Kairos Power

KP-NRC-1812-001

December 21, 2018

Project No. 99902069

US Nuclear Regulatory Commission
ATTN: Document Control Desk
Washington, DC 20555-0001

Subject: Kairos Power LLC
Topical Report Submittal
Principal Design Criteria for the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor

This letter submits the subject topical report which establishes the principal design criteria for the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor (KP-FHR). This topical report is provided for NRC review and approval and is expected to be used by future license applicants using the KP-FHR. The scope and schedule for submittal of this report was discussed in a public meeting with NRC staff November 7, 2018. Kairos Power respectfully requests NRC acceptance review be completed and a review schedule be provided within 60 days of the start of the 2019 calendar year. In recognition of an aggressive deployment schedule and substantial pre-application engagement, Kairos has established a generic assumption of a 12-month review for topical reports.

Portions of this topical report are considered proprietary, and Kairos Power requests it be withheld from public disclosure in accordance with the provisions of 10 CFR 2.390. Enclosure 1 provides the proprietary version of the report and Enclosure 2 provides the non-proprietary report. An affidavit supporting the withholding request is provided in Enclosure 3.

Additionally, the information indicated as proprietary has also been determined to contain Export Controlled Information. This information must be protected from disclosure pursuant to the requirements of 10 CFR 810.

If you have any questions or need any additional information, please contact Darrell Gardner at gardner@kairospower.com or (704)-769-1226.

Sincerely,

Peter Hastings, PE
Vice President, Regulatory Affairs and Quality

Enclosures:

1) Principal Design Criteria for the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor (Proprietary)
2) Principal Design Criteria for the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor (Non-Proprietary)
3) Affidavit Supporting Request for Withholding from Public Disclosure (10 CFR 2.390)

xc (w/enclosure):

J. P. Segala, Chief, NRO Advanced Reactor and Policy Branch
J. F. Williams, Project Manager, NRO Advanced Reactor and Policy Branch
S. L. Magruder, Project Manager, NRO Advanced Reactor and Policy Branch

Enclosure 2

Principal Design Criteria for the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor

(Non-Proprietary)

KP-TR-003

Kairos Power LLC
707 W. Tower Ave
Alameda, CA 94501

Principal Design Criteria for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor

Topical Report

Revision 0
December 2018

Non-Proprietary

REVISION LOG

Rev	Description of Change	Date
0	Initial Issuance	December 2018

Executive Summary

This topical report summarizes the methodology for development of the principal design criteria for the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor. The principal design criteria are developed based on the key design features of the KP-FHR technology and used the guidance of Regulatory Guide 1.232, "Guidance for Developing Principal Design Criteria for Advanced (Non-Light Water) Reactors." The resultant design criteria are comprehensive, reflect the key design features of the technology, and provide future license applicants under 10 CFR 50 or 10 CFR 52 a basis for design of the KP-FHR. Kairos Power is requesting Nuclear Regulatory Commission review and approval of these design criteria for use by future applicants.

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ABBREVIATIONS

Abbreviation or Acronym	Definition
AOO	Anticipated Operational Occurrences
ARDC	Advanced Reactor Design Criteria
CFR	Code of Federal Regulations
DC	Design Criteria
DOE	Department of Energy
EAB	Exclusion Area Boundary
ECCS	Emergency Core Cooling System
FHR	Fluoride High-Temperature Reactor
GDC	General Design Criteria
KP-FHR	Kairos Power Fluoride Salt-Cooled High Temperature Reactor
LWR	Light Water Reactor
MHTGR	Modular High Temperature Gas-Cooled Reactor
MHTGR-DC	MHTGR Design Criteria
NRC	Nuclear Regulatory Commission
PDC	Principal Design Criteria
RG	Regulatory Guide
SARRDL	Specified Acceptable System Radionuclide Release Design Limit
SAFDL	Specified Acceptable Fuel Design Limit
SFR	Sodium-Cooled Fast Reactor
SFR-DC	SFR Design Criteria
SSC	Structures, Systems, and Components
TRISO	Tri-structural Isotropic

