UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE COMMISSION

In the Matter of	)	**Docket No. 50-7513**
KAIROS POWER LLC	)	
(Kairos Power Hermes Reactor)	)	**September 28, 2023**

APPLICANT'S PRE-FILED TESTIMONY OF PETER HASTINGS
KAIROS POWER LLC
EVIDENTIARY HEARING

1. Witness Background

Question 1.1: Please state your name.

Answer 1.1: Peter Hastings

Question 1.2: By whom are you employed?

Answer 1.2: I am employed by Kairos Power LLC (Kairos Power).

Question 1.3: What is your position at Kairos Power?

Answer 1.3: I am the Vice President of Regulatory Affairs and Quality, with responsibility for Nuclear Regulatory Commission (NRC) licensing activities, reliability engineering, quality assurance, and government affairs.

Question 1.4: Describe your educational and professional background.

Answer 1.4: I have a Bachelor of Science degree in Nuclear Engineering from North Carolina State University (1984) and I am a registered professional engineer in North Carolina and South Carolina. Prior to joining Kairos Power in 2018, I ran a management and regulatory consulting firm specializing in new and advanced reactor development, consulting with the Electric Power Research Institute, the Nuclear Energy Institute, the Nuclear Innovation Alliance, the Tennessee Valley Authority, Southern Company, and

several advanced reactor developers. From 2011 to 2014, I worked for what is now BWX Technologies on the mPower small modular reactor project. Previously, I worked in multiple positions for Duke Energy, beginning in 1984. Those positions included reactor engineering at Oconee Nuclear Station; various positions supporting the Department of Energy's Office of Civilian Radioactive Waste Management; licensing and safety analysis manager for the Mixed Oxide Fuel Fabrication Facility; and director for AP1000 licensing, where I also was the design center lead for NuStart Energy Development. I am also active in numerous industry collaboration organizations, including leadership positions within the Nuclear Energy Institute, the US Nuclear Industry Council, and the World Nuclear Association.

Question 1.5: What is the purpose of your testimony?

Answer 1.5: The purpose of my testimony is to support the findings that the NRC must make as part of the evidentiary hearing for the construction permit (CP) for the Kairos Power Hermes Reactor.

Question 1.6: Describe the structure of your testimony.

Answer 1.6: The structure of this testimony is as follows:

- Section 1 – Witness background
- Section 2 – Description of the Construction Permit Application (CPA)
- Section 3 – NRC's review of the CPA
- Section 4 – Safety findings
- Section 5 – Environmental findings
- Section 6 – Conclusions

2. Description of the Construction Permit Application

Project Background Information

Question 2.1: Briefly describe the Hermes Reactor project.

Answer 2.1: The Hermes Reactor project is a 35 megawatt-thermal (MWth) non-power reactor facility to be located within the East Tennessee Technology Park near Oak Ridge, Tennessee. The purpose of the non-power reactor facility is to test and demonstrate the key technologies, design features, and safety functions of the Kairos Power fluoride salt-cooled, high-temperature reactor (KP-FHR) technology and its structures, systems, and components (SSCs). The facility will also provide data and insights for the safety analysis tools and computational methodologies used for the design and licensing of future KP-FHRs.

Question 2.2: Provide a high-level description of the Hermes Reactor.

Answer 2.2: The KP-FHR is an advanced reactor technology developed in the United States (U.S.) over the last decade. The technology follows from Department of Energy (DOE) sponsored research and development at universities and national laboratories. The fundamental concept is the combination of Tri-structural Isotropic (TRISO) particle fuel coupled with a molten fluoride salt coolant. This combination results in a high temperature, low-pressure reactor system with robust inherent safety characteristics. The combination of extremely high-temperature-tolerant fuel and low-pressure, single-phase, chemically stable reactor coolant removes entire classes of potential fuel-damage scenarios, greatly simplifying the design and reducing the number of safety systems. The intrinsic low pressure of the reactor and associated piping, along with the fission product retention provided by the TRISO fuel, enhances safety and eliminates the need for low-leakage, pressure retaining containment structures. Additionally, the design relies on passive decay heat removal and does not need an emergency core cooling system for decay heat removal or replacement of coolant inventory. The major plant systems are the reactor system (RS), the primary heat transport system (PHTS), and the decay heat removal system (DHRS).

Question 2.3: Where is the proposed site for the Hermes Reactor?

Answer 2.3: The site is located within the East Tennessee Technology Park (ETTP) in Oak Ridge, Tennessee. The property is at the site of the former Buildings K-31 and K-33 of the Oak Ridge Gaseous Diffusion Plant (ORGDP), where uranium enrichment operations occurred from 1954 until the mid-1980s.

Question 2.4: What is the license being sought for the Hermes Reactor?

Answer 2.4: Kairos Power is applying to the NRC to obtain a CP for a non-power reactor under Title 10, *Code of Federal Regulations* (CFR) Part 50 (10 CFR 50), "Domestic Licensing of Production and Utilization Facilities," specifically 10 CFR § 50.21(c).

Question 2.5: Describe the structure and organization of the Construction Permit Application.

Answer 2.5: The CPA was submitted in two parts as permitted by 10 CFR § 2.101(a)(5). A description of each part follows.

The first part of the CPA includes:

- the general information required by 10 CFR §§ 50.33(a)-(e), (h), and (j); 10 CFR § 50.34(a)(9); and 10 CFR § 50.55(a),
- the Preliminary Safety Analysis Report (PSAR) as required by 10 CFR § 50.34(a),
- the financial qualification information required by 10 CFR § 50.33(f)(1),
- Technical Report KP-TR-017-P, "KP-FHR Core Design and Analysis Methodology," which describes the nuclear design methods and supports Section 4.5 and Chapter 13 of the PSAR.
- Technical Report KP-TR-018-P, "Postulated Event Analysis Methodology," which describes the methodology for performing analyses in Chapter 13 of the PSAR.

The second part of the CPA includes the Environmental Report (ER) required by 10 CFR § 50.30(f).

Question 2.6: Describe the earliest date for completion of construction for the Hermes Project.

Answer 2.6: As indicated in Enclosure 1 of the submittal letter dated September 29, 2021, we anticipate completing construction by December 2026.

Question 2.7: Please describe the structure of the PSAR.

Answer 2.7: The PSAR is organized as follows:

- Chapter 1 – The Facility
- Chapter 2 – Site Characteristics
- Chapter 3 – Design of Structures, Systems, and Components
- Chapter 4 – Reactor Description
- Chapter 5 – Heat Transport System
- Chapter 6 – Engineered Safety Features
- Chapter 7 – Instrument and Control Systems
- Chapter 8 – Electric Power Systems
- Chapter 9 – Auxiliary Systems
- Chapter 10 – Experimental Facilities and Utilization
- Chapter 11 – Radiation Protection Program and Waste Management
- Chapter 12 – Conduct of Operations
- Chapter 13 – Accident Analysis
- Chapter 14 – Technical Specifications
- Chapter 15 – Financial Qualifications
- Chapter 16 – Other License Considerations
- Chapter 17 – Decommissioning and Possession-Only License Amendments
- Chapter 18 – Highly Enriched to Low Enriched Uranium Conversion

Question 2.8: Please describe the structure of the ER.

Answer 2.8: The ER is organized as follows:

- Chapter 1 – Introduction
- Chapter 2 – Proposed Action
- Chapter 3 – Description of the Affected Environment
- Chapter 4 – Impacts of Proposed Construction, Operations, and Decommissioning

- Chapter 5 – Alternatives
- Chapter 6 – Conclusions

Question 2.9: Discuss whether the form and content of the construction permit application conforms to NRC's regulatory guidance.

Answer 2.9: Kairos Power prepared the CPA for the Hermes Reactor to be generally consistent NRC's regulatory guidance in NUREG-1537, Parts 1 and 2 (ML042430055 and ML042430048, respectively) and the Interim Staff Guidance (ISG) that augments NUREG-1537, Parts 1 and 2 (ML12156A069 and ML12156A075, respectively).

Applicant Background Information

Question 2.10: Identify the applicant for the Hermes Reactor and its roles and responsibilities.

Answer 2.10: Kairos Power is the applicant for the CP of the Hermes Reactor. Kairos Power will design, construct, own, and operate the facility. Kairos Power will also manufacture many of the major components of the Hermes facility. Kairos Power is a privately held company that was created for the purpose of commercializing and deploying the KP-FHR technologies.

Question 2.11: When did Kairos Power submit the Construction Permit Application?

Answer 2.11: Kairos Power submitted the first part of the CPA that includes the general information, PSAR, financial qualification, and two technical reports, KP-TR-017-P and KP-TR-018-P, on September 29, 2021 (ML21272A376). Kairos Power submitted the second part of the CPA that included the ER on October 31, 2021 (ML21306A132). The Staff accepted the CPA for review on November 29, 2021 (ML21319A354). During the CPA review, Kairos Power submitted revisions to documents included in the original CPA submittal. The final docketed revision of the PSAR, Revision 3, was submitted on May 31, 2023 (ML23151A745). The final docketed revision of the ER, Revision 1, was submitted on March 31, 2023 (ML23089A388). The final docketed revisions of the financial qualifications (ML22263A032) and letter retracting the proposed exemptions from 10 CFR § 50.34(a)(4) and 10 CFR § 34(b)(4) (ML22263A035) were submitted on September 19, 2022. The final docketed revision of the technical reports, KP-TR-017-P Revision 1 (ML22272A594) and KP-TR-018-P Revision 2 (ML23055A673), were submitted on September 29, 2022, and February 24, 2023, respectively.

