Kairos Power

KP-NRC-1901-002

January 24, 2019

Project No. 99902069

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

Subject: Kairos Power LLC
Topical Report Submittal
Regulatory Analysis for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor

This letter submits the subject topical report which identifies the Nuclear Regulatory Commission (NRC) regulatory requirements applicable to 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 referenced 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 receipt of this letter. In recognition of an aggressive deployment schedule and substantial pre-application engagement, Kairos Power has established a generic assumption of a 12-month review for topical reports.

Portions of the attached 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 additional information, please contact James Tomkins at tomkins@kairospower.com or (805) 215-6129, or Darrell Gardner at gardner@kairospower.com or (704) 769-1226.

Sincerely,

Peter Hastings, PE
Vice President, Regulatory Affairs and Quality

Enclosures:

1) Regulatory Analysis for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor (Proprietary)
2) Regulatory Analysis 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

Regulatory Analysis for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor (Non-Proprietary)

KP-TR-004-NP

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

Regulatory Analysis for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor

Topical Report

Revision 0
January 2019

Non-Proprietary

Rev	Description of Change	Date
0	Initial Issuance	January 2019

Executive Summary

This topical report reviews and identifies the Nuclear Regulatory Commission (NRC) regulatory requirements applicable to the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor (KP-FHR). This regulatory review considers the relevant NRC requirements in Title 10 of the Code of Federal Regulations (10 CFR). The regulatory analysis identifies the regulations that apply to the KP-FHR, those that do not apply, those that do not apply but are relevant, and those that require an exemption from the regulations. The analysis is based on consideration of the unique design features of the KP-FHR technology which are summarized in this report.

Kairos Power has concluded that the regulatory requirements reflected herein are sufficient to conduct the NRC review of a license application and to reach a conclusion of reasonable assurance of adequate protection of public health and safety. Kairos Power is requesting NRC review and approval of this topical report for use by future applicants for licenses under 10 CFR 50 and 10 CFR 52 related to the KP-FHR.

In addition, the report reviews existing regulatory guidance in NRC Regulatory Guides for suitability to the design and licensing of the KP-FHR. However, Kairos Power is not requesting review and approval of the acceptability of Regulatory Guides or other guidance documents for use by future applicants at this time.

Table of Contents

ABBREVIATIONS

Abbreviation or Acronym	Definition
AC	Alternating Current
ALARA	As Low as Reasonably Achievable
ASME	American Society of Mechanical Engineers
ATWS	Anticipated Transient Without Scram
BWR	Boiling Water Reactor
B&W	Babcock and Wilcox
CFR	Code of Federal Regulations
COL	Combined License
CP	Construction Permit
DC	Design Certification
DOE	Department of Energy
ECCS	Emergency Core Cooling System
EPZ	Emergency Planning Zone
EQ	Environmental Qualification
ESP	Early Site Permit
FHR	Fluoride Salt-Cooled High Temperature Reactor
FSAR	Final Safety Analysis Report
GSI	Generic Safety Issue
HEU	Highly Enriched Uranium
ITAAC	Inspections, Tests, Analyses, and Acceptance Criteria
KP-FHR	Kairos Power Fluoride Salt-Cooled High Temperature Reactor
LCO	Limiting Condition for Operation
LLC	Limited Liability Corporation
LMP	Licensing Modernization Project
LWA	Limited Work Authorization
LWR	Light Water Reactor
MHTGR	Modular High Temperature Gas-Cooled Reactor
ML	Manufacturing License
OBE	Operating Basis Earthquake
OL	Operating License

Abbreviation or Acronym	Definition
NRC	Nuclear Regulatory Commission
PRA	Probabilistic Risk Assessment
PSAR	Preliminary Safety Analysis Report
PWR	Pressurized Water Reactor
QA	Quality Assurance
QC	Quality Control
RCS	Reactor Coolant System
RG	Regulatory Guide
SDA	Standard Design Approval
SNM	Special Nuclear Material
SRP	Standard Review Plan
SSC	Structures, Systems, and Components
TRISO	Tri-structural Isotropic

1 INTRODUCTION

Kairos Power LLC (Kairos Power) is pursuing the design, licensing, and deployment of a Fluoride Salt-Cooled, High Temperature Reactor (FHR). To support these objectives, Kairos Power has reviewed the regulations in 10 CFR to confirm the requirements that are applicable and appropriate to establish the framework for NRC review and licensing of the KP-FHR design. Nuclear Regulatory Commission (NRC) regulations in 10 CFR Part 50 and Part 52 provide most of the regulations associated with design and licensing of nuclear reactors. However, this review also included the remainder of 10 CFR Parts 1 through 199 to identify other relevant design and licensing requirements. The review of regulations summarized in this topical report categorizes the NRC regulations into those that apply, regulations that do not apply, and regulations that require exemption for the design and licensing of the KP-FHR. In some cases, regulations that do not "literally" apply to the KP-FHR are still considered "relevant" because of the intent or underlying issue of the regulation. These regulations that do not apply to the KP-FHR but are considered relevant are also identified in this analysis. The review of the regulations is performed in consideration of the KP-FHR unique design attributes.

