POLICY ISSUE
(Information)

August 23, 2023 SECY-23-0074

FOR: The Commissioners

FROM: Daniel H. Dorman
Executive Director for Operations

SUBJECT: STAFF'S STATEMENT IN SUPPORT OF THE UNCONTESTED HEARING FOR ISSUANCE OF A CONSTRUCTION PERMIT FOR THE KAIROS HERMES TEST REACTOR

PURPOSE:

The U.S. Nuclear Regulatory Commission (NRC) staff has completed its review of the Kairos Power LLC (Kairos) construction permit (CP) application for a testing facility known as Hermes. This paper serves as the NRC staff's primary pre-filed testimony for the uncontested (mandatory) hearing for issuance of a CP to Kairos under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50, "Domestic Licensing of Production and Utilization Facilities." This paper, with its references, also provides information to support the Commission's determination that the NRC staff's review adequately supports the findings for issuance of a CP under 10 CFR Part 50. These findings are set forth in 10 CFR 50.35, "Issuance of construction permits"; 10 CFR 50.40, "Common standards"; 10 CFR 50.50, "Issuance of licenses and construction permits"; and 10 CFR 51.105, "Public hearings in proceedings for issuance of construction permits or early site permits; limited work authorizations."

In accordance with the Internal Commission Procedures, this paper focuses on nonroutine matters supporting the findings related to 10 CFR Part 50 and 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions." Nonroutine matters of particular importance are matters that relate to unique features of the facility or novel issues that arose as part of the review process.

This paper does not address any new commitments or resource implications.

CONTACT: Matthew A. Hiser, NRR/DANU
301-415-2454

Tamsen S. Dozier, NMSS/REFS
301-415-2272

SUMMARY:

The NRC staff's review of the Hermes CP application under 10 CFR Part 50 is complete. The NRC staff documented the results of its safety review in the final safety evaluation (SE) completed in June 2023 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML23158A268). The NRC staff documented the results of its environmental review in the final environmental impact statement (EIS) completed in August 2023 as NUREG-2263, "Environmental Impact Statement for the Construction Permit for the Kairos Hermes Test Reactor" (ML23214A269). Drafts of the CP and Record of Decision are available (ML23209A659 and ML23192A766, respectively).

This paper focuses on nonroutine matters, such as unique features of the testing facility or novel review issues. Lastly, this paper addresses the findings in 10 CFR 50.35, 10 CFR 50.40, 10 CFR 50.50, and 10 CFR 51.105 and provides, with its references, an adequate basis for the Commission to conclude that each of these findings can be made for the Hermes test reactor CP application.

BACKGROUND:

I. Application History

Preapplication Activities by Kairos

Before submitting the application for a CP for the Hermes test reactor, Kairos engaged with the NRC staff in extensive preapplication activities. The preapplication activities included topical reports (TRs), public meetings, and audits.

Kairos submitted TRs on the following subjects for staff evaluation (asterisks indicate TRs referenced in the Hermes test reactor CP application):

- principal design criteria* (ML20167A174)
- regulatory analysis (which regulations apply and do not apply to the Kairos designs) * (ML22159A356)
- reactor coolant* (ML20219A590)
- scaling methodology for the testing program (ML21013A430)
- risk-informed performance-based licensing basis development (Licensing Modernization Project) methodology (ML20328A229)
- fuel performance methodology* (ML22125A278)
- fuel qualification methodology* (ML23089A398)
- metallic materials qualification* (ML23102A179)
- graphite materials qualification* (ML23108A317)

- quality assurance program (ML21350A347)

- mechanistic source term methodology* (ML22136A291)

The NRC staff reviewed each of the TRs and prepared an SE for each. Any condition or limitation on the use of a TR is provided in the approved version of the TR. The NRC staff review of the Hermes test reactor CP application confirmed that conditions or limitations for TRs referenced in the application were satisfied or could be reasonably left to the operating license application.

Preapplication meetings related to the Hermes test reactor CP application and brief descriptions of the topics discussed are noted below:

- January 27, 2021 - content of a CP application for the Hermes test reactor (ML21217A058)

- January 28, 2021 - site selection and the environmental report (ER) for the Hermes test reactor (ML21217A058)

- June 30, 2021 - meteorological information for the Hermes test reactor site (because of the sensitivity of the information discussed, this meeting was closed to the public) (ML21173A103)

- August 19, 2021 - content of the ER for the Hermes test reactor application (ML21231A150)

Preapplication audits related to the Hermes test reactor CP application took place in the following areas:

- instrumentation and control (ML19350C264)

- fuel and fluids phenomena identification and ranking table, core design, and source term (ML19351C770)

- lithium fluoride and beryllium fluoride (Flibe) thermophysical properties (ML21364A106)

- Hermes test reactor preliminary safety analysis report (PSAR) (ML22006A334)

Application, Ownership, and Location

By letter dated September 29, 2021 (ML21272A375), Kairos submitted a partial application containing the PSAR for a CP for the Hermes non-power test reactor. By letter dated October 31, 2021 (ML21306A131), Kairos submitted an ER in support of its Hermes test reactor CP application. Kairos submitted the latest revision (Revision 3) of the Hermes test reactor PSAR on May 31, 2023 (ML23151A743). Kairos submitted the latest revision (Revision 1) of the Hermes test reactor ER on March 30, 2023 (ML23089A386).

The publicly available portions of the application are available in ADAMS and on the NRC website at https://www.nrc.gov/reading-rm/adams.html. Portions of the application contain nonpublic information and have been withheld in accordance with 10 CFR 2.390, “Public

inspections, exemptions, requests for withholding." The nonpublic version of the application is also available in ADAMS but is restricted to authorized users.

Kairos Power LLC is a U.S.-based company developing a fluoride salt-cooled high-temperature reactor (KP-FHR) using tristructural isotropic (TRISO) fuel in pebble form. The Hermes test reactor facility is proposed to be located within the East Tennessee Technology Park in Oak Ridge, Tennessee. The property is at the site of the former Oak Ridge Gaseous Diffusion Plant and is approximately 185 acres (74.8 hectares). From the 1950s through the mid-1980s, uranium enrichment operations occurred at the plant. The U.S. Department of Energy (DOE) has since restored the site to a brownfield.

Overview of the NRC Staff's Review

The Hermes test reactor CP application review consisted of two concurrent reviews: (1) a safety review of the Hermes test reactor PSAR and (2) an environmental review of the Hermes test reactor ER. Kairos indicated it expects to apply for a Class 104c operating license for a utilization facility useful in the conduct of research and development activities. The NRC staff reviewed the Hermes test reactor PSAR against applicable regulatory requirements using appropriate regulatory guidance and standards, as discussed below, to assess the sufficiency of the preliminary Hermes test reactor design information. As part of this review, the NRC staff evaluated descriptions and discussions of the Hermes test reactor facility's structures, systems, and components (SSCs), with special attention given to design and operating characteristics, unusual or novel design features, and principal safety considerations. The preliminary design of the Hermes test reactor was evaluated to ensure the sufficiency of principal design criteria (PDC), design bases, and information relative to materials of construction, general arrangements, and approximate dimensions, to provide reasonable assurance that the final design will conform to the design bases. In addition, the NRC staff reviewed how Kairos identified and justified the selection of those variables, conditions, or other probable subjects of technical specifications for the facility, with special attention given to those items that may significantly influence the final design. The SSCs were also evaluated to ensure that they would adequately provide for the prevention of accidents and the mitigation of consequences of accidents. The NRC staff considered the preliminary analysis and evaluation of the design and performance of the SSCs of the Hermes test reactor with the objective of assessing the risk to public health and safety resulting from its operation.