1 INTRODUCTION

Kairos Power LLC (Kairos Power) is pursuing the design, licensing, and deployment of the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor (KP-FHR). To support these objectives, Kairos Power is developing Principal Design Criteria (PDC) applicable to the KP-FHR design. Nuclear Regulatory Commission (NRC) regulations in 10 CFR 50.34(a)(3)(i) require that applicants for a construction permit include the PDC for a facility. Similarly, NRC regulations in 10 CFR 52.47(a)(3)(i), 10 CFR 52.79(a)(4)(i), 10 CFR 52.137(a)(3)(i), and 10 CFR 52.157(a) require that applications for standard design certifications, combined licenses, standard design approvals, and manufacturing licenses include the PDC for a facility.

NRC regulations in 10 CFR 50, Appendix A provide General Design Criteria (GDC) that establish the minimum requirements for PDC for light water reactors (LWRs). The regulations note that the GDC are generally applicable to other types of reactor units and are intended to provide guidance in establishing the PDC for such other units. That is, the GDC in 10 CFR 50, Appendix A are guidance, not regulatory requirements, for non-LWRs. NRC has published Regulatory Guide (RG) 1.232, "Guidance for Developing Principal Design Criteria for Non-Light Water Reactors" (Reference 1), which provides guidance for establishing the PDC for non-light water reactor designs. RG 1.232 also includes PDC for two specific non-LWR designs, the Sodium-Cooled Fast Reactor (SFR) and the Modular High-Temperature Gas-Cooled Reactor (MHTGR).

This report provides the PDC for the KP-FHR which are developed using the guidance in RG 1.232 and in consideration of unique KP-FHR design attributes. Kairos Power requests NRC review and approval of these PDC to be used by applicants of the KP-FHR design for standard design certifications, combined licenses, standard design approvals, and manufacturing licenses under the applicable regulations in 10 CFR 52; or limited work authorizations, construction permits and operating licenses under 10 CFR 50. The approval of these PDC are based on the existence of the key design features of the KP-FHR technology identified in Section 1.1.2. The demonstration that the KP-FHR design satisfies these PDC will be provided within the license application documents (e.g., safety analysis reports) required to be submitted by the cited regulations.

1.1 DESIGN FEATURES

1.1.1 DESIGN BACKGROUND

To facilitate NRC review and approval of this report for use by future applicants, key design features are provided in Section 1.1.2 which are inherent to the KP-FHR technology. These features are not expected to change during the design development by Kairos Power and provide the basis to support the safety review of this report. Should fundamental changes occur to these key design features, or new or revised regulations be promulgated that affect the PDC for the KP-FHR, such changes would be reconciled and addressed in license application submittals.

The KP-FHR is a U.S.-developed Generation IV advanced reactor technology. In the last decade, U.S. national laboratories and universities have developed pre-conceptual Fluoride High-Temperature Reactor (FHR) designs with different fuel geometries, core configurations, heat transport system configurations, power cycles, and power levels. More recently, University of California at Berkeley developed the Mark 1 pebble-bed FHR, incorporating lessons learned from the previous decade of FHR pre-conceptual designs (Reference 2). Kairos Power has built on the foundation laid by Department of Energy (DOE)-sponsored university Integrated Research Projects (IRPs) to develop the KP-FHR.

Table 1 compares and contrasts the major design attributes of the KP-FHR with those reflected in RG 1.232, i.e. the SFR and the MHTGR. The purpose of this table is to aid in the understanding of the KP-FHR PDC development and the rationale for changes to wording from the RG. It should be emphasized that the KP-FHR contains design features similar in nature to those found in the SFR or MHTGR, and it does not add fundamentally new or unique features from those present in the SFR or MHTGR designs.

Although not intended to support the findings necessary to approve the PDC, additional design description information is provided in the technical report “Design Overview of the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor” (Reference 3).