Kairos Power is requesting NRC review and approval of this topical report, including concurrence with the applicability of design-related regulations in Appendix A and non-design related regulations in Appendix B. The results of this topical report, along with a separate topical report which establishes the principal design criteria for the KP-FHR (Reference 1), are expected to be used by applicants and NRC reviewers as a regulatory framework for licenses, approvals, and/or certifications of a KP-FHR under 10 CFR 50 and 10 CFR 52.

A review of NRC Regulatory Guides (RG) is also performed to identify those RGs that may be useful or relevant for demonstrating conformance to the set of applicable regulations. While NRC comments on the appropriateness of the RG conclusions in Appendix C are welcome, Kairos Power is not requesting formal review and approval of the acceptability of these RGs for use at this time. The degree of conformance or use of a particular RG will be identified as part of other license application documents such as safety analysis reports or topical and technical reports.

1.1 DESIGN FEATURES

1.1.1 Design Background

To facilitate NRC review and approval of the regulatory analysis for use by future applicants, key design features are provided in this section which are considered 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 the regulatory analysis. Should fundamental changes occur to these key design features or revised regulations be promulgated that affect the regulatory analysis for the KP-FHR, such changes would be reconciled and addressed in future 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 Salt-Cooled 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.

Although not intended to support the findings necessary to approve the applicability of regulations provided in this report, additional design description information is provided in the "Design Overview of the Kairos Power Fluoride Salt-Cooled, High Temperature Reactor (KP-FHR)" Technical Report (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 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, $2\cdot^{7}LiF:BeF_2$ (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 which 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 relies on a functional containment approach similar to the Modular High Temperature Gas-Cooled Reactor (MHTGR) instead of the typical light water reactor (LWR) low-leakage, pressure retaining containment structure. The KP-FHR functional containment safety 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, anticipated operational occurrences, 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 the KP-FHR as opposed to the MHTGR, the molten salt coolant 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 BACKGROUND

The NRC regulatory framework (regulations and guidance) for the design and licensing of nuclear power plants has evolved over many years of light water reactor licensing experience and is currently contained in the following document types:

- Regulations
  - 10 CFR Parts 1-199
- Guidance
  - NRC Regulatory Guides
  - Standard Review Plans
  - Interim Staff Guidance, Generic Letters, Bulletins, Generic Safety Issues (GSI)

The regulations in 10 CFR Parts 1-199 contain the requirements that must be met to design, license, and operate a nuclear power plant. Not all regulations are required to be addressed by every reactor design type (some are design specific) and some regulations are applicable only to non-reactor facilities or other NRC licensed activities. Additionally, the regulations allow for exemptions, if appropriate and properly justified. For example, 10 CFR 50.12 identifies the standard for exemptions from 10 CFR 50 requirements.

While the regulations in 10 CFR contain requirements that must be met (if applicable), NRC guidance provides approaches or methods that have been determined to be acceptable by the NRC for demonstrating a requirement has been met. However, regulatory guidance does not represent requirements and applicants for licenses may propose alternative approaches or methods for demonstrating conformance to regulations. Although conformance with guidance documents is not specifically required, they represent a useful tool for developing and submitting an application. Kairos Power has considered NRC Regulatory Guides for relevance to the requirements applicable to the design of the KP-FHR as part of this review.

There are several paths for licensing a nuclear power plant provided in 10 CFR 50 and 10 CFR 52. Kairos Power anticipates that the initial plant license applications for the KP-FHR will be submitted under 10 CFR 50. However, all licensing paths are viable, so all regulations are evaluated in this report, with a consideration of applicability of the license pathway. Kairos Power has also evaluated the NRC analysis in SECY-15-0002, “Proposed Updates of Licensing Policies, Rules, and Guidance for Future New Reactor Applications,” which recommends rulemaking to better align the requirements in 10 CFR 52 and 10 CFR 50. Accordingly, this report considers the recommendations in this SECY and associated staff requirements memorandum (SRM) as part of the evaluation of licensing requirements in both 10 CFR 50 and 10 CFR 52 for applicability to the KP-FHR design.