To issue a CP, the NRC staff is required to consider the environmental impacts of the proposed action under the National Environmental Policy Act of 1969 (NEPA). The NRC regulations implementing NEPA (10 CFR Part 51) identify issuance of a CP for a nuclear testing facility as a major Federal action that requires an EIS (10 CFR 51.20). The applicant's ER and the NRC staff's final EIS evaluated the potential environmental impacts from the construction, operation, and decommissioning of a testing facility at the proposed site as described in the Hermes test reactor CP application. The ER and the final EIS also include an evaluation of whether there is an environmentally preferable alternative to the proposed action. As part of its independent assessment of the information provided by Kairos, the NRC staff contacted Federal, State, and local agencies, as well as Federally recognized Indian Tribes. The NRC staff invited the public and local, state, and Federal agencies and Federally recognized Indian Tribes to provide information relevant to the environmental review during its scoping process and invited the public and local, state, and Federal agencies and Federally recognized Indian Tribes to comment on the draft EIS that was issued on September 26, 2022 (ML22243A251). The NRC staff considered all comments received in the preparation of the final EIS.

Advisory Committee on Reactor Safeguards

To support the Advisory Committee on Reactor Safeguards (ACRS) in providing an independent review and report to the Commission regarding the Hermes test reactor CP application, the NRC staff presented the results of its SE to the ACRS Kairos Subcommittee at five meetings on April 21, 2022, March 1, 2023, March 23–24, 2023, April 4, 2023, and April 18–19, 2023. The NRC staff presented the results of its Hermes test reactor CP application review to the ACRS full committee on May 3, 2023. The ACRS issued a letter on May 16, 2023 (ML23130A183), fulfilling the requirement in 10 CFR 50.58, "Hearings and report of the Advisory Committee on Reactor Safeguards" that the ACRS review and report on CP applications for testing facilities. The ACRS conclusions and recommendations, as well as the NRC staff's response, are discussed later in this paper.

II. Outreach

Public Meetings

The NRC staff held a virtual public meeting on February 9, 2022 (ML23156A668), to discuss questions related to the Hermes test reactor CP application on quality assurance, PDC, materials, and structural evaluations. On August 25 and August 30, 2022, the NRC staff held partially closed virtual public meetings (ML23181A107) to discuss the staff's requests for additional information (RAIs) for the safety review of the Hermes test reactor CP application PSAR.

On March 23, 2022, the NRC staff held a joint virtual public outreach and scoping meeting to discuss the safety and environmental reviews for the Hermes test reactor CP application and to obtain public input on the scope of the environmental review (ML22110A018). From February 28, 2022, to March 30, 2022, the NRC staff conducted a full scope environmental audit to support the staff's environmental review of the CP application. A virtual public observation meeting was held on March 30, 2022, to close out the environmental audit and to present a summary of audit activities and discussions, including a summary of the information obtained (ML22196A387). After issuing the draft EIS, a public meeting took place on November 16, 2022, in Oak Ridge, Tennessee, with the option for virtual attendance (ML23031A160). At this meeting, the NRC staff described the results of the environmental review, provided attendees with information to assist them in formulating comments on the draft EIS, responded to questions, and accepted comments.

Federal Register Notices

The NRC staff published *Federal Register* (FR) notices, as required, for key milestones of the licensing process as follows:

- After the NRC staff received the Hermes test reactor CP application on September 29, 2021, the agency published a notice of receipt on October 29, 2021 (86 FR 60077).

- On December 1, 2021, the NRC staff published a notice docketing the Hermes test reactor CP application (86 FR 68290).

- On February 9, 2022, the NRC staff published a notice of hearing and opportunity to petition for leave to intervene (87 FR 7503).

- On February 18, 2022, the NRC staff published a notice of intent to conduct a scoping process and prepare an EIS (87 FR 9394).

- On September 29, 2022, the NRC staff published a notice of the availability of the draft EIS for public comment and notice of public comment meeting (87 FR 59124).

- On August 22, 2023, the NRC staff published a notice of availability of the final EIS (88 FR 57137).

Consultations

In accordance with Section 657 of the Energy Policy Act of 2005, the NRC completed consultation with the U.S. Department of Homeland Security concerning the potential vulnerabilities to terrorist attack of the location of the proposed testing facility (ML23116A246). As part of its environmental review, and in accordance with NEPA and other applicable statutes, including the Endangered Species Act and the National Historic Preservation Act (NHPA), the NRC staff consulted with and obtained input from the appropriate Federal, State, and local agencies, as well as Federally recognized Indian Tribes. Government-to-government consultation was initiated by a Federally recognized Indian Tribe via comments submitted on the draft EIS. That Federally recognized Indian Tribe and the applicant have agreed upon a path forward to support NHPA Section 106 consultation closure. Kairos agreed to work with a geoarchaeologist to develop a methodology for a reconnaissance field investigation and make appropriate updates to the monitoring plan (ML23180A298 and ML23178A096). To complete the Section 106 process, the NRC's Record of Decision will document consultation closure. In the unlikely event that the consulting Federally recognized Indian Tribe requests additional actions from Kairos after the field survey is conducted and the monitoring plan updated, the Section 106 process can be completed with the consulting parties executing a formalized document, such as a Programmatic Agreement or a Memorandum of Agreement.

Adjudicatory Actions

On February 9, 2022, the NRC staff published in the *Federal Register* (87 FR 7503) a notice of opportunity to request a hearing and petition for leave to intervene and an order imposing procedures for access to sensitive unclassified nonsafeguards information. No petitions for leave to intervene were filed following publication of this notice.

III. Review Process and Methodology

The NRC staff used the processes and methodologies, as applicable, described in the following documents to ensure quality, consistency, and completeness in preparation of the NRC staff's final SE and final EIS:

- **NUREG-1537, Part 1,** "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content," issued February 1996 (ML042430055). The principal purpose of this format and content guide is to provide a uniform format for presenting information in non-power reactor applications, help ensure completeness of information, assist the NRC staff and others in locating information, and aid in increasing the efficiency of the review process.

- **NUREG-1537, Part 2,** "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria," issued February 1996 (ML042430048). The principal purpose of this standard review plan (SRP) is to guide quality and uniformity of NRC staff safety reviews. It is also a vehicle for disseminating information on regulatory matters concerning non-power reactors and clarifying the NRC staff review process for applicants, licensees, and the public. Each section of the SRP outlines areas of review, acceptance criteria, review procedures, and evaluation findings to facilitate the NRC staff's review.