1.1.2 KEY DESIGN FEATURES OF THE KP-FHR

The KP-FHR is a high temperature reactor with molten fluoride salt coolant operating at near-atmospheric pressure. The fuel in the KP-FHR is based on the tri-structural isotropic (TRISO) high-temperature, carbonaceous-matrix coated particle fuel (originally developed for high-temperature gas-cooled reactors) in a pebble fuel element. Coatings on the particle fuel provide retention of fission products. The reactor coolant is a chemically stable molten fluoride salt mixture, $2\times{}^{7}LiF{:}BeF_2$ (Flibe with [[ ]]) which also provides retention of fission products that escape from any fuel defects. A primary coolant loop circulates the reactor coolant using pumps and transfers the heat to an intermediate coolant loop via a heat exchanger. The pumped flow intermediate coolant loop utilizes a nitrate salt, compatible with reactor coolant, and transfers heat from the reactor coolant to the power conversion system through a steam generator. The design includes two decay heat removal systems. A normal decay heat removal system is used following normal shutdowns and anticipated operational occurrences. A separate passive decay heat removal system, which along with natural circulation in the reactor vessel, removes decay heat in response to a design basis accident and does not rely on electrical power.

The KP-FHR design uses a functional containment approach similar to the MHTGR instead of the typical LWR low-leakage, pressure retaining containment structure. The KP-FHR functional containment design objective is to meet 10 CFR 50.34 (10 CFR 52.79) offsite dose requirements at the plant's exclusion area boundary (EAB) with margin. A functional containment is defined in RG 1.232 as a "barrier, or set of barriers taken together, that effectively limit the physical transport and release of radionuclides to the environment across a full range of normal operating conditions, AOOs, and accident conditions." RG 1.232 includes an example design criterion for the functional containment (MHTGR Criterion 16). As also stated in RG 1.232, the NRC has reviewed the functional containment concept and found it “generally acceptable,” provided that “appropriate performance requirements and criteria” are developed. The NRC staff has developed a proposed methodology for establishing functional containment performance criteria for non-LWRs, which is presented in SECY-18-0096. This SECY document has been approved by the Commission.

The functional containment approach for the KP-FHR is to control radionuclides primarily at their source within the coated fuel particle under normal operations and accident conditions without requiring active design features or operator actions. The KP-FHR design relies primarily on the multiple barriers within the TRISO fuel particles and fuel pebble to ensure that the dose at the site boundary as a consequence of postulated accidents meets regulatory limits. However, in contrast to the MHTGR, the KP-FHR molten salt coolant also serves as a distinct barrier providing retention of fission products that escape the fuel particle and fuel pebble barriers. This additional retention is a key feature of the enhanced safety and reduced source term in the KP-FHR.

1.2 REGULATORY REVIEW

As previously noted, facilities licensed under 10 CFR Part 50, including both LWRs and non-LWRs, are required to describe the PDC in their preliminary safety analysis report supporting a construction permit application as described in 10 CFR 50.34(a)(3)(i). Likewise, applicants for standard design certifications, combined licenses, standard design approvals, and manufacturing licenses must include the PDC for a facility as described in 10 CFR 52.47(a)(3)(i), 10 CFR 52.79(a)(4)(i), 10 CFR 52.137(a)(3)(i), and 10 CFR 52.157(a).

The GDC in 10 CFR 50, Appendix A, provide minimum requirements for a plant's PDC, which establish the necessary design, fabrication, construction, testing, and performance requirements for structures, systems, and components (SSCs) that are safety significant. The GDC in Appendix A have served as a key part of the regulatory framework for LWRs for many years. As noted above, the GDC are generally applicable to other types of reactor units and are intended to provide guidance in establishing the PDC for such other units. With the advent of new non-light water reactor designs, the NRC and U.S. Department of Energy (DOE) implemented a joint initiative to assess the GDC and determine the extent to which they apply to non-LWR designs and to propose amended and/or additional design criteria that address non-LWR design features. The results of this effort culminated in NRC RG 1.232.