Question 2.12: Identify any exemption requests for the Hermes Reactor CPA.

Answer 2.12: Kairos Power has no exemption requests for the Hermes Reactor CPA. After further review and in discussion with the NRC Staff, the exemption requests originally proposed in the CPA were determined to be unnecessary and were retracted by letter as described in my previous response.

Question 2.13: Did the Construction Permit Application address all applicable NRC regulations?

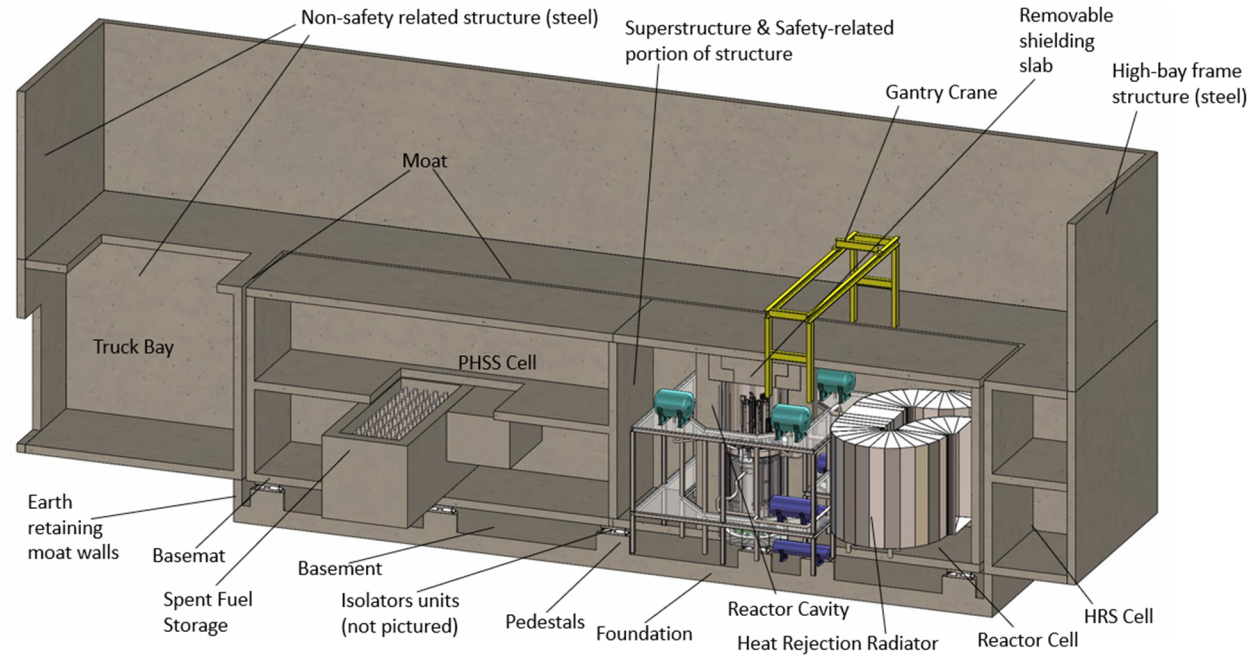
Answer 2.13: Yes. The Hermes Reactor CPA, including the latest docketed versions, provided the information required by applicable NRC regulations, including:

- 10 CFR § 50.30, "Filing of applications for licenses; oath or affirmation"
- 10 CFR § 50.33, "Contents of applications; general information"
- 10 CFR § 50.34, "Contents of applications; technical information"
- 10 CFR Part 51, "Environmental Protection Regulations for Domestic Licensing and Related Regulatory Functions"

General Description of the Hermes Reactor

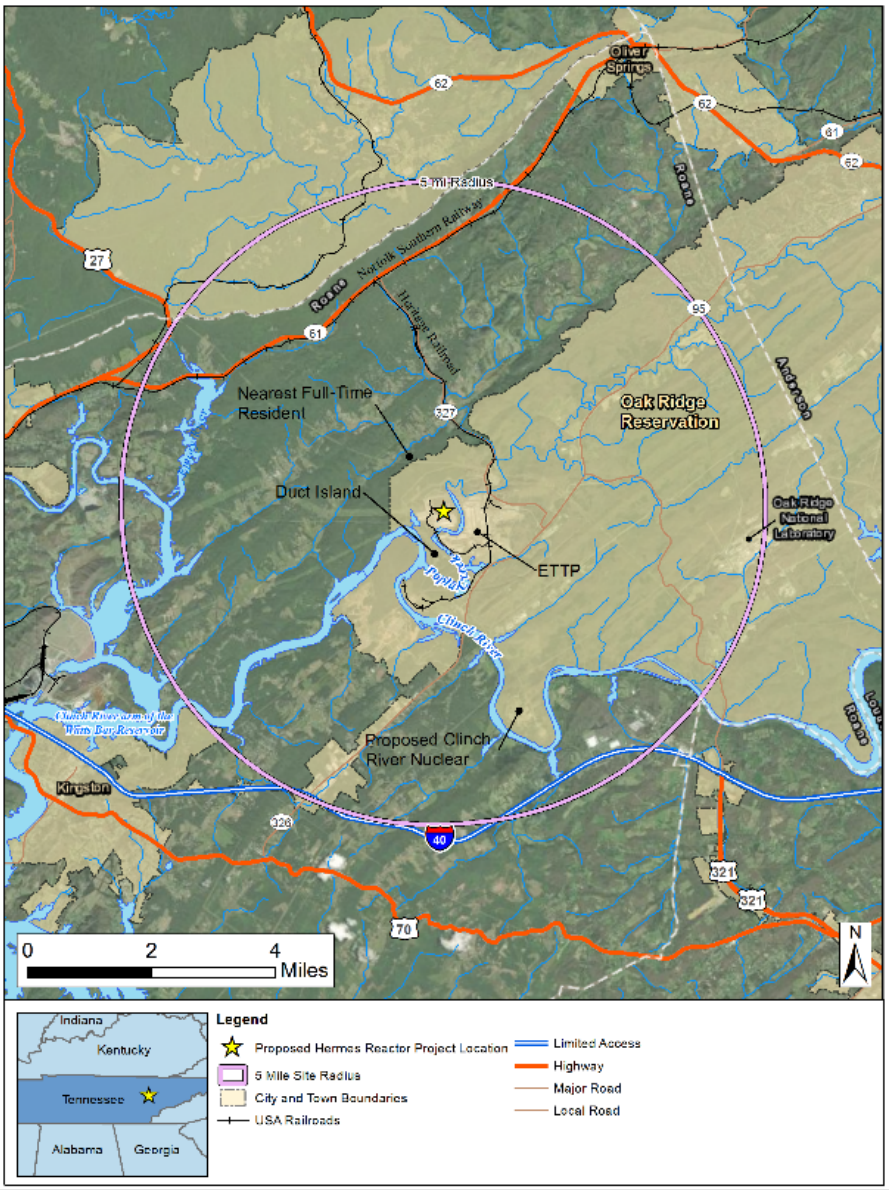
Question 2.14: Provide a general description of the Facility.

Answer 2.14: A schematic of the Hermes Reactor Building is provided in PSAR Section 3.5, Figure 3.5-1 (excerpted below). The building is approximately 250 ft long and 100 ft wide. A portion of the Reactor Building provides protection to safety-related SSCs from the effects of natural phenomena and external event hazards discussed in Sections 3.2, 3.3, and 3.4. PSAR Figure 3.5-1 shows the principal structural elements of the Reactor Building. The figure also shows the portion of the safety-related Reactor Building structure, which uses base isolation, and the non-safety related balance of the Reactor Building surrounding the isolated superstructure.



Question 2.15: What are the principal characteristics of the proposed site?

Answer 2.15: The principal characteristics of the site are described in detail in the ER, Chapter 2.0, "Site Characteristics." The overall site is an approximately 185 acre (74.8 hectare) parcel. The site was used as farmland prior to the construction of the ORGDP. DOE has since demolished and removed the ORGDP and its above-grade portions of the associated buildings. The site currently is considered a "brown field" site. As shown in PSAR Chapter 2, Figure 2.1-2 (excerpted below), the site is adjacent to Poplar Creek and 0.4 mile (0.6 kilometer [km]) from the Clinch River arm of the Watts Bar Reservoir. Poplar Creek is a tributary of the Clinch River arm of the Watts Bar Reservoir.



Question 2.16: In general, what are the principal design criteria for the Hermes Reactor?