- **Interim Staff Guidance Augmenting NUREG-1537, Part 1**, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Format and Content," dated October 17, 2012 (ML12156A069); **Interim Staff Guidance Augmenting NUREG-1537, Part 2**, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria," dated October 17, 2012 (ML12156A075). The Interim Staff Guidance (ISG) Augmenting NUREG-1537, Parts 1 and 2, was developed to update and expand the content of NUREG-1537, Parts 1 and 2, to provide additional guidance for license application preparation and NRC staff review of applications for radioisotope production facilities and aqueous homogeneous reactors. Although the Hermes test reactor is neither a radioisotope production facility nor an aqueous homogeneous reactor, the NRC staff determined the guidance in Chapter 19, "Environmental Review," of the ISG to NUREG-1537 to be the guidance most applicable to the environmental review of a test reactor such as the Kairos Hermes test reactor. NUREG-1537, Parts 1 and 2, provide only limited guidance for environmental reviews for non-power reactors and the staff determined the updated and expended guidance in Chapter 19 of the ISG to be sufficiently general to apply for a testing facility such as Hermes. The use of the guidance is not mandatory and does not substitute for compliance with NRC regulations. The NRC staff therefore ensured that its environmental review, as documented in the final EIS, met the applicable regulations in 10 CFR Part 51 and used the guidance associated with NUREG-1537 as supplementary direction.

- **NUREG-0849,** "Standard Review Plan for the Review and Evaluation of Emergency Plans for Research and Test Reactors," issued October 1983 (ML062190191). This SRP guides complete and uniform reviews of research and test reactor radiological emergency plans. As applicable, the NRC staff used NUREG-0849 to evaluate the Kairos preliminary emergency plan submitted in accordance with Appendix E, "Emergency Planning and Preparedness for Production and Utilization Facilities," to 10 CFR Part 50.

- **Regulatory Guide (RG) 1.232,** "Guidance for Developing Principal Design Criteria for Non-Light-Water Reactors," issued April 2018 (ML17325A611). RG 1.232 provides guidance for how the general design criteria in 10 CFR Part 50, Appendix A, "General Design Criteria for Nuclear Power Plants," may be adapted for non-light-water reactor (non-LWR) designs. The NRC staff used RG 1.232, in part, to determine the extent to which other established guidance and acceptance criteria were relevant to the review of the Hermes test reactor CP application.

- **Additional Regulatory Guides.** RGs provide guidance to licensees and applicants on implementing specific parts of the NRC's regulations, techniques used by the NRC staff in evaluating specific problems and scenarios, and information needed by the NRC staff

in its review of applications for permits or licenses. RGs from Division 2, “Research and Test Reactors,” are generally applicable to the Hermes test reactor. The Kairos PSAR identifies RGs from Division 2 and other divisions, including Division 1, “Power Reactors”; Division 4, “Environmental and Siting”; and Division 5, “Materials and Plant Protection”; as relevant to the Hermes test reactor CP application and discusses whether Kairos conformed to or departed from each RG. As appropriate, RGs endorse professional standards for use in the NRC staff’s reviews.

- **Office Instructions.** In its review, the NRC staff followed administrative guidance contained in applicable office instructions. These internal documents address a range of procedural matters, including the NRC staff’s processes for issuing RAIs, handling audits, ensuring the qualification and training of technical staff and managers, and overseeing interactions with applicants, intervenors, and the public.

IV. Advisory Committee on Reactor Safeguards Review

The ACRS review of the Hermes test reactor CP application culminated in a letter to the Commission dated May 16, 2023, recommending that a CP be issued to Kairos (ML23130A183).

The ACRS letter stated that the CP for the Hermes test reactor should be approved and that there is reasonable assurance that the facility can be constructed in accordance with applicable regulations. The ACRS letter highlighted the value of the Hermes test reactor to test and demonstrate key aspects of the KP-FHR technology and notes that the Hermes test reactor design results in projected doses far below the accident dose criteria in 10 CFR Part 100. The ACRS letter also stated that combustible gas generation associated with graphite oxidation should be evaluated during the operating license review of the final facility design.

Kairos has stated that the operating license application will evaluate numerous items, including graphite oxidation; the NRC staff is tracking these items in Appendix A to its SE.

DISCUSSION:

I. Excluded Matters

This paper does not discuss matters that will be addressed as part of a 10 CFR Part 50 operating license application review. The regulation at 10 CFR 50.35 states that an applicant can request the approval of design features or specifications to be included in the CP. Because Kairos did not request such approval, the NRC staff did not make any findings regarding the safety of any 10 CFR Part 50 design feature or specification. The staff will evaluate the final design and specifications of the Hermes test reactor as described in a final safety analysis report (FSAR) submitted as part of a 10 CFR Part 50 operating license application.

II. Exemptions from NRC Regulations

Kairos has not requested, and the NRC staff has not granted, any exemptions from NRC regulations for the Hermes test reactor CP application.

III. Nonroutine Matters, Unique Site Features, or Novel Issues

Safety Matters

Molten salt coolant

The Hermes test reactor will use a mixture of lithium fluoride and beryllium fluoride salts, known as Flibe, for the reactor coolant. In the Hermes test reactor design, the Flibe coolant is credited with supporting reactivity control and serving as a fission product barrier. The molten salt reactor design concept was first developed at Oak Ridge National Laboratory (ORNL) in the 1950s. In the 1960s, ORNL built and operated a molten salt reactor called the Molten Salt Reactor Experiment (MSRE) using a fuel salt mixture (LiF- BeF_2-ZrF_4-UF_4) in the primary system and a mixture of lithium fluoride and beryllium fluoride salts (Flibe) as its secondary coolant. More recently, the Thorium Molten Salt Reactor (TMSR) project in China led by the Chinese Academy of Sciences is also a fuel salt reactor like MSRE at ORNL. Notably, the Hermes test reactor uses Flibe coolant with TRISO-based pebble fuel and not a fuel salt mixture as with MSRE and TMSR.

The Flibe salt mixture in the Hermes test reactor has good heat transfer properties, is chemically stable at high temperatures, and has the ability to retain fission products, as described in the Kairos TRs on reactor coolant properties and mechanistic source term methodology and as credited in the Hermes test reactor functional containment design discussed below. Thus, when used as the primary coolant, Flibe provides an additional barrier to radionuclide release in the event of fuel failure. Flibe has a high freezing temperature and a high boiling temperature with no phase transition at operating and accident conditions, allowing operation of the reactor at near atmospheric pressures. The Hermes PSAR states that the reactor coolant performs safety functions associated with reactivity control and fission product retention.