RG 1.232 provides a set of advanced reactor design criteria (ARDC), which serve the same purpose for non-LWRs as the GDC serve for LWRs. The non-LWR designs considered during the joint initiative leading to the development of this RG included SFRs, lead-cooled fast reactors, gas-cooled fast reactors, MHTGRs, fluoride high-temperature reactors, and molten salt reactors. The ARDC are intended to be technology inclusive to align with the six technologies above. In addition to the technology-inclusive ARDC, RG 1.232 provides two sets of technology-specific, non-LWR design criteria. The two technology-specific design criteria are provided for the SFR and the MHTGR. The PDC provided for the SFR and MHTGR designs are referred to as the SFR design criteria (SFR-DC) and the MHTGR design criteria (MHTGR-DC), respectively. As indicated in RG 1.232, the NRC intends that the ARDC apply to the six advanced reactor technology types identified in the DOE report; however, in some instances, one or more of the criteria from the SFR-DC or MHTGR-DC may be more applicable to a design or technology than the ARDC.

Relevant excerpts from the guidance for development of PDC from RG 1.232 are provided below:

- "Since the GDC in 10 CFR 50 Appendix A are not regulatory requirements for non-LWR designs but provide guidance in establishing the PDC for non-LWR designs, non-LWR applicants would not need to request an exemption from the GDC in 10 CFR Part 50 when proposing PDC for a specific design."
- "Applicants may use this RG to develop all or part of the PDC and are free to choose among the ARDC, SFR-DC, or MHTGR-DC to develop each PDC after considering the underlying safety basis for the criterion and evaluating the rationale for the adaptation described in this RG. For example, Fluoride High Temperature Reactors (FHRs) are molten salt reactors that use TRISO fuel, which is the same fuel used for MHTGR technologies. An FHR designer could use the MHTGR-DC where appropriate for the design. Another example is the MSRs that use liquid fuel. An MSR designer may need to develop new PDC for liquid fuel and systems to support this design."
- "In each case, it is the responsibility of the designer or applicant to provide not only the PDC for the design but also supporting information that justifies to the NRC how the design meets the PDC submitted, and how the PDC demonstrate adequate assurance of safety."

- "Finally, the non-LWR design criteria as developed by the NRC staff are intended to provide stakeholders with insights into the staff's views on how the GDC could be interpreted to address non-LWR design features; however, these are not considered to be final or binding on what may eventually be required from a non-LWR applicant."

The PDC provided in this report are intended to be used by future license applicants using the KP-FHR design to satisfy the aforementioned regulatory requirements.

2 PDC DEVELOPMENT METHODOLOGY

This section describes the process used by Kairos Power to develop the PDC for the KP-FHR. The starting point for this process is a review of the ARDC from RG 1.232, Appendix A for its relevance to the key design features of the KP-FHR technology. Each ARDC in Appendix A of RG 1.232 is reviewed for applicability to the KP-FHR design, considering the underlying safety basis for the ARDC and the supporting information in Appendix A of RG 1.232. Note that in some cases, the ARDC in RG 1.232 adopts the GDC from 10 CFR 50, Appendix A without change.

Where the Kairos Power review of the ARDC concluded that the ARDC could be directly adopted for the KP-FHR, then the ARDC is selected as the PDC for the KP-FHR. Because of similarities with certain features of SFR and MHTGR technologies, the SFR-DC and MHTGR-DC are also reviewed for relevancy to the KP-FHR and to determine whether changes from the ARDC identified in RG 1.232, Appendix B or Appendix C for these technologies should be considered for inclusion in the PDC for the KP-FHR.

For those ARDC that did not fully apply to the key design features of the KP-FHR, then the SFR-DC and MHTGR-DC are assessed to determine if either could be directly adopted. If either the SFR-DC or MHTGR-DC are representative of the KP-FHR technology, then the one that is most representative is selected as the PDC.

If none of the ARDC, the SFR-DC, or the MHTGR-DC are adopted as written, a judgment is made as to which of the three is most representative of the KP-FHR key design features. This assessment is based on technical relevance and the amount of modification that would be necessary to conform the criteria to be representative of the KP-FHR. Modifications are then made to reflect the design of the KP-FHR and the departures from the underlying criteria are annotated.

