From: Beasley, Benjamin
Sent: Friday, April 8, 2022 9:55 AM
To: Drew Peebles
Cc: Darrell Gardner; Martin Bryan; Cuadrado de Jesus, Samuel; Helvenston, Edward
Subject: Questions on the Reactor Vessel System for the General Audit

Drew,

Below are some questions on the Reactor Vessel System for the General Audit. We would like to schedule an audit meeting when you are ready to discuss these.

Regards,
Ben
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3.0-1	The Hermes application has proposed changes from topical report KP-TR-003 for the principal design criteria. The Hermes PSAR identifies that the term safety-related is to be substituted for the term safety significant in the PDC developed in KP-TR-003 and that the SSC classification only uses two categories, safety-related and non-safety related. Also, the terms abnormal operational occurrence and accident are not used because the frequency of events is not considered in the Hermes licensing methodology, and the term postulated events is used. Based on the phone call with Kairos Power on February 9, 2022, Kairos Power is of the opinion that anything that would be considered as important to safety is classified as safety related. This would adequately address any concerns of having any items unaccounted for in the classification scheme. We would like Kairos to make the statement in the PSAR that with the change in terminology, anything that would be considered as important to safety under a different classification methodology is classified as safety related for the Hermes non-power test reactor.
3.6-1	PSAR Table 3.6-1 lists the “Reactor Vessel System” as safety related. However, the metallic material qualification topical report refers to the vessel as the only safety related metallic component. • The NRC staff requests clarification for which components in the reactor vessel system and internals are safety related. These include the fluidic diode device, reflector support structure, core barrel, top head, and other metallic components within the vessel. • If components other than the vessel are safety related, describe how the proposed testing in the metallic material qualification topical
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	report will bound the conditions experienced (e.g. temperature and fluence) by these other components. For example, the fluidic diode will be in direct contact with the graphite reflector. This can potentially cause increased corrosion rates of stainless steel. Although the metallic material qualification topical report includes graphite in the corrosion tests, it is not clear whether these will be designed to bound this specific part of the design.
4.1-3	Graphite 1. Has an analysis been done on how graphite dust could impact components? Will there be limits on acceptable amount of dust? 2. Does graphite dust have an impact on graphite/metal interactions such as increased corrosion rates?
4.1-4	PSAR Section 4.1.3 mentions a fluidic diode in a bypass flow path to direct coolant to the downcomer region during natural circulation mode. The fluidic diode is identified in section 1.3.9 as component requiring research and development. By regulation (10 CFR50.34(a)(8)), Kairos is required to identify what testing will be done and how and provide a schedule to demonstrate that the safety questions will be answered before the latest date in the application for completion of construction of the facility. Staff has the following questions: • What type of research and development program will be conducted for the fluidic diode? What is the schedule for the research and development program? • What quantity of flow is required through the fluidic diode? • What testing will be completed to demonstrate the fluidic diode in conjunction with the decay heat removal system can provide sufficient heat removal from the system to prevent the core fuel from overheating under all required conditions?
4.3-4	PSAR Section 4.3.3 describes how the graphite reflector will meet PDC 74 to allow for insertion of reactivity elements. However, this section does not describe how the reflector design will ensure the coolant flow path is maintained during normal operations and natural circulation (e.g. PDCs 34 and 35). The Kairos graphite qualification topical report states that the reflector supports conformance, in part, to PDCs 34 and 35. Additionally, the PSAR states that the reflector blocks provide a heat sink for the core. • Describe how the design of the graphite reflector meets PDCs 34 and 35 related to maintaining coolant flow path and decay heat removal during natural circulation. • Clarify whether the reflector is needed to perform a safety-related heat transfer function and if so, describe which PDC are applicable and how the reflector design meets these PDC.
4.3-5	In the basis for KP-FHR PDC 14, Kairos stated that "…safety significant components of the reactor coolant boundary will be subject to leakage monitoring." Describe how the plant control system will perform leakage monitoring.
4.3-6	PSAR Section 4.3.3 states that coolant purity design limits are established with consideration of chemical attack and fouling to partially meet PDC 31.