Answer 2.16: The principal design criteria (PDC) for the Hermes Reactor are addressed in PSAR Section 3.1 and are based on the PDC previously reviewed and approved by the NRC Staff in the topical report "Principal Design Criteria for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor, KP-TR-003-NP-A" (ML19212A756).

Question 2.17: What are the operating characteristics for the Hermes Reactor?

Answer 2.17: The Hermes Reactor operating characteristics are described in PSAR Chapters 4 and 5. PSAR Table 4.1-1 (excerpted below) provides a summary of key parameters for the reactor.

Parameter	Value
Thermal Power (MWth)	35
Reactor Outlet Temperature (°C)	650
Reactor Inlet Temperature (°C)	550
Reactor Vessel Operating Pressure (bar)	< 2
Reactor Coolant Type	Flibe
Fuel Type	TRISO particle; UCO kernel
Fuel Matrix	Pebble
Equilibrium Fuel Enrichment (wt%)	≤ 19.75
Reflector Type	ET-10 Graphite
Control Material	B_4C
Neutron Spectrum	Thermal

The key design parameters for the primary heat transport system are provided in PSAR Table 5.1-1 (excerpted below).

Parameter	Value
Thermal duty	35 MWth
Number of heat rejection radiators (HRRs)	1
Number of hot legs	1
Number of cold legs	2
Primary loop line size	8-12 in nominal pipe size
HRR inlet coolant temperature	600-650°C
HRR outlet coolant temperature	550°C
Nominal Flow Rate	210 kg/s
PHTS Design Pressure	525 kPa(g)

Question 2.18: What are the engineered safety features for the facility?

Answer 2.18: The Engineered safety features (ESFs) are discussed in the PSAR, Chapter 6. The ESF are designed to mitigate the consequences of postulated events, ensuring that any potential dose consequences are within acceptable values. The ESFs credited for mitigation of postulated events are the functional containment and the DHRS.

The NRC defines functional containment in SECY-18-0096 as "a barrier or set of barriers taken together, that effectively limits the physical transport of radioactive material to the environment." This functional containment concept was approved in SRM-SECY-18-0096 (ML18338A502). Hermes functional containment refers to an approach to radionuclide retention that includes safety features inherent in KP-FHR technology and multiple barriers to release of radioactive material at risk. For fuel inside the reactor core, which can have high decay heat generation, the multiple barriers to release include the TRISO layers of the fuel and the radionuclide retention properties of Flibe. For fuel in the pebble handling and storage system (PHSS), which has low decay heat generation, the TRISO layers of the fuel provide the barriers to release. The inherent safety features of KP-FHR technology that facilitate the functional containment approach include a near-atmospheric operating pressure, a robust fuel design with radionuclide retention capabilities qualified to withstand peak temperatures of 1600°C, and a coolant design with a high boiling point. The functional containment is credited with radionuclide retention in postulated events.

The DHRS is the ESF that removes heat from the reactor vessel in postulated events where the normal heat rejection system is unavailable. The DHRS, along with natural circulation flow within the core, provides heat removal from fuel in the reactor core during postulated events via thermal radiation and convection without the need for external sources of electrical power or operator intervention. The heat removal provided by the DHRS and natural circulation is adequate to ensure that the vessel temperature remains below design limits and the fuel integrity is not challenged. The DHRS consists of four independent trains to provide redundancy in the event of a single failure. The DHRS is credited for decay heat removal from the reactor vessel in all of the limiting postulated events described in PSAR Section 13.1.

Question 2.19: Describe the reactor system and primary heat transport system.

Answer 2.19: The reactor system is designed with a functional capability to achieve a thermal power of up to 35 MWth at a reactor outlet temperature of 650°C. The normal reactor inlet temperature is 550°C. The reactor system design employs a high-temperature graphite-matrix coated tri-structural isotropic (TRISO) particle fuel and a chemically stable, low-pressure molten fluoride salt coolant (Flibe). TRISO fuel and Flibe constitute the functional containment which is relied on as a means of retaining fission products and preventing radionuclide release to the environment during normal operations and postulated events.

The reactor system includes:

- Reactor Core
    - Reactor Fuel
    - Reactivity Control and Shutdown System
    - Neutron Startup Source
- Reactor Vessel and the Reactor Vessel Internals
- Biological Shield
- Reactor Vessel Support System

The reactor system generates heat by the controlled fission of special nuclear material contained within the TRISO fuel. The reactor transfers heat to the reactor coolant and provides for circulation of reactor coolant through the reactor core. Control elements are provided to control the reactivity of the core. A separate and independent set of shutdown elements provides for safe shutdown of the reactor during off-normal conditions. A neutron source is provided during initial pre-critical operations to assist with initial startup of the reactor core. The online refueling capability of the reactor compensates for changes in reactivity due to depletion of fuel and accumulation of fission products. The design of the reactor vessel and internals ensures that a coolable geometry is maintained for the reactor core under all normal operations and postulated events. The reactor design includes provisions for online monitoring to support control and protection functions, as well as the capability for in-service inspection, maintenance, and replacement activities. Shielding is included to limit radiation doses to workers and equipment.

The primary heat transport system (PHTS) transfers heat from the reactor core by circulating reactor coolant between the packed bed of fuel elements (pebbles) and reflector in the reactor core and the heat rejection subsystem during normal operations. The PHTS includes a primary salt pump (PSP), heat rejection subsystem, and associated piping. The heat rejection subsystem includes a heat rejection radiator (HRR), heat rejection blower, and associated ducting. The PHTS also includes thermal management features to maintain the reactor coolant in the liquid phase when the reactor core is not generating heat, and capability to drain external piping and the HRR to allow cooldown, inspection, and maintenance. The primary system functions of the PHTS are non-safety related.

Question 2.20: Describe the instrumentation, control, and electrical systems.

Answer 2.20: The instrumentation and control (I&C) systems monitor and control plant operations during normal operations and planned transients. The systems also monitor and actuate protection systems in the event of unplanned transients. I&C is comprised of four parts, described in the bulleted list below. Each of the four parts are described in further detail in subsections of the PSAR. The architectural design of the system accounts for interconnection interfaces for plant I&C SSCs.

- The plant control system (PCS) provides the capability to reliably control the plant systems during normal, steady state, and planned transient power operations, including normal plant startup, power maneuvering, and shutdown.
- The reactor protection system (RPS) provides protection for reactor operations by initiating signals to mitigate the consequences of postulated events and to ensure safe shutdown.
- The main control room and remote onsite shutdown panel provide the capability for plant operators to monitor plant systems, control plant systems, and to initiate plant shutdown.
- Sensors provide input to multiple control and protection systems.

The purpose of the electrical system is to provide power to plant equipment for operation. The electrical system consists of the non-Class 1E normal power system and the backup power system. During normal operations, the local utility supplies AC electrical power to the normal power system. If the normal power source fails, the backup power system supplies plant power. The backup power system utilizes backup generators and uninterruptible power supplies to achieve this function.

Owing to the passive design of the Hermes Reactor, safety-related SSCs do not require electric power to perform safety-related functions following a postulated event. Therefore, AC power from off-site or backup power sources is not required to mitigate a postulated event.

Question 2.21: What other notable auxiliary systems are part of the Hermes Reactor?

Answer 2.21: The Hermes Reactor has the following auxiliary systems:

- Chemistry Control System
- Inert Gas System

- Tritium Management System
- Inventory Management System
- Reactor Thermal Management System
- Reactor Building Heating, Ventilation, and Air Conditioning System
- Pebble Handling and Storage System
- Fire protection systems
- Communication systems
- Plant water systems
- Remote Maintenance and Inspection System
- Spent Fuel Cooling System
- Compressed Air System
- Cranes and Rigging
- Auxiliary Site Services

Question 2.22: Describe the Hermes Reactor radiation protection programs and radioactive waste management.

Answer 2.22: The sources of radiation that present a potential hazard to workers and the public in the facility result from fission in the fuel (fission products and decay products) and neutron activation products (including tritium) generated as a result of exposure to neutrons. In the unlikely event of manufacturing defects in the TRISO layers, for example, fission products generated in the TRISO fuel could leak into the Flibe. Fission products also may be generated from potential uranium impurity in the reactor coolant. Activation products are located in the coolant, cover gas, and structures, and are the result of neutron activation of various isotopes, and corrosion and wear products.

A radiation protection program is required by 10 CFR § 20.1101. The radiation protection program implemented for Hermes will comply with the regulatory requirements in 10 CFR Parts 19 and 20, and will be developed, documented, and implemented commensurate with the scope and extent of licensed activities for a test reactor facility. A description of the program will be provided in the Operating License application.

The radioactive waste handling systems provide for the collection, packaging, storing, and dispositioning of low-level radioactive wastes in solid, and liquid forms. A description of the radwaste handling systems will be provided in the Operating License application.

3. NRC Review of the Kairos Power Hermes Reactor CPA

Question 3.1: Did the NRC staff document its safety and environmental reviews of the Construction Permit Application for the Hermes Reactor?