During reactor operations, the Flibe coolant is expected to accumulate impurities, which may affect the corrosion of primary system components, create some circulating activity in the primary system, affect reactivity characteristics, and potentially affect thermophysical properties. Thus, as described in the reactor coolant TR, coolant chemistry control is planned to ensure the Flibe maintains the expected thermophysical properties needed for natural circulation heat transfer. Based on its technical evaluation, the NRC staff finds that the preliminary information on the Hermes test reactor primary coolant system is consistent with the relevant PDC and NUREG-1537 acceptance criteria and meets the applicable guidance and regulatory requirements for the issuance of a CP in accordance with 10 CFR 50.35 and 10 CFR 50.40.

TRISO fuel in a pebble

The Hermes test reactor will use TRISO fuel particles embedded in a carbon matrix pebble. The TRISO fuel particle is composed of a uranium oxycarbide (UCO) fuel kernel encased in coating layers to limit fission product releases. The coating layers are composed of pyrolytic carbon and silicon carbide. In addition, a porous carbon buffer layer located between the kernel and the inner pyrolytic carbon layer provides a void volume to accommodate fission gases and limit pressure buildup. The TRISO fuel particle is credited with limiting radionuclide releases to the environment as part of the Hermes test reactor functional containment design discussed below. The Hermes TRISO particle specification is based on the DOE Advanced Gas Reactor (AGR) program, and the AGR experimental results form the basis for the TRISO particle qualification, as discussed in Electric Power Research Institute (EPRI) TR EPRI-AR-1(NP)-A, “Uranium

Oxycarbide (UCO) Tristructural Isotropic (TRISO) Coated Particle Fuel Performance," issued November 2020 (ML20336A052). The TRISO particles are arranged in a fuel annulus near the outer diameter of the pebble. There is a protective carbon matrix overcoat (fuel free) outside the fuel region, which protects the TRISO particles during pebble handling, pebble-to-pebble interactions, and potential chemical interactions with the Flibe coolant. The pebble has a lower density inner core, which maintains positive pebble buoyancy during normal operations and transient conditions.

The TRISO fuel in pebble form is similar to that developed for high-temperature gas-cooled reactors. Coatings on the particle fuel have been demonstrated to provide retention of fission products to temperatures in excess of 1,600 degrees Celsius (°C) (2,912°F). The primary international experience in production and testing of TRISO includes work in Germany, China, and Japan. The DOE initiated the AGR Fuel Development and Qualification Program in 2002 to establish the capability to fabricate high-quality TRISO fuel with a low failure rate. The test temperatures of the AGR TRISO fuel particles in the AGR testing program done to demonstrate the robustness of the particles were significantly higher and the durations were significantly longer than expected in transients in the Hermes test reactor.

The Hermes test reactor fuel (TRISO particles in fuel pebbles) has the following functional requirements:

- Contain and confine actinides and fission products.
- Maintain the physical form and geometry of the pebble without damage to the TRISO particles during operation, storage, shipping, and handling.
- Maintain net positive buoyancy in the coolant for normal operation and postulated events.
- Prevent chemical interaction with reactor coolant.

The qualification of the Hermes test reactor fuel is based on domestic and international historical experience with TRISO fuel elements and the advancement in fuel technology through the DOE AGR program. This historical experience helps demonstrate that Hermes will operate with large thermal margins and, therefore, the integrity of the fuel is not expected to be challenged. The result of the DOE AGR project was a TRISO fuel particle design that was fabricated at laboratory and engineering scales and irradiated in a series of tests in the Advanced Test Reactor at the Idaho National Laboratory. These irradiation tests serve as a foundation for the qualification of a TRISO fuel particle design for application in the KP-FHR test reactor.

Kairos submitted a TR on the fuel qualification methodology for the KP-FHR reactors, "Fuel Qualification Methodology for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor (KP-FHR)," dated July 5, 2022 (ML22186A213 (cover letter only)). Kairos relies on EPRI-AR-1(NP)-A for qualification of the TRISO fuel particles.

The Kairos TR provides details on the qualification of the fuel pebble form used in the Kairos reactor designs. The Kairos fuel qualification program has the following main elements:

- DOE AGR and legacy data
- fuel specification, manufacturing, and quality control through inspection
- fuel element phenomena identification and ranking table
- development of operating envelope
- fuel element laboratory testing
- fuel irradiation test program
- fuel performance modeling
- fuel surveillance program

The NRC staff evaluated the Kairos fuel qualification program as described in the TR and concluded that it meets the applicable regulatory requirements. In the Hermes test reactor CP application, Kairos provided the relevant PDC, a design description of the TRISO particle and corresponding fuel elements (pebbles), and a preliminary analysis and evaluation of the fuel element demonstrating the margins of safety during normal operations and transient conditions anticipated during the life of the facility. The NRC staff SE concludes that the information in the PSAR section on reactor fuel is sufficient and meets the applicable guidance and regulatory requirements for the issuance of a CP in accordance with 10 CFR 50.35 and 10 CFR 50.40.

Functional containment

In SECY-18-0096, “Functional Containment Performance Criteria for Non-Light-Water-Reactors,” dated September 28, 2018 (ML18114A546), the NRC staff recognized that non-LWR technologies may allow or require approaches different from those of LWRs to fulfill the safety function of limiting the release of radioactive materials. Therefore, the NRC staff proposed a methodology for establishing functional containment performance criteria for non-LWRs. SECY-18-0096 describes “functional containment” as, “a barrier, or a set of barriers taken together, that effectively limits the physical transport of radioactive materials to the environment.” The methodology calls for designers to establish performance criteria and specific functions to be performed by SSCs for each event category (normal operations, anticipated operational occurrences, design-basis events, beyond-design-basis events, and design-basis accidents). The design of each SSC would then be based on the aggregate of performance requirements from all event categories and fundamental safety functions, as well as any other roles chosen for the SSC. The Commission approved the NRC staff’s proposed approach in SRM-SECY-18-0096 (ML18338A502), dated December 4, 2018.

The Hermes test reactor uses a functional containment comprised of the TRISO particle fuel and Flibe coolant in a low-pressure primary system. The TRISO particle fuel and the Flibe coolant are both credited for retaining radionuclides.

The TRISO fuel particles retain most of the radioactive material at risk for release. In addition, significant margin to the TRISO fuel design temperature of 1,600°C (2,912°F) will be maintained under transient conditions. Furthermore, the TRISO particles are contained within an annular shell inside a spherical pebble, which provides physical protection for the TRISO particles against mechanical damage. The TRISO fuel particle design provides four of the five credited safety-related fission product barriers to the release of radioactivity from the reactor, which constitute the functional containment. These four barriers are the fuel kernel itself, an inner pyrolytic carbon layer, a silicon carbide layer, and an outer pyrolytic carbon layer.

The secondary barrier credited in the Hermes test reactor functional containment is the reactor coolant. The reactor coolant serves as a fission product barrier providing retention of fission products that escape the fuel particle and fuel pebble barriers.

While the NRC staff notes that the Hermes test reactor CP application does not use the event categorization scheme described in SECY-18-0096, it does identify anticipated operational occurrences, design-basis events, and beyond-design-basis events, consistent with a maximum hypothetical accident (MHA) approach. The MHA is intended to bound all postulated events in terms of dose consequences, consistent with the guidance for non-power reactors in NUREG-1537. The NRC staff's analysis concludes that Kairos's MHA analysis demonstrates that the dose consequences of the MHA are within the accident dose criteria of 10 CFR 100.11(a).