Kairos Power is engaged with the industry/NRC/Department of Energy (DOE) effort to modernize the licensing process, referred to as the Licensing Modernization Project (LMP). The objective of the LMP is to facilitate a risk-informed and performance-based design and licensing of advanced non-LWRs. Kairos intends to use the LMP guidance, described in NEI 18-04, to identify licensing basis events, classify structures, systems, and components (SSCs), and determine defense-in-depth adequacy. In addition, safety significance insights from the implementation of the LMP will be used to inform the level of detail to be included in license applications for the KP-FHR design.

2 REGULATORY ANALYSIS METHODOLOGY

2.1 SCOPE

This section describes the process used by Kairos Power to perform the regulatory analysis for the KP-FHR. NRC regulations and guidance were reviewed to establish a licensing framework applicable for the design and licensing of the KP-FHR. The scope of regulations and guidance included in this review includes the NRC document types in Section 1.2.

2.2 METHODOLOGY

A methodical process was used to review NRC regulations and guidance to determine if the licensing framework is applicable and sufficient for the design and licensing of the KP-FHR. The regulations and guidance documents in Section 1.2 were compiled in a tabular form to facilitate screening, review and evaluation. Different levels of granularity were used in the review of different document types. For example, 10 CFRs 50 and 52 were compiled in smaller discrete elements to aid in assigning them as requirements for the Kairos Power design. CFRs other than Part 50 and 52 were screened and reviewed at the part level. Note that the selection of principal design criteria required by 10 CFR 50, Appendix A, was performed separate from this review and documented in a separate topical report (Reference 1), using the guidance in Regulatory Guide 1.232 (Reference 4).

For each regulation, the content was screened by a cross-discipline engineering and licensing team and categorized based on the type or nature of the regulation. Note that these screening categories are not defined in NRC regulations or guidance but were defined by the review team to facilitate and document the review. One objective of the initial screening of the regulations was to distinguish requirements specifically relevant to the design of the plant from requirements considered to be administrative, process, or programmatic in nature. This distinction is useful to the development of functional design requirements and performance of design reviews. The screening categories established by the team are defined below:

- **Regulatory Process** – Rules and guidance associated with NRC implemented activities. Example: conduct of inspections by the NRC.
- **Not applicable** – Rules and guidance not applicable to nuclear reactors. Example: regulations specific to a production or fuel fabrication facility.
- **Administrative** – Rules, guidance, and support information associated with the conduct of an applicant or licensee. Examples: 50.5, 50.7, 50.9.
- **Process** – Rules and guidance related to regulatory processes required for an applicant or licensee (primarily activities that require procedures).
- **Program** – Rules and guidance related to regulatory or operational programs. Examples: in-service inspection, quality assurance.
- **Design** – Rules and guidance related to plant design, engineering, and analyses. In cases where requirements include administrative, process or program requirements in addition to design, the requirement is conservatively categorized as design. Examples are those regulations related to the contents of applications, or that establish criticality requirements.

These requirements have elements consistent with the definitions of multiple review categories.

Regulations that were not initially screened out as not applicable were subsequently further evaluated for specific applicability to the KP-FHR technology. The requirements categorized as "Design" and found to be applicable to the KP-FHR technology establish the list of regulatory requirements to be addressed as part of the KP-FHR design requirements identification process.

The evaluation categories are defined:

- **Applies –** The regulation applies to the KP-FHR as written.
- **Does Not Apply –** The regulation is not literally applicable to the KP-FHR due to the wording of the rule and is not technically relevant or directly applicable to the KP-FHR design. Examples are requirements that apply to LWRs only, certain reactor developers/vendors, or to existing licensed plants only.
- **Does Not Apply, but are Relevant –** The regulation does not literally apply as discussed above, however, the underlying issue is considered relevant. An example of this is 10 CFR 50 Appendix I, application of As Low as Reasonably Achievable (ALARA) principles to radioactive effluents, which states that it applies to LWRs only. These principles are relevant to any reactor technology, and Kairos Power intends to use ALARA principles to inform its design.
- **Exemption –** This category is used where the regulation is literally applicable to the design of KP-FHR, [[

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Design-related regulatory requirements determined to be applicable to the KP-FHR are allocated to the appropriate KP-FHR system using the design architecture shown in Figure 1. The intent is to allocate the specific regulatory requirements to the system level, where appropriate, and establish a set of regulatory acceptance criteria that may be used to perform licensing reviews of the KP-FHR design at a system level.