Answer 3.1: Yes. The NRC documented its safety review in the final safety evaluation report (FSER) issued on June 13, 2023 (ML23158A268) and documented its environmental review in the final environmental impact statement (FEIS) (NUREG-2263) issued on August 17, 2023 (ML23214A269).

Question 3.2: What were the conclusions of the NRC staff?

Answer 3.2: In the FSER, the staff concluded that the preliminary design and analysis of the Hermes test reactor, including the principal design criteria; design bases; information relative to materials of construction and general arrangement; and preliminary analysis and evaluation of the design and performance of structures, systems, and components of the facility: (1) provide reasonable assurance that the final design will conform to the design basis; (2) include an adequate margin of safety; (3) describe the SSCs which will provide for the prevention of accidents and the mitigation of consequences of accidents; and (4) meet applicable regulatory requirements and satisfy applicable NRC guidance. Therefore, the staff recommended that the Commission make the necessary findings to issue the CP.

In the FEIS, the staff concluded that after weighing the environmental, economic, technical, and other benefits against the environmental and other costs, and considering reasonable alternatives, that the Commission should issue the CP after the requirements of the National Historic Preservation Act (NHPA) Section 106 process are met.

Question 3.3: Has the Advisory Committee on Reactor Safeguards (ACRS) conducted a review of the Construction Permit Application for the Hermes facility?

Answer 3.3: Yes. The ACRS provided an independent review and report to the Commission regarding the Kairos Power Hermes Reactor CPA. The ACRS Kairos Power Licensing Subcommittee reviewed the PSAR and draft safety evaluation report during meetings on March 1, 2023; March 23–24, 2023; April 4, 2023; and April 18–19, 2023. The full ACRS considered the Hermes Reactor CPA during its 705th meeting on May 3–5, 2023.

Question 3.4: What were the conclusions of the ACRS?

Answer 3.4: The ACRS issued a letter report dated May 16, 2023 supporting issuance of the CP (ML23130A183). The ACRS concluded: "There is confidence that the facility can be constructed in accordance with relevant regulations and the design bases outlined in the PSAR. The construction permit for Hermes should be approved."

The ACRS also identified topics to be further addressed prior to completion of construction, including confirming fuel pebble behavior; high temperature material qualification and surveillance; oxidation of graphite; validation of computer codes; development of a fluidic diode, justification of thermodynamic and vapor pressure correlations used in source term analysis; development of process sensor technology for key reactor process variables; and development of reactor coolant chemical monitoring instrumentation. The NRC staff acknowledged the ACRS recommendations in a letter dated June 20, 2023 (ML23160A255).

Question 3.5: Have you reviewed SECY-23-0074, "Staff Statement in Support of the Uncontested Hearing for Issuance of Construction Permit for the Kairos Hermes Test Reactor," dated August 23, 2023, that was submitted by the NRC staff to support the mandatory hearing for the Hermes facility?

Answer 3.5: Yes.

Question 3.6: Do you agree with the staff's conclusions in SECY-23-0074 regarding the staff safety review, ACRS Report, exemptions, and the safety matters the staff considers to be "Nonroutine Unique Facility Features or Novel Issues"?

Answer 3.6: Yes.

Question 3.7: Does SECY-23-0074 address the safety and environmental findings that must be made to issue the CP for the Hermes facility?

Answer 3.7: Yes.

Question 3.8: What are the staff's conclusions in SECY-23-0074 regarding those findings?

Answer 3.8: The staff concluded that there is sufficient information in the record to support the required findings to issue the CP to Kairos Power once the requirements of the NHPA Section 106 process as outlined in the final EIS have been met. In summary, the NRC staff found that, subject to certain conditions (FSER, Appendix A), the Kairos Power preliminary design and analysis of the Hermes Reactor as described in the

CPA, is sufficient and meets the applicable regulatory requirements and guidance for the issuance of a CP in accordance with 10 CFR Part 50. Each finding is discussed in additional detail in subsequent sections of my testimony.

Question 3.9: Do you agree with the overall conclusions reached in SECY-23-0074?

Answer 3.9: Yes.

Question 3.10: Were any petitions to intervene submitted on the Hermes Reactor Construction Permit Application?

Answer 3.10: No.

4. Safety Findings

Question 4.1: Describe the regulatory requirements applicable to the safety review of the Hermes Reactor Construction Permit Application.

Answer 4.1: The regulatory requirements applicable to the safety review of the CPA are primarily contained in 10 CFR Part 50. Specifically:

- 10 CFR § 50.2, "Definitions"
- 10 CFR § 50.21, "Class 104 licenses; for medical therapy and research and development facilities," paragraph (c)
- 10 CFR § 50.33, "Contents of applications; general information," paragraph (f)
- 10 CFR § 50.34, "Contents of applications; technical information," paragraph (a), "Preliminary safety analysis report"
- 10 CFR § 50.35, "Issuance of construction permits"
- 10 CFR § 50.40, "Common standards"
- 10 CFR § 50.41, "Additional standards for class 104 licenses"
- 10 CFR § 50.50, "Issuance of licenses and construction permits"
- 10 CFR § 50.55, "Conditions of construction permits, early site permits, combined licenses, and manufacturing licenses"
- 10 CFR § 50.58, "Hearings and report of the Advisory Committee on Reactor Safeguards"
- 10 CFR Part 50, Appendix C, "A Guide for the Financial Data and Related Information Required to Establish Financial Qualifications for Construction Permits and Combined Licenses"
- 10 CFR Part 50, Appendix E, "Emergency Planning and Preparedness for Production and Utilization Facilities"

Other regulatory requirements applicable to the Hermes Reactor CPA include:

- 10 CFR § 100.10, "Factors to be considered when evaluating sites"
- 10 CFR § 100.11, "Determination of exclusion area, low population zone, and population center

distance"

Question 4.2: Summarize the NRC staff's safety review of the Hermes Reactor Construction Permit Application.

Answer 4.2: The NRC staff's review is summarized in SECY-23-0074 (ML23123A064). The NRC staff conducted and documented the results of five audits as part of the safety review. Kairos Power supplemented the PSAR and provided clarifications through timely responses to several hundred NRC staff questions during audit meetings and in docketed correspondence. Also, three requests for additional information (RAI) and one request for confirmation of information (RCI) were developed by the NRC staff and responded to by Kairos Power. The audit reports, RAIs, and RCI indicate the depth of the staff's review of the CPA for the Hermes Reactor.

Question 4.3: What safety findings must the Commission make under 10 CFR Part 50 in order to issue the CP for the Hermes Reactor?

Answer 4.3: The safety findings necessary to issue a CP are found in 10 CFR §§ 50.35(a), 50.40, and 50.50. These findings are:

Finding 1: *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.*

Finding 2: *10 CFR § 50.35(a)(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.*

Finding 3: *10 CFR § 50.35(a)(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.*

Finding 4: *10 CFR § 50.35(a)(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.

(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.

Finding 5: *10 CFR § 50.40(a) – Except for an early site permit or manufacturing license, the processes to be performed, the operating procedures, the facility and equipment, the use of the facility, and other technical specifications, or the proposals, in regard to any of the foregoing collectively provide reasonable assurance that the applicant will comply with the regulations in this chapter, including the regulations in part 20 of this chapter, and that the health and safety of the public will not be endangered.*

Finding 6: *10 CFR § 50.40(b) – The applicant for a construction permit… is technically and financially qualified to engage in the proposed activities in accordance with the regulations in this chapter.*

Finding 7: *10 CFR § 50.40(c) – The issuance of a construction permit… to the applicant will not, in the opinion of the Commission, be inimical to the common defense and security or to the health and safety of the public.*

Finding 8: *10 CFR § 50.40(d) – Any applicable requirements of subpart A of 10 CFR part 51 have been satisfied.*

Finding 9: : *10 CFR § 50.50 – Upon determination that an application for a license meets the standards and requirements of the act and regulations, and that notifications, if any, to other agencies or bodies have been duly made, the Commission will issue a license, or if appropriate a construction permit, in such form and containing such conditions and limitations including technical specifications, as it deems appropriate and necessary.*

Question 4.4: What is the staff's conclusion in the FSER regarding the Hermes Reactor?

Answer 4.4: The FSER concludes that:

> *"On the basis of its review of the construction permit application, the staff has determined that the preliminary design and analysis of the Hermes test reactor, including the principal design criteria; design bases; information relative to materials of construction and general arrangement; and preliminary analysis and evaluation of the design and performance of structures, systems, and components of the facility: (1) provides reasonable assurance that the final design will conform to the design basis; (2) includes an adequate margin of safety; (3) describes the structures, systems, and components which will provide for the prevention of accidents and the mitigation of consequences of accidents; and (4) meets applicable regulatory requirements and satisfies applicable NRC guidance. Therefore, the staff recommends that the Commission make the necessary findings with respect to the safety of the construction permit in accordance with 10 CFR 50.35, "Issuance of construction permits"; 50.40, "Common standards"; and 50.50, "Issuance of licenses and construction permits."*

Question 4.5: Are the necessary findings in 10 CFR Part 50 met for the Hermes Reactor Facility?