The testing facility siting regulation in 10 CFR 100.11(a) provides, in part, that as an aid in evaluating a proposed site, an applicant's analysis should assume a fission product release from the core based on a major accident and include the expected demonstrable leak rate from the containment. Historically, for their siting and safety analyses, LWR power reactors have used a source term based on a sustained loss of coolant from the reactor resulting in substantial core damage and credited a low-leakage containment building to retain the fission product release from the core. Testing facilities subject to 10 CFR 100.11(a) have used an MHA approach in demonstrating appropriate siting.

Unlike existing LWRs, the low-pressure primary system in Hermes means an energetic release of coolant cannot occur during a loss-of-coolant type accident (ML22136A089[1]). Therefore, it is not considered credible for the Hermes test reactor to have a loss of coolant from the reactor comparable to existing LWRs. The MHA described in the Hermes PSAR assumes a bounding temperature profile to result in radionuclide releases that bound the range of credible accidents, which is consistent with consideration of a major accident. The Hermes MHA radiological consequence analysis uses a functional containment approach that evaluates the radionuclide retention within and transport across each of the barriers that together provide the radionuclide containment function, to estimate the total release to the environment for the event or accident. Kairos commitments for testing of the fuel prior to its use, fuel surveillance during operation (both from the approved fuel qualification methodology topical report), and continuing assessment of fission product concentrations in the coolant and cover gas during reactor operation (from Hermes PSAR Chapter 14) support the analysis assumptions on release as the expected demonstrable leak rate from the functional containment. The Kairos MHA provides an acceptable analysis of the overall capability of the Hermes test reactor, including the SSCs that provide the radionuclide containment function, to ensure that offsite doses remain below the dose criteria.

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[1] "Kairos Power, LLC - Safety Evaluation for, "Regulatory Analysis for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor," Revision 4," dated May 26, 2022

The Hermes test reactor PSAR describes the components and operating conditions that define the Hermes test reactor functional containment, which include the TRISO fuel particle, Flibe coolant, and low primary system pressure. The PSAR also identifies key performance criteria on specific SSCs to ensure the MHA remains bounding: specified acceptable system radionuclide release design limits for the fuel and circulating activity limits for the Flibe coolant. The acceptability of the functional containment is demonstrated through design and analysis of these individual features as well as their combined capability. The NRC staff's evaluation of the functional containment concludes that the information in the PSAR section on functional containment is consistent with the approach described in SECY-18-0096 and SRM-SECY-18-0096 and that it is sufficient and meets the applicable guidance and regulatory requirements for the issuance of a CP in accordance with 10 CFR 50.35 and 10 CFR 50.40.

No active components or operator action needed for accident response

The Hermes test reactor is designed with three safety-related shutdown elements, which are credited for shutting down the reactor during postulated events. The shutdown elements are located to optimize reactivity worth and to meet shutdown margin requirements. These elements have two positions, fully withdrawn or fully inserted, and are positioned using counter-weighted winch systems. The shutdown elements accomplish a safe shutdown (reactor trip) through gravity insertion on a reactor trip signal or on a loss of normal electrical power, after a short time delay to mitigate spurious trips. When the reactor trip system actuates, the energy holding control relays closed is removed, and this loss of supply power initiates a reactor trip. Shutdown elements fall into the core by gravity when power is removed from the electromagnetic clutch holding the winch. Thus, the shutdown elements are designed to fail into a safe state due to gravity insertion that initiates with the removal or loss of power.

The Hermes test reactor design relies on passive decay heat removal and does not need an active emergency core cooling system for decay heat removal or replacement of coolant inventory. The downcomer, graphite reflector, hot well, fluidic diode pathway, and fluidic diodes are used to establish a flow path for continuous natural circulation of coolant through the core into the downcomer annulus during postulated events. During and following a postulated event, this natural circulation path transfers decay heat from the reactor core to the vessel shell and then to the decay heat removal system (DHRS), thereby cooling the core passively.

The DHRS removes residual decay heat from the reactor core through the reactor vessel wall during normal and off-normal conditions. The portions of the DHRS that must function to perform the decay heat removal are designated as safety-related and are all passive. There are no active safety-related portions of the DHRS, and the DHRS does not require electrical power to perform safety functions during postulated events. The DHRS is an ex-vessel (external to the reactor vessel) system that continuously operates when the reactor is operating above a threshold power by removing energy from the vessel wall through thermal radiation and convective heat transfer to water-based thermosyphons. Inventory in the thermosyphons is boiled off and vents directly to the atmosphere outside the reactor building. The DHRS has sufficient inventory to sustain passive operation of the DHRS for up to 7 days as needed to mitigate a postulated event where normal cooling systems are unavailable.

The fluidic diode and reactor design allow for a passive natural circulation flow path that can be monitored, and fluidic diode integrity will be ensured by planned qualification testing as well as the ability to inspect the fluidic diode. The NRC staff's evaluation concluded that there is reasonable assurance that the reactor vessel system will perform its safety functions of

maintaining structural integrity, geometry, and coolant inventory to ensure sufficient heat removal. The staff's evaluation also concluded that Kairos provided sufficient preliminary information on development of a DHRS design that will perform its safety function of passive residual heat removal.

High-temperature reactor and need for materials qualification.

The Hermes test reactor design operates at higher temperatures than LWRs and uses graphite as a moderator and reflector. The Hermes test reactor normal operating temperature is up to 650°C (1,202°F). Primary system components must be qualified for these high temperatures as well as for the Flibe coolant environment.

Regulatory Guide 1.87, "Acceptability of ASME Code Section III, Division 5, 'High Temperature Reactors,'" Revision 2, issued January 2023 (ML22101A263), describes an acceptable approach to ensure the mechanical and structural integrity of components that operate in elevated temperature environments and that are subject to time-dependent material properties and failure modes. The Hermes test reactor vessel will be designed and constructed in accordance with American Society of Mechanical Engineers (ASME) Boiler and Pressure Vessel Code (BPVC), Section III, Division 5, and will consist of 316H stainless steel welded with ER16-8-2 weld metal. The NRC staff notes that 316H stainless steel is an allowable material for use in high-temperature applications in accordance with ASME BPVC, Section III, Division 5.

Kairos submitted a TR that describes the qualification plan for metallic structural materials used in Flibe-wetted areas for safety-related high-temperature components of KP-FHR reactors, including the Hermes test reactor. The metallic materials qualification plan includes extensive testing to quantify degradation mechanisms in normal and postulated accident conditions. The NRC staff evaluation of the TR concluded that the Kairos qualification program for metallic materials meets regulatory requirements related to the qualification of 316H and ER16-8-2 in the Flibe environment.

The Hermes test reactor design includes graphite reflector blocks to moderate and reflect neutrons back into the reactor core and protect the reactor vessel from the effects of neutron fluence. The reflector blocks provide a heat sink for the core and form coolant flow channels, the pebble defueling chute, and channels for the insertion and withdrawal of reactivity control and shutdown elements.

