

SUMMARY REPORT FOR THE KAIROS POWER LLC SAFETY ANALYSIS METHODS

TOPICAL REPORT PRE-SUBMITTAL AUDIT

APRIL - MAY 2024

1.0 BACKGROUND AND PURPOSE

Kairos Power LLC (Kairos) began pre-application discussions with the U.S. Nuclear Regulatory Commission (NRC) staff on its proposed Kairos Power Fluoride-Salt-Cooled, High-Temperature Reactor (KP-FHR) in October 2018. By letter dated September 29, 2021 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21272A375), Kairos submitted the Hermes test reactor construction permit (CP) application including the Preliminary Safety Analysis Report (PSAR). On December 14, 2023, the NRC staff issued a CP to Kairos for the Hermes test reactor (ML23338A260). As discussed in a public meeting held on February 20, 2024 (ML24061A113), Kairos plans to submit a topical report (TR) on their safety analysis methodology in support of a future application for an operating license (OL) for the Hermes test reactor in accordance with Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities." The Hermes PSAR followed the guidance in NUREG-1537, Part 1, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors, Format and Content" (ML042430055), and it is expected that the Hermes final safety analysis report will similarly align with NUREG-1537.

2.0 AUDIT REGULATORY BASES

The bases for the audit are the regulations in 10 CFR pertinent to the NRC staff's review of a future Hermes OL application, particularly 10 CFR Part 50, Sections 50.34, "Contents of applications; technical information," 50.40, "Common standards," and 50.57, "Issuance of operating license."

3.0 AUDIT OBJECTIVES

This audit provided the NRC staff an opportunity to assess the readiness of the draft TR before it is submitted for the NRC staff's review. The audit allowed the NRC staff to (1) identify any required information that is missing from the TR, (2) identify technical or regulatory issues that may complicate the acceptance or technical review of the TR, (3) become familiar with the content of the TR, particularly in areas where Kairos plans to propose new concepts, and (4) become familiar with the separate and integral effects tests facilities supporting the safety analysis methodology.

4.0 SCOPE OF THE AUDIT AND AUDIT ACTIVITIES

The audit was conducted from April to May 2024, via the Kairos electronic reading room (ERR) and an in-person NRC staff visit to Kairos Headquarters (HQ). The staff conducted the audit in accordance with the Office of Nuclear Reactor Regulation (NRR) Office Instruction NRR-LIC-111, Revision 1 "Regulatory Audits" (ML19226A274).

Members of the audit team, listed below, were selected based on their detailed knowledge of the subject. Audit team members included:

- Pravin Sawant, NRR (Senior Nuclear Engineer, Lead Technical Reviewer)
- Alexandra Siwy, NRR (Senior Nuclear Engineer)
- Michelle Hart, NRR (Senior Reactor Engineer)
- Benjamin Parks, NRR (Senior Technical Advisor for Systems and Fuels)
- Andrew Bielen, Office of Nuclear Regulatory Research (Senior Reactor Systems Engineer)
- Ben Adams, NRR (General Engineer)
- Alexander Chereskin, NRR (Materials Engineer)
- Lance Kingsbury, NRR (Reactor Systems Engineer)
- Matt Hiser, NRR (Senior Project Manager, Lead Project Manager)
- Tanny Santos, NRR (Senior Project Manager)
- Brian Bettes, NRR (Project Manager)

The following table documents dates when audit meetings were held:

Audit Meetings
April 4, 2024 (entrance meeting)
April 16 and 17, 2024 (in-person visit to Kairos HQ)
May 9, 2024 (exit meeting)

The staff reviewed the following documents via the ERR:

- Draft versions of KP-TR-020-P, “Safety Analysis Methodology for the Kairos Power Fluoride Salt-Cooled High-Temperature Test Reactor”
- KP-RPT-000231-Rev0, “KP-SAM Theory Manual”
- KP-RPT-000226-Rev0, “KP-SAM Users Guide”

5.0 SUMMARY OF AUDIT OUTCOME

The NRC staff’s summary of observations listed below is based on the notes taken by the staff during the audit. The NRC staff did not acquire any documents during the audit. The main purpose of the audit was to assess the readiness of the draft TR before it is submitted for the NRC staff’s review. Specific NRC observations are provided below:

- The TR should include additional discussion and justification for all changes from the approved mechanistic source term (MST) methodology TR (KP-TR-012-NP-A, ML22136A291), including the method to determine the new radionuclide groupings. In addition, the TR should discuss the effect of the changes in the source term modeling on the maximum hypothetical accident (MHA) source term and offsite dose results previously described in the Hermes PSAR.
- The TR should provide more discussion and justification for the dose figure of merit based on evaluation of an MHA 30-day total effective dose equivalent at the exclusion area boundary, considering the 10 CFR 100.11, “Determination of exclusion area, low population zone, and population center distance,” siting criteria are given in terms of whole body and thyroid doses for a 2-hr exposure at the EAB and duration of accident at the low population zone.
- The TR could benefit from the mapping of high-ranked phenomena from the phenomena identification and ranking tables (PIRTs), code models and correlations, and proposed validation activities.

- Adequate details on design and process parameters would be needed to effectively evaluate the applicability of specific code models and correlations.
- The NRC staff would need access to the user and theory manuals of the system analysis codes used in the methodology.
- The use of the word “applicability” in the draft report is not consistent with how the term is used in Regulatory Guide (RG) 1.203, “Transient and Accident Analysis Methods,” which is referenced in the report.
- The TR should include a summary of the PIRT for source term analysis.
- Augmentation of the code validation basis by including legacy assessments from the code developmental manual and fundamental/analytical validations would assist in evaluating the code applicability.
- The TR should document any assumptions and limitations of the code.
- The TR should address all the elements of RG 1.203 or provide a plan or strategy to address incomplete portions of the methodology (e.g., data under development).
- The TR should provide additional justification for certain biases in the event-specific methods (e.g., reactor coolant average temperature). The staff noted that investigating such parameters as sensitivities could lead to more limiting results due to reaching a different trip setpoint first. In addition, the most conservative initial conditions for an event may be different depending on the figures of merit being investigated.
- For the increase in heat removal events, the TR should identify whether the methodology is intended to identify the most limiting overpower or overcooling scenarios.

6.0 EXIT BRIEFING

The staff conducted an audit closeout meeting on May 9, 2024. At the exit briefing the staff reiterated the purpose of the audit and discussed their activities.

7.0 ADDITIONAL INFORMATION RESULTING FROM AUDIT

The formal request for additional information process was not used as part of this audit. The staff provided Kairos several questions during the audit, which Kairos could consider and use to revise the TR prior to submittal.

8.0 OPEN ITEMS AND PROPOSED CLOSURE PATHS

Not applicable. There were no open items or deviations from the audit plan.

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DATED: JUNE 2024

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