interest to be reviewed during the audit. Subsequently, the NRC staff and X-energy agreed to have an audit (ML24248A241). X-energy provided written responses via the eRR to the topics during multiple closed meetings held between September 16, 2024 and April 25, 2025.

During the audit, X-energy provided the following documents in the eRR:

- Draft of Revision 3, of the TR titled: "XENITH™ Principal Design Criteria Licensing Topical Report"

- Draft of Revision 4, of the TR titled: “XENITH™ Principal Design Criteria Licensing Topical Report”

In addition, X-energy made its responses to the audit topics available in the eRR to facilitate the audit, where the NRC staff directed its focus.

The audit followed the guidance in the Office of Nuclear Reactor Regulation Office Instruction LIC-111, “Regulatory Audits” (ML19226A274).

Members of the audit team are listed below.

Name	Division	Branch
Patrick Boyle	Division of Advanced Reactors and Non-Power Production and Utilization Facilities (DANU)	Advanced Reactor Licensing Branch 2 (UAL2)
Ayesha Athar	DANU	Advanced Reactor Technical Branch 1 (UTB1)
Mathew Gordon	DANU	UTB1
Meg Audrain	DANU	UTB1

On April 25, 2025, the NRC staff held an audit exit meeting with X-energy and summarized the audit purpose, activities, observations, and high-level results. No open items or additional information requests were discussed at the exit meeting.

5.0 SUMMARY OF OBSERVATIONS

During the audit, the NRC staff reviewed the documents provided in the eRR and asked X-energy questions during the audit meetings. During these meetings, the NRC staff and X-energy staff discussed the topics of interest. The summary of the NRC staff’s main observations is described below.

- The XENITH™ reactor design is in progress at the time of the PDC TR review. Similarly, X-energy’s implementation of the Licensing Modernization Project (LMP) process and its development of the probabilistic risk assessment (PRA) for the XENITH™ reactor design are in progress. The LMP process is laid out in RG 1.233, “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,” Revision 0 (ML20091L698). RG 1.233, Revision 0, endorses Nuclear Energy Institute (NEI) 18-04, “Risk-Informed Performance-Based Technology Inclusive Guidance for Non-Light Water Reactor Licensing Basis Development,” Revision 1, (ML19241A472). The XENITH™ PDCs are based on the implementation of the LMP process along with the use of RG 1.232. Therefore, the XENITH™ PDCs at the time of a licensing application, such as a construction permit or operating license

application, will need to be confirmed or updated based on the more mature design and the further implementation of the LMP process.

- The NRC staff submitted a preliminary information request to support the review. X-energy provided this information regarding the design of the XENITH™ reactor and updated the TR to Revision 2, accordingly.
- The NRC staff requested clarification of the contents of several PDCs in Revision 2 and discussed these topics with X-energy. X-energy addressed the clarification questions in Revision 3.
- The NRC staff identified editorial inconsistencies on several PDCs during the review and discussed them with X-energy. X-energy addressed these inconsistencies in Revision 3 of the TR.
- The NRC staff identified additional editorial inconsistencies on several PDCs during the review and discussed them with X-energy. X-energy addressed these inconsistencies in Revision 4 of the TR.

6.0 REQUESTS FOR ADDITIONAL INFORMATION RESULTING FROM AUDIT

Based on the additional docketed information, this audit resulted in no additional requests for information.

7.0 OPEN ITEMS AND PROPOSED CLOSURE PATHS

This audit resulted in no open items.