Kairos submitted a TR describing the testing required to qualify ET-10 nuclear-grade graphite intended for safety-related components providing structural support in the Hermes test reactor. Irradiation of graphite causes material property changes as a function of neutron fluence and irradiation temperature. One of the most important changes is irradiation-induced dimensional change. As the neutron fluence increases, graphite first densifies until reaching a fluence known as turnaround. Above the turnaround fluence, the graphite expands, and the volume increases to its preirradiated level at a fluence called the crossover, after which the graphite keeps expanding. Turnaround and crossover fluences decrease with increasing irradiation temperature. The behavior of graphite as a function of fluence and temperature is an important design consideration to ensure graphite components maintain their integrity and perform their design functions throughout their operating life.

The TR on graphite qualification describes a methodology to characterize the effects of the environment (i.e., molten salt and pebbles) on graphite in the reflector blocks to provide data that can be used to demonstrate compliance with design criteria and to satisfy the applicable

regulatory requirements. The NRC staff evaluation of the graphite qualification TR concluded that the methodology is acceptable because it is generally consistent with applicable portions of ASME BPVC, Section III, Division 5, with departures evaluated by the NRC staff related to graphite material qualification. The NRC staff evaluation of the Hermes test reactor CP application concludes that the preliminary design of the reactor vessel system is consistent with the relevant PDC based on its commitment to use ASME BPVC, Section III, Division 5, and the graphite qualification TR for design and qualification of graphite components.

Environmental Matters

The NRC staff issued the final EIS, NUREG-2263, "Environmental Impact Statement for the Construction Permit for the Kairos Hermes Test Reactor," in August 2023. The NRC staff's environmental review had no novel issues.

IV. Construction Permit Findings

10 CFR 50.35(a)

> (1) The applicant has described the proposed design of the facility, including, but not limited to, the principal architectural and engineering criteria for the design, and has identified the major features or components incorporated therein for the protection of the health and safety of the public.

The Kairos PSAR presents the principal architectural and engineering criteria incorporated into the proposed design of the Kairos testing facility to protect public health and safety. The following PSAR chapters contain the PDC, design bases, administrative controls, passive safety features, and active safety features:

- Chapter 1.0 The Facility
- Chapter 2.0 Site Characteristics
- Chapter 3.0 Design of Structures, Systems, and Components
- Chapter 4.0 Reactor Description
- Chapter 5.0 Reactor Coolant Systems
- Chapter 6.0 Engineered Safety Features
- Chapter 7.0 Instrumentation and Control Systems
- Chapter 8.0 Electrical Power Systems
- Chapter 9.0 Auxiliary Systems
- Chapter 11.0 Radiation Protection and Waste Management
- Chapter 12.0 Conduct of Operations

- Chapter 13.0 Accident Analyses
- Chapter 14.0 Technical Specifications

The NRC staff evaluated the preliminary design to ensure the sufficiency of PDC; design bases; and information relative to materials of construction, general arrangement, and approximate dimensions. As part of its review of the preliminary design, the NRC staff evaluated descriptions and discussions of the testing facility's SSCs, giving special attention to design and operating characteristics, unusual or novel design features, and principal safety considerations. Based on its evaluation, the NRC staff concludes that the preliminary design is sufficient to provide reasonable assurance that the final design will conform to the design bases. In addition, the NRC staff reviewed the identification and justification for the selection of variables, conditions, or other items that are probable subjects of technical specifications for the Hermes test reactor.

In areas for which the NRC staff found that the information submitted initially was incomplete or insufficient to reach a conclusion, the NRC staff conducted audits. Kairos supplemented the PSAR and provided clarifications through timely responses to the NRC staff's questions during audit meetings and in docketed correspondence. The NRC staff documented the results of the audits in the following audit reports for the safety review:

- Accident Analysis Audit Report (ML23160A287)
- DHRS Audit Report (ML23115A480)
- General Audit Report (ML23160A287)
- Instrumentation and Controls Audit Report (ML23115A480)
- Site Characteristics Audit Report (ML23115A480)

The NRC staff also prepared and issued three RAIs (ML22220A299; ML22227A180; ML22227A192) and one request for confirmation of information (ML22230D076). The NRC staff reviewed Kairos's responses (ML22243A247; ML22251A400; ML22231B228) to ensure that the additional information was sufficient to support its conclusion.

The NRC staff finds that the preliminary design and analysis of the Hermes testing facility are sufficient because they (1) provide reasonable assurance that the final design will conform to the design bases, (2) include an adequate margin of safety, (3) demonstrate that SSCs adequately provide for the prevention of accidents and the mitigation of consequences of accidents, and (4) meet all applicable regulatory requirements and acceptance criteria included or referenced in NUREG-1537. Notably, releases of radioactive material and waste from operation of the facility are expected to remain below the limits in Subpart D, "Radiation Dose Limits for Individual Members of the Public," to 10 CFR Part 20, "Standards for Protection Against Radiation." This supports the NRC staff's conclusion that issuance of the permit will not be inimical to the common defense and security or to public health and safety. As discussed in Chapter 1.0 of its SE, the NRC staff made its inimicality finding after determining that Kairos met all applicable regulations and acceptance criteria.

Based on its review, the NRC staff concludes that Kairos has described the proposed design of the facility, including, but not limited to, the principal architectural and engineering criteria for the

design, and has identified the major features or components incorporated therein for the protection of public health and safety in accordance with 10 CFR 50.35(a)(1). Thus, the NRC staff concludes that Kairos has met the applicable standards and requirements of the Atomic Energy Act of 1954, as amended (AEA), and the Commission's regulations.

> (2) Such further technical or design information as may be required to complete the safety analysis, and which can reasonably be left for later consideration, will be supplied in the final safety analysis report.

The NRC staff evaluated the sufficiency of the preliminary design of the Hermes test reactor based on the Kairos design methodology and ability to provide reasonable assurance that the final design will conform to the design bases. As such, the NRC staff's evaluation of the Kairos preliminary design does not constitute approval of the safety of any design feature or specification. Such approval, if granted, would occur only after the NRC staff completes an evaluation of the final design of the Hermes test reactor, as described in an FSAR submitted as part of a Kairos operating license application.

Throughout the PSAR, and in responses to audit questions and RAIs, Kairos described the items for which an FSAR would provide further technical or design information. A list of these items is provided in Appendix A to the NRC staff's SE. The NRC staff will evaluate the status of these items as part of its review of an operating license application.

Based on its review of the application and responses to audit questions and RAIs, the NRC staff concludes that Kairos has demonstrated that further technical or design information can reasonably be left for later consideration in the FSAR in accordance with 10 CFR 50.35(a)(2). Thus, the NRC staff concludes that Kairos has met the applicable standards and requirements of the AEA and the Commission's regulations.

> (3) Safety features or components, if any, which require research and development have been described by the applicant and the applicant has identified, and there will be conducted, a research and development program reasonably designed to resolve any safety questions associated with such features or components.