In a number of cases, the ARDC addressed a system or component that does not exist nor would be necessary or desirable to implement the KP-FHR technology. Examples include a containment building or emergency core cooling system. In these instances, these ARDC are determined to be not applicable for the KP-FHR PDC, similar to the conclusion for the MHTGR-DC in RG 1.232.

RG 1.232 includes a number of SFR and MHTGR technology-specific additional design criteria (numbered 70 and higher) in Appendix B and Appendix C. Each of these technology specific criteria are evaluated for applicability to the KP-FHR. As previously noted, the KP-FHR technology includes some features similar to those of the SFR and MHTGR.

Once the complete set of KP-FHR PDC are developed, a methodical review is performed to ensure that the PDC collectively provide a comprehensive design and regulatory framework for the KP-FHR. This is done by evaluating each of the major unique design attributes of the KP-FHR and comparing it against the set of PDC to ensure that there is a PDC that captures the attribute or issue.

The RG 1.232 review method described above is performed by Kairos Power personnel knowledgeable in the KP-FHR technology and development of the ARDC. The results of the review are documented along with a basis for selection of the KP-FHR PDC. The results of the review and KP-FHR PDC are provided in Section 3. The KP-FHR PDC are internally reviewed by Kairos Power engineering and licensing personnel. Additionally, an external team of industry experts knowledgeable of the KP-FHR, SFR, MHTGR, and LWR technologies, performed an independent review of the PDC. Feedback from this review is used to inform the results. Figure 1 provides a flow chart of the methodology described above to develop the PDC.

3 RESULTS

3.1 SUMMARY OF RESULTS

This section provides a summary of the results of the evaluation of the criteria in RG 1.232 and their applicability to the KP-FHR. Further details are provided in later sections and in the Appendices. The results are summarized in the following sections consistent with RG 1.232:

Section I—Overall Requirements (Criteria 1–5)

Section II—Multiple Barriers (Criteria 10–19)

Section III—Reactivity Control (Criteria 20–29)

Section IV—Fluid Systems (Criteria 30–46) for ARDCs, and SFR-DC, entitled Heat Transport Systems (Criteria 30-46) for MHTGR-DC

Section V—Reactor Containment (Criteria 50–57)

Section VI—Fuel and Radioactivity Control (Criteria 60–64)

Section VII—Additional SFR-DC (Criteria 70–77)

Section VII—Additional MHTGR-DC (Criteria 70–72)

Section I—Overall Requirements (Criteria 1–5)

These design criteria involve quality standards and records, design bases for protection against natural phenomena, fire protection, environmental and dynamic effects, and sharing of structures, systems, and components. There are five requirements in this category and they are general non-design specific requirements. [[ ]]

Section II—Multiple Barriers (Criteria 10–19)

These criteria involve the barriers to the release of radioactivity, specifically reactor design, reactor inherent protection, suppression of reactor power oscillations, instrumentation and control, reactor coolant boundary, reactor coolant system design, containment design, electric power systems, inspection and testing of electric power systems, and control room. These criteria are more specific to the key design features of the technology. As a result, some modifications to the design criteria in this category are necessary to align with the KP-FHR technology.

There are ten requirements in this category. [[

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Section III—Reactivity Control (Criteria 20–29)

These criteria involve protection system functions, protection system reliability and testability, protection system independence, protection system failure modes, separation of protection and control systems, protection system requirements for reactivity control malfunctions, reactivity control systems, combined reactivity control systems capability, reactivity limits, and protection against anticipated operational occurrences.

There are nine requirements in this category. These design criteria are not design specific. [[

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Section IV—Fluid Systems (Criteria 30–46) for ARDCs, and SFR-DC, entitled Heat Transport Systems (Criteria 30-46) for MHTGR-DC

These design criteria relate to fluid systems used for advanced reactors and sodium fast reactors. The criteria in this section are called heat transport systems for the MHTGR because it uses a gas for cooling. These criteria relate to the quality of reactor coolant boundary, fracture prevention of reactor coolant boundary, inspection of reactor coolant boundary, reactor coolant inventory maintenance, residual heat removal, emergency core cooling, inspection of emergency core cooling system, testing of emergency core cooling system, containment heat removal, inspection of containment heat removal system, testing of containment heat removal system, containment atmospheric cleanup, inspection of containment atmosphere cleanup, testing of containment atmosphere cleanup systems, structural and equipment cooling, inspection of structural and equipment cooling systems, and testing of structural and equipment cooling systems.