Answer 4.5: Yes. Based on the staff's conclusions discussed in my previous response, and as summarized on pages 15 through 22 of SECY-23-0074, each of the relevant findings in 10 CFR Part 50 have been met. I address each of these findings in more detail below.

Finding 1: *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.*

Question 4.6: Discuss whether Kairos Power has described the proposed design of the facility.

Answer 4.6: Kairos Power described the proposed design of the facility throughout the PSAR. Some of the relevant portions of the PSAR include Chapter 1 (The Facility), Chapter 3 (Design of Structures, Systems, and Components), Chapter 4 (Reactor Description), Chapter 5 (Heat Transport System), Chapter 6

(Engineered Safety Features), Chapter 7 (Instrument and Control Systems), Chapter 8 (Electrical Power Systems), and Chapter 9 (Auxiliary Systems). The PSAR includes principal architectural and engineering criteria for the design and major features or components incorporated therein for the protection of the health and safety of the public.

Question 4.7: Has the NRC staff reached a conclusion on this finding?

Answer 4.7: Yes. The staff discusses this finding on pages 15-17 of SECY-23-0074 and 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).*"

Question 4.8: Do you agree with the NRC staff's conclusion?

Answer 4.8: Yes.

Finding 2: *10 CFR § 50.35(a)(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.*

Question 4.9: Has Kairos Power identified technical or design information that is required to complete the safety analysis and will be provided in the future Final Safety Analysis Report (FSAR)?

Answer 4.9: Yes, Kairos Power recognizes that additional technical and design information for the Hermes Reactor that needs to be provided to support operation of the Facility. Kairos Power identified, throughout the PSAR and in responses to NRC staff questions, areas in which further information would be expected to be provided in the FSAR to complete the safety analysis. Additionally, Appendix A, Section A.2 of the FSER identifies issues that must be addressed in the Operating License Application.

Question 4.10: Has the NRC staff reached a conclusion on this finding?

Answer 4.10: Yes, the staff discusses this finding on page 17 of SECY-23-0074 and 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).

Question 4.11: Do you agree with the NRC staff's conclusion?

Answer 4.11: Yes.

Finding 3: *10 CFR § 50.35(a)(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.*

Question 4.12: Did Kairos Power identify safety features or components which require research and development?

Answer 4.12: Yes, in accordance with 10 CFR § 50.34(a), PSAR Section 1.3.9 includes identification of those SSCs of the Facility which require research and development to confirm the adequacy of their design; and identification and description of the research and development program which will be conducted to resolve any safety questions associated with such SSCs prior to completion of construction of the Facility. As described in Appendix A, Section A.3 of the FSER, Kairos Power has identified the following research and development activities:

- Performance of a laboratory testing program to confirm fuel pebble behavior.
- Performance of testing of high temperature material to qualify Alloy 316H and ER16-8-2.
- Performance of analysis related to potential oxidation in certain postulated events for the qualification of the graphite used in the reflector structure.
- Development of a high temperature material surveillance sampling program for the reactor vessel and internals.
- Development and validation of computer codes for core design and analysis methodology.
- Development and performance of qualification testing for a fluidic diode device.
- Justification of thermodynamic data and associated vapor pressure correlations of representative species.
- Development of process sensor technology for key reactor process variables.
- Development of reactor coolant chemical monitoring instrumentation.

Question 4.13: Has the NRC staff reached a conclusion on this finding?

Answer 4.13: Yes, the staff discusses this finding on pages 17 and 18 of SECY-23-0074 and concludes that Kairos Power has described safety features and components that require research and development in accordance with 10 CFR § 50.35(a)(3) and that Kairos Power has demonstrated that it will conduct a research and development program reasonably designed to resolve any safety questions.

Question 4.14: Do you agree with the NRC staff's conclusion?

Answer 4.14: Yes.

Finding 4: *10 CFR § 50.35(a)(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.

(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.

Question 4.15: Explain why there is reasonable assurance that safety questions will be satisfactorily resolved at or before the latest date for completion of construction.

Answer 4.15: Kairos Power has informed the NRC that the latest date for completing construction of the Hermes Facility is expected to be December 2026. As described in Appendix A, Section A.3 of the FSER, Kairos Power has identified several ongoing research and development activities. By letter dated December 8, 2022 (ML22342B282), Kairos Power informed the NRC that these activities will be completed prior to the completion of construction. There is sufficient time before the latest date for completing construction to provide reasonable assurance that the identified research and development activities will be completed and that any related safety questions will be resolved prior to the latest date for completion of construction.

Question 4.16: Explain why there is reasonable assurance that the Hermes facility can be constructed and operated at the proposed location, taking into consideration the site criteria contained in 10 CFR Part 100, without undue risk to the health and safety of the public.

Answer 4.16: Kairos Power considered the relevant siting criteria in 10 CFR Part 100, as indicated by NRC guidance in NUREG-1537. Chapter 2 of the CPA documents consideration of site characteristics, such as geography and demography; nearby industrial, transportation, and military facilities; meteorology; hydrology; and geology, seismology, and geotechnical engineering. Other relevant portions of the CPA include the commitments to a Radiation Protection Program in Chapter 11, operations plans in Chapter 12, and the preliminary accident analysis in Chapter 13. This information and other portions of the CPA provide reasonable assurance that the Hermes Reactor Facility can be constructed and operated at the proposed location without undue risk to the health and safety of the public.

Question 4.17: What actions did the NRC staff take to satisfy itself that the Hermes Facility could be constructed and operated safely?

Answer 4.17: In addition to reviewing the CPA material provided by Kairos Power, the NRC staff conducted audits and reviews of Kairos Power documents and analyses. The staff performed confirmatory analyses to confirm conclusions made by Kairos Power.

Question 4.18: Has the NRC staff reached a conclusion on this finding?

Answer 4.18: Yes. The staff discusses this finding on pages 18 and 19 of SECY-23-0074 and concludes that (1) there is reasonable assurance that Kairos will satisfactorily resolve the safety questions at or before the latest date for completing construction of the testing facility and that the applicable standards and requirements of the Atomic Energy Act of 1954 (as amended)(AEA) and the Commission's regulations have been met; and (2) 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 and that the provisions of the AEA and the Commission's regulations have been met. In some cases, the staff's finding required the inclusion of conditions that are listed in the draft CP.

Question 4.19: Do you agree with the NRC staff's conclusion?

Answer 4.19: Yes.

Finding 5: *10 CFR § 50.40(a) – Except for an early site permit or manufacturing license, the processes to be performed, the operating procedures, the facility and equipment, the use of the facility, and other technical specifications, or the proposals, in regard to any of the foregoing collectively provide reasonable assurance that the applicant will comply with the regulations in this chapter, including the regulations in part 20 of this chapter, and that the health and safety of the public will not be endangered.*

Question 4.20: Discuss how Kairos Power and the Hermes Facility will comply with NRC regulations, including those in 10 CFR Part 20, and that the health and safety of the public will not be endangered.

Answer 4.20: The CPA was prepared based on NRC regulations and applicable portions of NRC guidance, such as NUREGs. The NRC staff reviewed the CPA and evaluated it against the applicable regulations in 10 CFR Parts 20 and 50. The NRC staff also considered applicable portions of its guidance. Based on the CPA and the NRC staff's review, documented in the FSER and the FEIS, Kairos Power concludes that, for the purpose of issuing the CP for the Hermes Facility, the applicable standards and requirements of the Commission's regulations have been met. Compliance with these regulations ensures that the health and safety of the public will not be endangered.

Question 4.21: Did the NRC staff reach a conclusion on whether the applicable Commission regulations have been met by the CP Application for the Hermes Facility?

Answer 4.21: Yes. The staff discusses findings related to 10 CFR § 50.40 on page 22 of SECY-23-0074. The staff determined there is reasonable assurance that the construction of the Hermes test reactor will not endanger public health and safety, and that construction activities can be conducted in compliance with the Commission's regulations.

Question 4.22: Do you agree with the NRC staff's conclusion?

Answer 4.24: Yes.

Finding 6: *10 CFR § 50.40(b) – The applicant for a construction permit… is technically and financially qualified to engage in the proposed activities in accordance with the regulations in this chapter.*

Question 4.23: Discuss why Kairos Power is technically qualified to engage in the activities to be authorized by the CP for the Hermes facility.

Answer 4.23: Kairos Power is a nuclear energy engineering, design, and manufacturing company singularly focused on the commercialization of the KP-FHR. Kairos Power has a staff of over 350 employees, with Engineering staff accounting for approximately 90% of the total. Kairos Power is employing a novel approach to nuclear development that includes iterative hardware demonstrations and in-house manufacturing to achieve our goals. Kairos Power engineering and management staff were responsible for the development, review, and approval of the preliminary design and development of the PSAR. Kairos Power has engaged in strategic partnerships with other qualified organizations to supplement our in-house expertise and abilities where needed. We will continue to collaborate with qualified organizations to complete the detailed design, manufacturing, and construction of the Hermes Facility. Kairos Power engineering and management staff will continue to be responsible for the detailed design, manufacturing, and construction of the Hermes Facility and will provide oversight and detailed review of activities performed by our partner organizations. The Hermes Quality Assurance Program will guide the activities authorized by the CP to ensure the completed facility meets the applicable regulations and the design criteria described in the PSAR.