As described in Hermes test reactor PSAR Chapter 1.0, Kairos identified several research and development activities:

- Perform a laboratory testing program to confirm fuel pebble behavior.
- Develop a high-temperature material surveillance sampling program for the reactor vessel and internals.
- Perform testing of high-temperature material to qualify Alloy 316H and ER16-8-2.
- Perform an analysis related to potential oxidation in certain postulated events for the qualification of the graphite used in the reflector structure.
- Develop and validate computer codes for core design and analysis methodology.

- Develop a fluidic diode device to ensure proper circulation during normal operation and passive cooling by natural circulation.

- Justify thermodynamic data and associated vapor pressure correlations of representative species.

- Develop process sensor technology for key reactor process variables.

- Develop the reactor coolant chemical monitoring instrumentation.

In support of these activities, Kairos has described the affected SSCs and the remaining work to be performed. The NRC staff identified these research and development activities in Appendix A to its SE and will verify that these activities are completed prior to the completion of construction.

Based on its review of the Hermes test reactor CP application, the NRC staff concludes that Kairos has described safety features and components that require research and development in accordance with 10 CFR 50.35(a)(3). Furthermore, Kairos has demonstrated that it will conduct a research and development program reasonably designed to resolve any safety questions.

However, the NRC staff determined that the CP should be conditioned in two areas. First, although the Kairos application addresses geotechnical evaluations, additional information is needed to confirm that karstic[2] features that could affect the Hermes test reactor are not present. Accordingly, as described in Section 2.5 of the NRC staff's SE, the CP would be conditioned upon Kairos performing detailed geologic mapping of excavations for safety-related engineered structures and reporting on the excavations. Second, the CP would be conditioned on Kairos implementing its quality assurance program for design, procurement, and construction of the Hermes test reactor, subject to provisions identified in Section 12.9 of the SE. The draft CP lists these two conditions, and the NRC staff has also listed them in Appendix A to its SE. These conditions are confirmatory in nature since they do not require evaluation by the NRC staff to make its findings with respect to the issuance of the CP.

Thus, the NRC staff concludes that Kairos meets the applicable standards and requirements of the AEA and the Commission's regulations.

(4) On the basis of the foregoing, there is reasonable assurance that,

(i) such safety questions will be satisfactorily resolved at or before the latest date stated in the application for completion of construction of the proposed facility.

By letter dated December 8, 2022 (ML22342B282), Kairos stated that the latest date for completion of construction is expected to be December 2026, and that it will finish its research and development activities identified in PSAR Chapter 1 before the completion of construction.

Based on its review of the Hermes test reactor CP application, the NRC staff concludes that there is reasonable assurance that Kairos will satisfactorily resolve the safety questions at or before the latest date for the completion of construction of the testing facility. Thus, the NRC

[2] The term karst describes a distinctive topography that indicates dissolution of underlying soluble rocks by surface water or groundwater.

staff concludes that the applicable standards and requirements of the AEA and the Commission's regulations have been met.

> (ii) taking into consideration the site criteria contained in Part 100 of this chapter, the proposed facility can be constructed and operated at the proposed location without undue risk to the health and safety of the public.

The NRC staff reviewed the application to ensure that issuance of the CP will not be inimical to the common defense and security or to public health and safety. The NRC staff notes that the site criteria contained in 10 CFR Part 100, "Reactor Site Criteria," are applicable to nuclear power reactors and testing facilities. The NRC staff evaluated the testing facility's site-specific conditions considering the site criteria in 10 CFR Part 100 by using the guidance in NUREG-1537. The NRC staff's review in Chapter 2.0 of its SE evaluated the geography and demography of the site; nearby industrial, transportation, and military facilities; site meteorology; site hydrology; and site geology, seismology, and geotechnical engineering, to ensure that issuance of the CP will not be inimical to public health and safety. The NRC staff also evaluated SSCs and equipment designed to ensure safe operation, performance, and shutdown when subjected to extreme weather, floods, seismic events, missiles (including aircraft impacts), chemical and radiological releases, and loss of offsite power.

As discussed in Chapter 13.0 of its SE, the NRC staff's review confirmed that radiological consequences of potential accidents will be consistent with the criteria in 10 CFR Part 100. Thus, the NRC staff concludes that the issuance of the CP will not be inimical to public health and safety.

The NRC staff's review of the Kairos preliminary emergency planning information concluded that the preliminary emergency plan contains the information required in Appendix E to 10 CFR Part 50. Therefore, as discussed in Chapter 12.0 of the NRC staff's SE, the preliminary plan is acceptable and supports its conclusion that issuance of the CP will not be inimical to the common defense and security or to public health and safety.

Based on its review of the application, as discussed in this paper and in the referenced documents, the NRC staff concludes that there is reasonable assurance that the proposed testing facility can be constructed and operated at the proposed location without undue risk to public health and safety. The NRC staff also concludes that the provisions of the AEA and the Commission's regulations have been met. In some cases, the NRC staff's finding required the inclusion of conditions in the CP. The draft CP lists these conditions.

10 CFR 51.105(a)

> (1) Determine whether the requirements of Sections 102(2) (A), (C), and (E) of NEPA and the regulations in this Subpart [Subpart A, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions," of 10 CFR Part 51] have been met.

The NRC staff reviewed the Hermes test reactor CP application and evaluated it against the applicable regulations in 10 CFR Parts 50, 51, and 100. The NRC staff performed this evaluation using applicable portions of the ISG augmenting NUREG-1537, other ISG documents, and RGs.

In accordance with NEPA Section 102(2)(A) (42 U.S.C. § 4332(2)(A)), the NRC staff prepared the final EIS based on its independent assessment of the information provided by the applicant and information developed independently by the NRC staff, including through consultation with local, state, and other Federal agencies and Federally recognized Indian Tribes. The NRC staff's technical analysis used a systematic, interdisciplinary approach to integrate information from many fields, including the natural and social sciences.

In accordance with NEPA Sections 102(2)(C)(i–v) (42 U.S.C. § 4332(2)(C)(i–v)), the final EIS for the Kairos Hermes test reactor CP addresses (1) the environmental impacts of the proposed action and mitigation measures, (2) any unavoidable adverse environmental effects, (3) alternatives to the proposed action, (4) the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity, and (5) any irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented.

Section 3.5 of the final EIS documents the NRC's NHPA Section 106 consultation administrative record and references correspondence and publicly available summaries related to the staff's interactions with the Advisory Council on Historic Preservation, National Park Service, Tennessee Historical Commission, and Federally recognized Indian Tribes during the environmental review. Based on a Tribal request submitted during the comment period for the draft EIS, the staff engaged in government-to-government consultations with that Federally recognized Indian Tribe. The Federally recognized Indian Tribe requested additional information related to the site and to participate in the development of an Archaeological Resources Monitoring and Unanticipated Discovery Plan. At the time of publishing of the final EIS, the consulting parties have agreed upon a path forward to support NHPA Section 106 consultation closure. As discussed above, the NHPA Section 106 process will be completed with the documentation of consultation closure into the NRC's Record of Decision. In the alternative, the parties may execute a Programmatic Agreement or a Memorandum of Agreement. As supported by the documentation included in the final EIS regarding the status of the consultations and the plan for consultation closure, the NRC staff concludes that it has fulfilled the requirement of NEPA Section 102(2)(C) by engaging in consultation with and obtaining comments from other Federal, State, and local agencies with jurisdiction by law or special expertise. The NRC staff also filed both the draft and final EIS with the U.S. Environmental Protection Agency, furnished it to commenting agencies, and made it available to the public.