There are seventeen design criteria in this category. [[

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Section V—Reactor Containment (Criteria 50–57)

These design criteria relate to reactor containment structures. These criteria are very specific to a pressure retaining containment structure and include containment design basis, fracture prevention of containment pressure boundary, capability for containment leakage rate testing, provisions for containment testing and inspection, piping systems penetrating containment, reactor coolant boundary penetrating containment, containment isolation, and closed system isolation valves. All eight of these criteria are deemed to be not applicable, which is consistent with the MHTGR-DC.

Section VI—Fuel and Radioactivity Control (Criteria 60–64)

These design criteria relate to fuel and radioactivity control, including control of releases of radioactive material to the environment, fuel storage and handling and radioactivity control, prevention of criticality in fuel storage and handling, monitoring fuel and waste storage, and monitoring radioactivity releases. There are five criteria. [[

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Section VII—Additional SFR-DC (Criteria 70–79)

These design criteria are technology specific to SFRs and relate to the intermediate coolant system, primary coolant and cover gas purity control, sodium heating systems, sodium leakage detection and reaction prevention and mitigation, sodium/water reaction prevention/mitigation, quality of the intermediate coolant boundary, fracture prevention of the intermediate coolant boundary, inspection of the intermediate coolant boundary, primary coolant system interfaces, and cover gas inventory maintenance.

Of the ten technology-specific SFR-DC, [[

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Section VII—Additional MHTGR-DC (Criteria 70–72)

These design criteria are technology specific to MHTGRs and relate to the reactor vessel and reactor system structural design basis, reactor building design basis, and provisions for periodic reactor building inspection. [[

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3.2 SUMMARY OF CHANGES TO THE ARDC

An overall summary of the results of the PDC development is provided in Table 2. As can be seen from the table, many of the criteria from the ARDC apply. Of the ones that do not apply, in most cases the analogous MHTGR-DC are a closer fit than the SFR-DC. This is expected in that the key design features of the KP-FHR are generally closer to the design features of an MHTGR than to an SFR. Table 3 provides a summary of the primary modifications made to the ARDC, SFR-DC, and MHTGR-DC and to which KP-FHR PDC they apply. This review confirmed that there are no unique design attributes in the KP-FHR that are not addressed by the selected set of PDC. Accordingly, no new KP-FHR DC were identified as necessary.

There are several common themes in the modifications to the ARDC, SFR-DC or MHTGR-DC that are made for KP-FHR. These are described in the subsections below.

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3.3 DETAILED KP-FHR PDC RESULTS

The detailed final results of the development of the KP-FHR PDC are provided in Appendix A and Appendix B of this report. Appendix A provides the PDC for the KP-FHR. Appendix B identifies those RG 1.232 PDC which are determined to be not applicable to the KP-FHR design. The PDC numbering system used herein is consistent with 10 CFR 50 Appendix A, which is also used in the appendices to RG 1.232. An exception to the numbering exists with respect to the technology specific PDC for SFR and MHTGR, which are re-numbered starting with PDC 70 as they are in the appendices to RG 1.232.

The detailed evaluation results are organized in a tabular form for each PDC as follows:

Title: This content reflects the number and the title of the PDC. In most cases, the titles from the RG 1.232 ARDC apply. In some cases, the title is changed to reflect KP-FHR design features.

KP-FHR PDC: This content reflects the final PDC wording for the KP-FHR.

Position: This content provides a determination of whether a given ARDC, MHTGR-DC, or SFR-DC is relevant and whether it is adopted with or without changes. Where changes are determined necessary, this content identifies the modifications made to the underlying criteria to derive the KP-FHR PDC. Wording removed is shown in **red** text with a strikethrough and wording added is shown in **blue** text with underline.