Question 4.24: Did the NRC staff conclude that Kairos Power is technically qualified to engage in the activities authorized by the CP?

Answer 4.24: Yes. On page 22 of SECY-23-0074, the staff concluded: "Kairos is technically qualified to engage in the construction of its proposed testing facility in accordance with the Commission's regulations."

Question 4.25: Do you agree with the NRC staff's conclusion?

Answer 4.25: Yes.

Question 4.28: Discuss why Kairos Power is financially qualified to engage in the activities proposed for the Hermes facility.

Answer 4.26: In accordance with NRC regulatory requirements, and as discussed in PSAR Chapter 15.1 and the updated financial qualifications information submitted on September 19, 2022 (ML22263A032), Kairos Power provided information to demonstrate that it possesses or has reasonable assurance of obtaining the necessary funds to cover estimated construction costs and related fuel cycle costs. That included proprietary budget estimates, sources of financing, and financing plans.

Question 4.27: Did the NRC staff conclude that the Kairos Power is financially qualified to engage in the activities authorized by the CP?

Answer 4.27: Yes. On page 22 of SECY-23-0074, the staff concluded: "Kairos is financially qualified to engage in the construction of its proposed testing facility in accordance with the Commission's regulations."

Question 4.28: Do you agree with the NRC staff's conclusion?

Answer 4.28: Yes.

Finding 7: *10 CFR § 50.40(c) – The issuance of a construction permit… to the applicant will not, in the opinion of the Commission, be inimical to the common defense and security or to the health and safety of the public.*

Question 4.29: Discuss whether the issuance of the CP will be inimical to the common defense and security or to the health and safety of the public.

Answer 4.29: Kairos Power provided information, analysis, and conclusions regarding site-specific conditions, including 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. In addition to a review of that information, Kairos Power also evaluated the design of SSCs to ensure safe operation, performance, and shutdown when subject to events, such as extreme weather, floods, seismic events, and missiles.

Additionally, Kairos Power is not owned, controlled, or dominated by foreign entities or individuals. In particular, Kairos Power is a privately held company with a limited number of investors that solely own the company and its assets. Current investors are U.S. citizens or entities owned or controlled by U.S.

citizens.

This and other information in the CP Application demonstrates that issuance of the CP will not be inimical to the common defense and security or to the health and safety of the public.

Question 4.30: Did the NRC staff make an overall inimicality finding?

Answer 4.30: Yes. On page 22 of SECY-23-0074, the staff concluded: "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."

Question 4.31: Do you agree with the NRC staff's conclusion?

Answer 4.31: Yes.

Finding 8: *10 CFR § 50.40(d) – Any applicable requirements of subpart A of 10 CFR part 51 have been satisfied.*

Question 4.32: Discuss whether the NRC staff's review has been adequate to support the findings set forth in 10 CFR § 51.105(a).

Answer 4.32: As will be discussed in Section 5 of my testimony, the NRC staff's environmental review has been adequate to support the findings set forth in 10 CFR § 51.105(a).

Finding 9: *10 CFR § 50.50 – Upon determination that an application for a license meets the standards and requirements of the act and regulations, and that notifications, if any, to other agencies or bodies have been duly made, the Commission will issue a license, or if appropriate a construction permit, in such form and containing such conditions and limitations including technical specifications, as it deems appropriate and necessary.*

Question 4.33: Discuss why the applicable standards and requirements of the AEA and the Commission's regulations have been met by the CPA for the Hermes facility.

Answer 4.33: As discussed above, the CPA was prepared based on NRC regulations and applicable portions of NRC guidance, such as NUREGs. The NRC staff reviewed the CPA and evaluated it against the applicable regulations in 10 CFR Part 50. The NRC staff considered applicable portions of its guidance.

Based on the CPA and the NRC staff's review, documented in the FSER and the FEIS, Kairos Power concludes that, for the purpose of issuing the CP for the Hermes Reactor Facility, the applicable standards and requirements of the AEA and the Commission's regulations have been met.

Question 4.34: Has the staff identified any proposed conditions for the CP for the Hermes Facility?

Answer 4.34: Yes. As discussed in Appendix A, Section A.1 of the FSER, the staff determined that a CP for the Hermes Facility needs to be conditioned to require Kairos Power to (1) perform analysis of excavations for safety related structures and the site; and (2) implement its Quality Assurance Program during construction.

Question 4.35: Did the NRC staff reach a conclusion on whether the applicable standards and requirements of the AEA and the Commission's regulations have been met by the CPA for the Hermes Facility, and whether the required notifications to other agencies and bodies have been made?

Answer 4.35: Yes. On page 22 of SECY-23-0074, the staff concluded: "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."

Question 4.36: Do you agree with the NRC staff's conclusion?

Answer 4.36: Yes.

5. Environmental Findings

Question 5.1: Describe the regulatory requirements applicable to the environmental review for the Hermes Facility.

Answer 5.1: 10 CFR § 50.30(f) (Environmental report) states that "[a]n application for a construction permit . . .for a nuclear . . .testing facility . . .whose construction or operation may be determined by the Commission to have a significant impact in the environment, shall be accompanied by an Environmental Report required under subpart A of part 51 of this chapter." Kairos Power provided its Environmental Report (ER) by letter dated October 31, 2021, and supplemented by letter dated March 30, 2023. The ER follows and is organized consistent with the NRC guidance provided in Final ISG for NUREG-1537, Part 1, Chapter 19. Although this ISG is specific to medical isotope facilities, it reflects more recent NRC staff guidance for ERs and is useful for other non-power reactor facilities. The regulations in 10 CFR Part 51, as described in the guidance, require an ER to include a description of: the proposed action and its purposes; regulatory provisions, permits, and required consultations; the environment affected and the impact of the proposed action on the environment; alternatives to the proposed action; unavoidable adverse environmental impacts of the proposed action; the relationship between short-term uses of the environment and the maintenance and enhancement of long-term productivity; any irreversible and irretrievable commitments of resources; and the benefits and costs of the proposed action and its alternatives.

Question 5.2: Describe the content of the ER for the Hermes Facility.

Answer 5.2: The Hermes Reactor Facility ER contains the following sections:

- Chapter 1 Introduction
    - 1.1 Introduction to the Environmental Report
    - 1.2 Site History
    - 1.3 Purpose and Need for the Proposed Action
    - 1.4 Regulatory Provisions, Permits, and Required Consultations
- Chapter 2 Proposed Action
    - 2.1 Proposed Action
    - 2.2 Site Location and Layout

- 2.3 Non-Power Reactor
- 2.4 Water Consumption and Treatment
- 2.5 Cooling and Heat Removal Systems
- 2.6 Waste Systems
- 2.7 Storage, Treatment, and Transportation of Radioactive and Nonradioactive Materials

- Chapter 3 Description of the Affected Environment
  - 3.1 Land Use and Visual Resources
  - 3.2 Meteorology, Climatology, Air Quality, and Noise
  - 3.3 Geologic Environment
  - 3.4 Water Resources
  - 3.5 Ecological Resources
  - 3.6 Historic and Cultural Resources
  - 3.7 Socioeconomics
  - 3.8 Human Health
  - 3.9 Environmental Justice
- Chapter 4 Impacts of Proposed Construction, Operations, and Decommissioning
  - 4.1 Land Use and Visual Resources
  - 4.2 Air Quality, and Noise
  - 4.3 Geologic Environment
  - 4.4 Water Resources
  - 4.5 Ecological Resources
  - 4.6 Historic and Cultural Resources
  - 4.7 Socioeconomics
  - 4.8 Human Health
  - 4.9 Waste Management
  - 4.10 Transportation
  - 4.11 Postulated Events

- 4.12 Environmental Justice
- 4.13 Cumulative Effects

- Chapter 5 Alternatives
  - 5.1 No-Action Alternative
  - 5.2 Alternatives Eliminated from Further Discussion
  - 5.3 Reasonable Alternatives
  - 5.4 Evaluation of Reasonable Alternative Sites Discussion
  - 5.5 Cost-Benefit of the Alternatives
  - 5.6 Comparison of the Potential Environmental Impacts
- Chapter 6 Conclusions
  - 6.1 Unavoidable Adverse Environmental Impacts
  - 6.2 Relationship Between Short-Term Uses and Long-Term Productivity of the Environment
  - 6.3 Irreversible and Irretrievable Commitments of Resources

Question 5.3: Does the ER for the Hermes Facility satisfy the requirements of 10 CFR Part 51 and the National Environmental Policy Act (NEPA)?

Answer 5.3: Yes. The ER for the Hermes Facility satisfies the requirements of 10 CFR Part 51 and NEPA.

Question 5.4: What conclusions does the ER for the Hermes Facility make regarding unavoidable adverse environmental impacts?