	NUREG-1537 Section 5.2, "Primary Coolant System," states that the primary coolant system should maintain high quality coolant to limit corrosion of fuel cladding, control rods, the vessel, and other essential components. However, purity limits do not appear to be in Chapter 4 or 9 of the PSAR. Additionally, the testing described in the metallic material qualification report does not appear to consider fouling in any tests. Describe how purity limits will be established for the Hermes reactor and whether the limits will consider factors beyond chemical attack of 316H SS.
4.3-7	PSAR Section 4.3.3 states that no tensile or fracture toughness monitoring and testing programs are necessary to demonstrate compliance with PDC 32 as per the metallic material qualification topical report. However, the referenced topical report does not discuss whether monitoring programs are needed as it only discusses qualification testing. Therefore, provide the justification for why tensile or fracture toughness monitoring is not needed to demonstrate compliance with PDC 32.
4.3-8	Section 4.3.3 states that coupons will be used to confirm irradiation-affected corrosion is non-existent or manageable. Appendix E of the metallic materials qualification topical report states that the non-power test reactor will use coupons to ensure materials performance with both metal and graphite samples exposed. • Will graphite coupons be utilized in Hermes? If so, what properties will these coupons be used to confirm? • Will the metallic coupons be examined for more than just irradiated-assisted corrosion?
4.3-9	Provide documents and/or data that describe vessel design relating to operating temperatures, fluence, and stresses.
4.3-10	Provide piping arrangement and anti-siphon device drawings that show how the anti-siphoning works following a pipe break.
4.3-11	Describe how vessel integrity will be assured through design and monitoring programs. For example, is the vessel designed to be inspected? Will there be a monitoring program for indications in the vessel or in the weld between vessel and bottom head?
4.3-12	PSAR Section 3.1.1, “Design Criteria,” of the PSAR references document KP-TR-003-NP-A, "Principal Design Criteria for the Kairos Power Fluoride-Salt Cooled, High Temperature Reactor," Revision 1, to provide the principal design criteria for the Hermes test reactor. KP-FHR PDC 32, "Inspection of the reactor coolant boundary,” describes requirements to inspect portions of the reactor coolant boundary. The basis for this PDC states that "…the potential for flow blockages/restriction from failed internals (such as graphite reflector blocks) is addressed as part of compliance with PDC 35, 36, and 37, including inspections if appropriate." This indicates that PDCs 35, 36, and 37 may be applicable to vessel internals as well as other components in the residual heat removal system. Section 4.3.3 of the PSAR describes how the components in the reactor vessel system meet specific PDC. However, it does not describe how certain components meet PDC 36. Therefore, the staff have the following questions:

	• It appears that a potential failure of graphite reflector blocks could cause flow blockages or restrictions of the natural circulation flow path. However, PSAR section 4.3.3 does not appear to describe how the graphite reflector design meets PDC 36. Indicate whether vessel internals need to meet PDC 36 and describe how the graphite reflector design allows for periodic inspections to meet PDC 36. • The fluidic diode device described in Section 4.3.3 appears to be safety related. The CP states it is used to establish the flow path for natural circulation but does not appear to describe how it meets PDC 36. Describe how the fluidic diode is designed to meet PDC 36
4.3-13	The Reactor Vessel System Requirements Document (HER-EP-RQT-114-0000) states that “the reactor vessel shall, where applicable, conform to the requirements of ASME BPVC Section XI, Division 2”. PSAR Section 6.3.4 also indicates that Reliability and Integrity Management (RIM) will be used; however it is not mentioned in other sections of the PSAR. Clarify if/how a RIM program will be implemented. Provide the scope of components to be inspected as well as potential locations for inspection.

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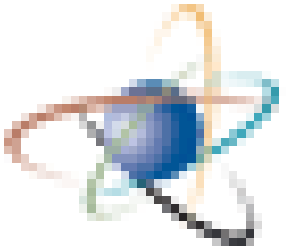

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