Basis: This content provides the justification and rationale for the final KP-FHR PDC.

Source: This content identifies the origin of the design criteria that is evaluated, and which informed the basis of review for the KP-FHR.

3.4 CONCLUSIONS

Kairos Power performed a comprehensive review of the Advanced Reactor Design Criteria in RG 1.232 and developed [[ ]] PDC that meet the underlying safety objectives of 10 CFR 50 Appendix A. These PDC reflect the key design features of the KP-FHR technology and provide an appropriate set of requirements to facilitate the design and licensing of the KP-FHR. As such, these PDC apply for use by future license applicants under either 10 CFR 50 or 10 CFR 52 as long as the details of the KP-FHR progresses consistent with the key design attributes identified in Section 1.1.2.

4 REFERENCES

1. US Nuclear Regulatory Commission, "Guidance for Developing Principal Design Criteria for Non-Light Water Reactors," RG 1.232, Revision 0.
2. University of California Berkley Nuclear Engineering. 2015. *Fluoride Salt Cooled High Temperature Reactor*. [ONLINE] Available at: http://fhr.nuc.berkeley.edu. [Accessed 26 June 2018].
3. Kairos Power, LLC, "Design Overview of the Kairos Power Fluoride Salt Cooled, High Temperature Reactor (KP-FHR)", November 2018.
4. US Nuclear Regulatory Commission, "Preapplication Safety Evaluation Report for Power Reactor Innovative Small Modular (PRISM) Liquid-Metal Reactor," NUREG-1368, Final Report, February 1994.
5. Nuclear Energy Institute, "Risk-Informed Performance-Based Guidance for Non-Light Water Reactor Licensing Basis Development," NEI 18-04 (Draft).
6. Nuclear Regulatory Commission, "Policy and Technical Issues Associated with the Regulatory Treatment of Non-Safety Systems in Passive Plant Designs," SECY-94-084, March 1994.

Table 1. Comparison of Advanced Reactor Designs

Design Attribute or Issue	Sodium Fast Reactor	Modular High Temperature Gas-Cooled Reactor	Kairos Power Fluoride-Cooled High Temperature Reactor
Core Design	Oxide or metal fuel with metal cladding	Fully ceramic pebble fuel	Fully ceramic pebble fuel
Power Density	Very High	Low	Intermediate
Coolant	Molten sodium	Helium gas	Molten salt (Flibe)
Coolant Chemical Activity	High (sodium/water or air)	Low (graphite/air)	Very low
Operating Pressure	Near Atmospheric	High	Near Atmospheric
Solid fission product mobility following fuel damage	Low (retained in sodium)	Low (retention in fuel)	Extremely low (retention in fuel and in Flibe coolant)
Containment Concept	Pressure-retaining, low-leakage containment	Functional containment	Functional containment
Decay Heat Removal	Passive	Passive	Passive
Intermediate Loop (between primary and power conversion)	Yes	No	Yes

Table 2. Summary of RG 1.232 Criteria Applicable to KP-FHR

Section	Total # Criteria	Applicable Criteria (adopted as is or modified)			Not Applicable	Comments
		ARDC	SFR	MHTGR		
Overall	[[					
Multiple Barriers						
Reactivity Control						
Fluid Systems/Heat Transport Systems						
Reactor Containment						
Fuel and Radioactivity Control						
Additional SFR-DC						
Additional MHTGR-DC						
TOTAL						]]

NA – Not Applicable

Table 3. Modifications Made to ARDC, SFR-DC, and MHTGR-DC

Modification	PDC
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Figure 1. Flow Chart of PDC Development Methodology

APPENDIX A. PDC FOR THE KP-FHR

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II. Multiple Barriers

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III. Reactivity Control

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IV. Heat Transport System

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V. Reactor Containment

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VI. Fuel and Radioactivity

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VII. Additional KP-FHR PDC

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APPENDIX B. RG 1.232 DESIGN CRITERIA NOT APPLICABLE TO THE KP-FHR

I. Overall Requirements

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II. Multiple Barriers

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III. Reactivity Control

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IV. Fluid Systems/Heat Transport