Answer 5.4: Tables 6.1-1 and 6.1-2 in the ER for the Hermes Facility indicate that unavoidable adverse environmental impacts associated with construction and operation of the Hermes Facility are minimal. Tables 6.1-1 and 6.1-2 in the ER for the Hermes Facility also identify mitigation measures, where appropriate, to reduce these impacts. Most of the impacts from construction and operation are minor due to the use of design features that reduce potential levels of impacts; best management practices that control and mitigate emissions and discharges to air and water; use of a brownfield site that was previously altered or disturbed; and applicable federal, state, and local regulatory requirements and permitting requirements designed to protect humans and the environment. These impacts are generally not anticipated at all, or are only minimally adverse (i.e., SMALL).

Question 5.5: What conclusions does the ER for the Hermes Facility make regarding alternatives to the project?

Answer 5.5: Chapter 5 of the ER for the Hermes Facility evaluates the following types of alternatives:

- No-Action Alternative
- Alternative Sites

The ER makes the following conclusions:

- Construction and operation of the Hermes Test Reactor provides a means to test key KP-FHR technologies, design features, and safety functions at a reduced scale relative to the anticipated commercial power reactor. The programmatic benefits support deployment of advanced nuclear technologies that result in less reliance on carbon fuel-based forms of energy productions. Construction and operation of the test reactor provides socioeconomic benefits, including increased tax revenues to local jurisdictions. Considering these benefits, the No-Action alternative is not preferrable. Although the No-Action alternative avoids the adverse environmental consequences identified in the ER, these adverse impacts are SMALL; the benefit of avoiding them is not significant; and the programmatic benefits that support the deployment of clean energy technologies would not be realized under the No-Action alternative.
- After an evaluation of candidate sites as described in Section 5.3 of the ER, a candidate site (Eagle Rock) was identified as the proposed alternative site. The alternative site would not reduce or avoid the adverse effects as compared to the proposed Kairos Power site and is judged not to be clearly superior.
    - Table 5.6-1 of the ER provides a comparison of the expected environmental impacts of construction at the Kairos Power site and the proposed alternative site. Construction impacts for the Kairos Power site are SMALL for every resource category. The alternative site has MODERATE construction impacts on Visual Resources, Wildlife, and Historical and Cultural Resources.
    - Table 5.6-2 of the ER provides a comparison of the expected environmental impacts of project operation at the Kairos Power site and the proposed alternative site. Operations

impacts for the Kairos Power site are SMALL for every resource category. The alternative site has a MODERATE operation impact on Visual Resources.

Question 5.6: What conclusions does the ER for the Hermes Facility make regarding irreversible and irretrievable commitments of resources?

Answer 5.6: The ER makes the following conclusions regarding irreversible and irretrievable commitments of resources:

- The land used for the Hermes Reactor Facility is not irreversibly committed because once the Hermes reactor ceases operations and the facility is decommissioned in accordance with NRC requirements, the land supporting the facilities could be returned to other industrial uses (as the DOE has done with several sites, including the Hermes site, within the ORGDP). There would be no permanent storage or disposal of radioactive or nonradioactive wastes at the site
- During construction, operation, and decommissioning, the commitment of land resources needed for offsite disposal of wastes would be irreversible. These wastes include nonradioactive and nonhazardous construction and demolition waste, routine sanitary waste and trash, hazardous wastes, and low-level radioactive wastes. However, due to the relatively small scale of the project compared to other nonradiological industrial projects and the operations and decommissioning of large commercial nuclear power reactors, the volumes of waste would have a SMALL impact on the irretrievable commitment of land resources for disposal facilities.
- There are no direct impacts to water quality or hydrology from the facility; therefore, there will be no irreversible impacts.
- Long-term irreversible losses of terrestrial biota are not anticipated. Subsequent to the completion of construction, floral and faunal resources are expected to recover in areas that are not affected by ongoing operations. There are no operational impacts associated with impingement or entrainment of aquatic biota. Furthermore, the facility would not discharge process water directly into Poplar Creek or any other nearby water body, avoiding any impacts associated with pollutant or thermal discharges to aquatic resources. There would be no irreversible impacts to aquatic flora or fauna.
- No irreversible commitments will be made to socioeconomic resources because they are reallocated

for other purposes once the facility is decommissioned.

- No known historic or cultural resources are irreversibly altered due to the facility.
- Mitigation measures will minimize impacts from dust and other emissions during construction. Emissions during operations are in compliance with applicable Federal and State regulations, minimizing their impact on public health and the environment. No irreversible impacts to air quality are anticipated.
- Irretrievable commitments of resources during new plant construction are generally similar to that of any small-scale industrial facility construction project. During operations, the main resources that are irretrievably committed are the nuclear fuel and the Flibe liquid salt coolant. The spent nuclear fuel is not expected to be recycled, and the coolant salt would be disposed of as low-level radioactive waste. Materials used in the construction of the reactor, spent fuel canisters, and other waste containers and metals and concrete activated as result of reactor operations will also be irretrievably committed and disposed of as radioactive waste. While a given quantity of material consumed during new facility construction and operation at the site is irretrievable, the impact on their availability is SMALL.

Question 5.7: What conclusions does the ER for the Hermes Facility make regarding the relationship between short-term uses and long-term productivity of the human environment?

Answer 5.7: Hermes Facility construction and operation result in both adverse and beneficial short-term impacts. The principal short-term adverse impacts are SMALL residual impacts (after implementing mitigation measures) to land use, visual resources, terrestrial ecology, local traffic, noise, and air quality. There are no long-term adverse impacts to the environment. The principal short-term benefits are the creation of additional jobs, additional tax revenues, and improvements to local infrastructure. Long-term benefits of the Hermes test reactor project including the continued availability of the improved infrastructure and potential benefits from increased tax revenues after facility decommissioning, as well as the primary benefit of demonstrating the technology as discussed in the next response. The short-term impacts and benefits and long-term benefits do not affect long-term productive use of the site.

Question 5.8: What is the overall conclusion in the ER for the Hermes Facility regarding the benefits and costs of the proposed project?

Answer 5.8: The primary benefit of the proposed Hermes test reactor project is the demonstration of key technologies of the KP-FHR for future commercial deployment. This supports Kairos Power's mission, as well as the DOE's goal (under the Advanced Reactor Demonstration Program) of designing and developing safe and affordable reactor technologies that can be licensed and deployed over the next 10 to 14 years. Additional economic benefits of the project include jobs (approximately 425 construction jobs during peak construction activities and 68 operational positions during the operating period) and tax payments. The costs from construction and operation of the Hermes Facility are economic and some environmental impacts including land use, visual resources, air quality, ecological resources, and socioeconomics, but all of the environmental impacts are SMALL. As such, Kairos Power concludes that the that the benefits of the project far outweigh the costs.

Question 5.9: What environmental findings must the Commission make under 10 CFR Part 51 in order to issue the CP for the Hermes Facility?

Answer 5.9: Under 10 CFR § 51.105(a), the Commission must do the following:

- Determine whether the requirements of Sections 102(2) (A), (C), and (E) of NEPA and the regulations in Subpart A of 10 CFR Part 51 have been met;
- 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;
- Determine, after weighing the environmental, economic, technical, and other benefits against environmental and other costs, and considering reasonable alternatives, whether the CP should be issued, denied, or appropriately conditioned to protect environmental values; and
- Determine whether the NEPA review conducted by the NRC staff has been adequate.

Question 5.10: Are the findings in 10 CFR § 51.105(a) met for the Hermes Facility?

Answer 5.10: Yes, as discussed in more detail below.

Finding 10: *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.*

Question 5.11 Describe the NRC staff's environmental review process for the CP and whether it utilized a systematic, interdisciplinary approach.

Answer 5.11: The NRC staff prepared the FEIS for the Hermes Facility based on its independent assessment of the information in the ER and other information provided by the Kairos Power. The staff also developed some of the information in the FEIS independently. The staff's technical analysis used a systematic, interdisciplinary approach to integrate information from many fields, including use of individuals experienced in the fields of water resources, land use, human health, waste management, accidents, historic and cultural resources, socioeconomic impacts, and Environmental Justice, as listed in Appendix A to the FEIS.

Question 5.12 Discuss whether the FEIS for the Hermes Facility discusses the environmental impacts of the project, any adverse environmental effects that cannot be avoided, alternatives, the relationship between local short term uses of the environment and the maintenance of long-term productivity, and any irreversible and irretrievable commitments of resources.

Answer 5.12: The FEIS for the Hermes Facility addressed (1) the environmental impacts of the proposed action (Section 3 of the FEIS); (2) unavoidable adverse environmental effects (Section 5.3.1 of the FEIS): (3) alternatives to the proposed action (Section 4 of the FEIS): (4) the relationship between local short-term uses of the environment and the maintenance and enhancement of long-term productivity (Section 5.3.2 of the FEIS); and (5) irreversible and irretrievable commitments of resources that would be involved in the proposed action should it be implemented (Section 5.3.3 of the FEIS).

Question 5.13 Did the NRC staff consult with other agencies in preparing the FEIS for the Hermes Facility?