The NRC staff concludes that the final EIS demonstrates that the NRC staff adequately considered alternatives to the proposed action and did not identify any unresolved conflicts concerning alternative uses of available resources, consistent with the requirements of NEPA Section 102(2)(E) (42 U.S.C. § 4332(2)(E)). The range of reasonable alternatives considered in detail in the final EIS include the no-action alternative and building the Hermes test reactor at an alternative site.

For the reasons given above, the NRC staff also concludes that its review meets the NRC's requirements in 10 CFR Part 51, Subpart A. The NRC staff concludes that the environmental findings in the final EIS constitute the "hard look" required by NEPA and have reasonable support in logic and fact.

(2) Independently consider the final balance among conflicting factors contained in the record of the proceeding with a view to determining the appropriate action to be taken.

Section 4.3 of the final EIS provides the NRC staff summary of the cost-benefit assessment. The NRC staff concluded that, "building, operating, and decommissioning the proposed Hermes test reactor (with the appropriate mitigation measures identified by the NRC staff), would have accrued benefits that most likely would outweigh its economic, environmental, and social costs."

(3) Determine, after weighing the environmental, economic, technical, and other benefits against environmental and other costs, and considering reasonable alternatives, whether the construction permit should be issued, denied, or appropriately conditioned to protect environmental values.

As noted above, in its final EIS, the NRC staff considered the cost-benefit balancing as well as reasonable alternatives. Based on that analysis, the NRC staff recommends that the CP be issued once the NHPA Section 106 process is complete. The NRC staff based its recommendation on (1) the Kairos Hermes test reactor ER submitted as part of its CP application, information gathered during the environmental audit, and responses to requests for clarifying information, (2) consultation with Federal, State, and local agencies and Federally recognized Indian Tribes, (3) the NRC staff's independent review, (4) the NRC staff's consideration of public scoping comments related to the environmental review, (5) the NRC staff's consideration of public comments on the draft EIS, and (6) the assessments summarized in the EIS, including the potential mitigation measures identified.

(4) Determine, in an uncontested proceeding, whether the NEPA review conducted by the NRC staff has been adequate.

The NRC staff conducted an independent evaluation of the application; developed independent, reliable information; and conducted a systematic, interdisciplinary review of the potential impacts of the proposed action on the human environment and reasonable alternatives to the proposed action. Before developing the draft EIS, the NRC staff issued a notice of intent and invited the public to provide any information relevant to the environmental review. The NRC staff also provided opportunities for governmental and general public participation during the public meeting on the draft EIS.

The NRC staff considered the purpose of and need for the proposed action, the environment that could be affected by the action, and the impacts of the proposed action, including mitigation that could reduce impacts. The final EIS considered the no-action alternative and an alternative site. The final EIS compared the impacts of the alternatives to those of the proposed action. The NRC staff considered any adverse environmental effects that could not be avoided should the proposed action be implemented, the relationship between short-term uses of the human environment and the maintenance and enhancement of long-term productivity, and any irreversible or irretrievable commitments of resources that would be involved in the proposed project.

The NRC staff filed the draft EIS with the U.S. Environmental Protection Agency for its review consistent with the requirements of Section 309 of the Clean Air Act (42 U.S.C. § 7609). The NRC staff considered all comments received on the draft EIS and, in Appendix G to the final EIS, described the manner in which each comment was dispositioned.

On these bases, the NRC staff concludes that, for the purpose of issuing the CP, it conducted a thorough and complete environmental review that was sufficient to meet the requirements of

NEPA and the NRC's regulations and adequate to inform the Commission's action on the Hermes test reactor CP application.

CONCLUSION:

Based on the findings of its review in accordance with 10 CFR 50.35(a) and 10 CFR 51.105, the NRC staff concludes that there is sufficient information for the Commission to issue the subject CP to Kairos once the NHPA Section 106 process is complete, as guided by the following considerations described in 10 CFR 50.40 and 10 CFR 50.50, and as described in Chapter 1.0 of the NRC staff's SE for the Kairos application:

- There is reasonable assurance: (i) that the construction of the Hermes test reactor will not endanger public health and safety, and (ii) that construction activities can be conducted in compliance with the Commission's regulations.

- Kairos is technically qualified to engage in the construction of its proposed testing facility in accordance with the Commission's regulations.

- Kairos is financially qualified to engage in the construction of its proposed testing facility in accordance with the Commission's regulations.

- The issuance of a permit for the construction of the testing facility would not be inimical to the common defense and security or to public health and safety.

- After weighing the environmental, economic, technical, and other benefits of the proposed action against environmental and other costs and considering reasonable alternatives, the issuance of the CP, subject to the conditions for protection of the environment set forth therein, is in accordance with Subpart A of 10 CFR Part 51 of the Commission's regulations and all applicable requirements have been satisfied.

- The application meets the standards and requirements of the AEA and the Commission's regulations, and notifications, if any, to other agencies or bodies have been duly made.

COORDINATION:

This paper has been coordinated with the Office of the General Counsel, which has no legal objection.

Signed by Dorman, Dan
on 08/23/23

Daniel H. Dorman
Executive Director
for Operations

SUBJECT: STAFF'S STATEMENT IN SUPPORT OF THE UNCONTESTED HEARING FOR ISSUANCE OF A CONSTRUCTION PERMIT FOR THE KAIROS HERMES TEST REACTOR DATED: AUGUST 23, 2023

ADAMS Accession No.: ML23123A064 ***e-concurrence**

OFFICE	NRR/DANU/UAL1/PM*	NMSS/REFS/ERNRB/PM*	QTE*	NRR/DANU/UAL1/LA*
NAME	BBeasley	TDozier	JDoughtery	DGreene
DATE	5/8/2023	5/11/2023	5/15/2023	5/15/2023
OFFICE	NMSS/REFS/ERNRB/BC*	NRR/DANU/UAL1/BC*	NRR/DANU/UTB2/BC*	OGC*
NAME	KErwin (DPalmrose for)	AProffitt	CdeMessieres	MWright (NLO)
DATE	6/22/2023	6/23/2023	6/26/2023	7/13/2023
OFFICE	NRR/DANU/D*	NMSS/REFS/D*	NMSS/D*	NRR/D*
NAME	MShams	CRegan	JLubinski	AVeil
DATE	7/21/2023	7/24/2023	7/31/2023	8/10/2023
OFFICE	EDO*			
NAME	DDorman			
DATE	8/23/2023			

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