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V. Reactor Containment

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VI. Fuel and Radioactivity Control

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VII. Additional SFR-DC

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Enclosure 3

Kairos Power LLC Affidavit and Request for Withholding from Public Disclosure (10 CFR 2.390)

I, Peter Hastings, hereby state:

1. I am Vice President, Regulatory Affairs and Quality at Kairos Power LLC ("Kairos"), and as such I have been authorized by Kairos to review information sought to be withheld from public disclosure in connection with the development, testing, licensing, and deployment of the Kairos reactor and its associated structures, systems, and components, and to apply for its withholding from public disclosure on behalf of Kairos.
2. The information sought to be withheld, in its entirety, is contained in Kairos' Enclosure 1 to this letter.
3. I am making this request for withholding, and executing this affidavit in support thereof, pursuant to the provisions of 10 CFR 2.390(b)(1).
4. I have personal knowledge of the criteria and procedures utilized by Kairos in designating information as a trade secret, privileged, or as confidential commercial or financial information. Some examples of information Kairos considers proprietary and eligible for withholding under §2.390(a)(4) include:
    a. Information which discloses process, method, or apparatus, including supporting data and analyses, where prevention of its use by Kairos competitors without license or contract from Kairos constitutes a competitive economic advantage over other companies in the industry;
    b. Information, which if used by a competitor, would reduce his expenditure of resources or improve his competitive position in design, manufacture, shipment, installation, assurance of quality;
    c. Information which reveals cost or price information, production capacities, budget levels, or commercial strategies of Kairos, its customers, its partners, or its suppliers;
    d. Information which reveals aspects of past, present, or future Kairos or customer funded development plans or programs, of potential commercial value to Kairos;
    e. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection; and/or
    f. Information obtained through Kairos actions which could reveal additional insights into reactor system development, testing, qualification processes, and/or regulatory proceedings, and which are not otherwise readily obtainable by a competitor.
5. Kairos' information contained in Enclosure 1 to this letter contains details of Kairos' regulatory and development strategies intended to support NRC staff review. These strategies include aspects of Kairos' planning that could provide a competitor with a commercial advantage if the information were to be revealed publicly, prior to submittal of a license application.

6. Pursuant to the provisions of §2.390(b)(4), the following is furnished for consideration by the Commission in determining whether the information sought to be withheld from public disclosure should be withheld:

   a. The information sought to be withheld from public disclosure is owned and has been held in confidence by Kairos.

   b. The information is of a type customarily held in confidence by Kairos and not customarily disclosed to the public. Kairos has a rational basis for determining the types of information customarily held in confidence by it and, in that connection, utilizes a system to determine when and whether to hold certain types of information in confidence. The application of that system and the substance of that system constitute Kairos policy and provide the rational basis required.

   c. The information is being transmitted to the Commission in confidence and, under the provisions of 10 CFR 2.390, it is to be received in confidence by the Commission.

   d. This information is not readily available in public sources.

   e. Public disclosure of this proprietary information is likely to cause substantial harm to the competitive position of Kairos, because it would enhance the ability of competitors to provide similar products and services by reducing their expenditure of resources using similar project methods, equipment, testing approach, contractors, or licensing approaches. This information is the result of considerable expense to Kairos and has great value in that it will assist Kairos in providing products and services to new, expanding markets not currently served by the company.

   f. The information could reveal or could be used to infer price information, cost information, budget levels, or commercial strategies of Kairos.

   g. Each component of proprietary information pertinent to a particular competitive advantage is potentially as valuable as the total competitive advantage. If competitors acquire components of proprietary information, any one component may be the key to the entire puzzle, thereby depriving Kairos of a competitive advantage.

   h. Unrestricted disclosure would jeopardize the position of Kairos in the world market, and thereby give a market advantage to the competition in those countries.

I declare under penalty of perjury that the foregoing is true and correct.

Executed on: December 21, 2018

Peter Hastings
Vice President, Regulatory Affairs and Quality