Answer 5.13: Yes. The staff consulted with and received comments from Tribal Officials and other agencies such as the National Park Service, Tennessee Historical Commission, Advisory Council on Historic Preservation, and U.S. Fish & Wildlife Service.

Question 5.14 Discuss whether the requirements of Sections 102(2) (A), (C), and (E) of NEPA and the regulations in Subpart A of 10 CFR Part 51 have been met with respect to the CP for the Hermes Facility.

Answer 5.14: Based upon my responses to previous questions, I conclude that the requirements of Sections 102(2) (A), (C), and (E) of NEPA and the regulations in Part 51 have been met with respect to the CP for the Hermes Facility.

Finding 11: *10 CFR § 51.105(a)(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.*

Question 5.15 Discuss whether the NRC staff has independently considered the final balance among conflicting factors contained in the record of the proceeding with a view to determining the appropriate action to be taken with respect to the Hermes Facility.

Answer 5.15: In FEIS Section 4.3, the NRC staff provides its summary for cost-benefit balancing for the Hermes Facility. The staff concluded that building, operating, and decommissioning the proposed Hermes 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.

Question 5.16 Do you agree with the conclusions of the NRC staff on this factor?

Answer 5.16: Yes.

Finding 12: *10 CFR § 51.105(a)(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.*

Question 5.17 Discuss whether the NRC staff has weighed the environmental, economic, technical, and other benefits against environmental and other costs with respect to the Hermes Facility.

Answer 5.17: Based on the assessment summarized in FEIS Section 4.3, the NRC staff concluded that building, operating, and decommissioning the proposed Hermes Reactor Facility (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.

Question 5.18 Discuss whether the NRC staff has considered reasonable alternatives with respect to the Hermes Facility.

Answer 5.18: The NRC staff summarized their consideration of alternatives to the proposed action in FEIS Section 4. Alternatives considered include the no-action alternative and site alternatives. The FEIS demonstrates that the NRC staff adequately considered alternatives to the proposed action, consistent with the requirements of NEPA.

Question 5.19 Discuss whether the NRC staff has determined whether the CP should be issued, after weighing the environmental, economic, technical, and other benefits against environmental and other costs, and considering reasonable alternatives.

Answer 5.19: As discussed in FEIS Section 5.4, after weighing the environmental, economic, technical, and other benefits against environmental and other costs, and considering reasonable alternatives, the NRC staff's recommendation to the Commission is that the NRC issue the CP to Kairos Power for the Hermes Reactor Facility once the requirements of the NHPA Section 106 process have been met.

Question 5.20 Do you agree with the conclusions of the NRC staff on this factor?

Answer 5.20: Yes.

Finding 13: *10 CFR § 51.105(a)(4) – Determine, in an uncontested proceeding, whether the NEPA review conducted by the staff has been adequate.*

Question 5.21 Discuss whether the NRC staff's NEPA review has been adequate with respect to the Hermes Reactor Facility.

Answer 5.21: The NRC staff conducted an independent evaluation of the CPA over approximately 21 months. The NRC staff developed independent, reliable information and conducted a systematic, interdisciplinary review of the potential impacts of the proposed action on the environment and reasonable alternatives to the proposed action. The NRC staff considered the purpose of and need for the proposed action, the environment that could be affected by the action and the consequences of the proposed action, including mitigation that could reduce impacts. The FEIS considered whether there is a need for the Hermes Reactor Facility. The FEIS compared the alternatives to the proposed action. The NRC staff considered the

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 irreversible or irretrievable commitments of resources that would be involved in the proposed project. In summary, the NRC staff's NEPA review has been more than adequate with respect to the Hermes Reactor Facility.

Question 5.22 Discuss whether the NRC staff's environmental review for the Hermes Facility followed NRC regulations and guidance.

Answer 5.22: As discussed in FEIS for the Hermes Facility, the NRC staff ensured that its environmental review met the applicable regulations of 10 CFR Part 51. The staff used the guidance contained in Final ISG Augmenting NUREG-1537, Part 1 and Part 2, as supplementary direction for conducting its environmental review. The ISG for NUREG-1537 provides guidance for the relevant regulations in Part 51 for environmental reviews for radioisotope production facilities and aqueous homogeneous reactors. Because the Hermes project is a non-power reactor, the staff considered the guidance developed to accompany NUREG-1537 to be the best available NRC guidance most applicable to licensing a test reactor project.

Question 5.23 Did the NRC staff's review satisfy NEPA?

Answer 5.23: Yes. As I have discussed in my previous answers, the staff's review satisfied Sections 102(2) (A), (C), and (E) of NEPA. Additionally, by implementing the detailed procedures in the regulations in 10 CFR Part 51, the NRC staff's review ensured compliance with NEPA. The environmental findings in the FEIS constitute the "hard look" required by NEPA for the Hermes Reactor Facility.

Question 5.24 Was the public permitted to participate in the environmental review process for the Hermes Reactor Facility?

Answer 5.24: Yes. At the start of the environmental review, the NRC staff issued a notice of intent to prepare an EIS and invited the public to provide any information relevant to the environmental review, including holding a virtual joint public outreach and scoping meeting on March 23, 2022. The NRC also provided opportunities for governmental and general public participation during the public meeting on the draft EIS (DEIS) and sought, received, and responded to the comments on the DEIS from the public. Those responses are documented in Appendix G of the FEIS.

Question 5.25 What are your overall conclusions regarding the NRC staff's environmental review for the Hermes Reactor Facility?

Answer 5.25: The NRC staff conducted a thorough and complete environmental review for the CP for the Hermes Reactor Facility. That review has been sufficient to meet the requirements of NEPA.

6. Conclusions

Question 6.1: What are your overall safety conclusions regarding issuance of the Construction Permit?

Answer 6.1: The CPA contains sufficient information to demonstrate compliance with the applicable standards and requirements in the AEA and the Commission's regulations. Kairos Power has sufficiently described the proposed design of the facility in the CPA. Further technical, design, and operational information will be supplied in the FSAR. Appendix A, Section A.2 of the FSER identifies the issues that must be addressed as part of an Operating License Application and are being tracked by Kairos Power and the NRC staff. There is reasonable assurance that safety questions will be satisfactorily resolved before the latest date stated for completion of construction of the Hermes Reactor Facility, and that the proposed test reactor can be constructed and operated at the proposed location without undue risk to the health and safety of the public. Issuance of the CP for the test reactor will not be inimical to the common defense and security or the health and safety of the public. Furthermore, the review of the CPA by the NRC staff has been adequate to support these conclusions.

Question 6.2: What are your overall environmental conclusions regarding issuance of the Construction Permit?

Answer 6.2: The environmental review conducted by the NRC staff pursuant to 10 CFR 51 has been adequate; the requirements of Sections 102(2) (A), (C), and (E) of NEPA have been satisfied; an independent weighing and balancing of the environmental, technical, and other costs and benefits of the Hermes Facility supports issuance of the CP and the requested CP should be issued.

Question 6.3: Do the Construction Permit Application for the Hermes Reactor Facility and the associated NRC staff's review of the application satisfy the requirements for issuance of the Construction Permit?

Answer 6.3: Yes.

Question 6.4: Does this conclude your testimony?

Answer 6.4: Yes.

TERMS

Acronyms and Abbreviations

ACRS	Advisory Committee on Reactor Safeguards
AEA	Atomic Energy Act
CFR	Code of Federal Regulations
CP	Construction Permit
CPA	Construction Permit Application
DEIS	draft environmental impact statement
DHRS	decay heat removal system
DOE	U.S. Department of Energy
EIS	environmental impact statement
ER	environmental report
ESF	engineered safety feature
ETTP	East Tennessee Technology Park
FEIS	final environmental impact statement
Flibe	chemically stable, low-pressure molten fluoride salt coolant
FR	Federal Register
FSAR	final safety analysis report
FSER	final safety evaluation report
I&C	instrumentation and control
ISG	Interim Staff Guidance
Kairos Power	Kairos Power LLC
KP-FHR	Kairos Power fluoride salt-cooled, high temperature reactor
MHA	maximum hypothetical accident
NEPA	National Environmental Policy Act
NHPA	National Historic Preservation Act
NRC	U.S. Nuclear Regulatory Commission
ORGDP	Oak Ridge Gaseous Diffusion Plant
PCS	plant control system
PHSS	pebble handling and storage system
PHTS	primary heat transport system
PSAR	preliminary safety analysis report
RAI	request for additional information
RCI	request for confirmation of information
RPS	reactor protection system
RS	reactor system
SSC	structures, systems, and components
TRISO	tri-structural isotropic
TVA	Tennessee Valley Authority
U.S.	United States

CERTIFICATION AND DECLARATION OF WITNESS

I certify that this testimony was prepared by me or under my direction; and that I adopt these responses as part of my sworn testimony in this proceeding.

I declare under penalty of perjury that the foregoing written testimony is true and correct to the best of my information, knowledge, and belief.

Executed on September 27, 2023.

Respectfully submitted,

Executed in Accord with 10 C.F.R. § 2.304(d)

Signed by Peter Hastings
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