In some instances, specific regulatory requirements in the 10 CFR may be applicable to the KP-FHR design, but only for a certain licensing pathway or application type. In these cases, requirements deemed applicable to a specific KP-FHR licensing path or application type are designated with an application type. These license application types are listed below:

CP – Construction Permit

OL – Operating License

LWA – Limited Work Authorization

SDA – Standard Design Approval

COL – Combined License

DC – Design Certification

ML – Manufacturing License

ESP – Early Site Permit

3 REGULATORY ANALYSIS RESULTS

The regulations in 10 CFR Parts 1-199 and relevant regulatory guidance documents were reviewed and categorized with respect to their applicability as described in Section 2.2. In the remainder of this document, the regulations in 10 CFR 1-199 are referred to as 10 CFR. The results of the review are summarized in the subsections below.

3.1 REGULATION REVIEW RESULTS

Section 3.1.1 discusses the design-related requirements in 10 CFR that apply, Section 3.1.2 the design related requirements that do not apply, Section 3.1.3 the requirements that do not apply but are relevant, Section 3.1.4 the requirements that require an exemption, and Section 3.1.5 all of the non-design requirements.

3.1.1 Design Regulatory Requirements in 10 CFR That Apply

A review was conducted of the design-related regulations in 10 CFR to determine which requirements apply to the KP-FHR technology. The review category descriptions provided in Section 2.2 were used in making these determinations.

The results of this review are tabulated in Appendix A for design-related requirements. The regulations determined to apply to the design of the KP-FHR are listed in Table A-1 for 10 CFR. Each applicable requirement is allocated to the plant architecture defined in Figure 1 and an application type is assigned as described in Section 2.2.

3.1.2 Design Regulatory Requirements in 10 CFR That Do Not Apply

A review was conducted of design-related regulations in 10 CFR to determine which requirements do not apply to the KP-FHR technology. These design-related requirements do not literally apply to KP-FHR (e.g. applicable to LWRs only, certain developers/vendors, or to existing plants only).

The results of this review are tabulated in Table A-2. The table provides an explanation for why the regulation does not apply to the KP-FHR.

3.1.3 Design Regulatory Requirements in 10 CFR That Do Not Apply, but are Relevant

As discussed in Section 2.2, some of the 10 CFR regulations that do not apply to the KP-FHR are considered relevant or partially relevant. These are captured in Table A-3 for design related requirements and Table B-3 for non-design requirements. While these regulations literally do not apply, elements of these regulations are considered relevant in some cases because the underlying issue is relevant to the KP-FHR design. The rationale for the consideration of relevance and how these requirements will be considered for the KP-FHR design is summarized in the subsections below and in Table A-3. In 10 CFR 52, many of the regulations are repeated in Subpart A (Early Site Permits), Subpart B (Standard Design Certifications), Subpart C (Combined Licenses), Subpart E (Standard Design Approvals), and Subpart F (Manufacturing Licenses).

It should be noted that many of these rules stem from Three Mile Island requirements and therefore only apply to LWRs. It should also be noted that Kairos Power is not formally committing to meet these

regulations that do not apply but are relevant, but is stating the intent to consider the relevant portions of these rules as part of the design and licensing process.

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3.1.4 Regulatory Requirements in 10 CFR That Require an Exemption

As discussed in Section 2.2, some of the regulations in 10 CFR require an exemption for use with the KP-FHR. The 10 CFR regulations that are determined to require an exemption to license the KP-FHR design are provided in Table A-4. Note that this table includes all exemptions for the 10 CFRs for both design and non-design, unlike the other tables in this Appendix, to ensure each exemption "topic" includes all relevant regulations. [[

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3.1.5 Non-Design Regulatory Requirements in 10 CFR

Non-design related regulations in 10 CFR are summarized in Appendix B. Non-design related regulations include Administrative, Regulatory Process, Process, and Program as described in Section 2.2. The majority of these regulations apply to licensing of the KP-FHR. The non-design regulations that apply to KP-FHR are provided in Table B-1 and those that do not apply are provided in Table B-2. The non-design regulations that do not apply but are relevant are provided in Table B-3. As previously discussed, the exemptions to non-design regulations are not included in Appendix B and instead are included with the design-related exemptions in Appendix A, Table A-4.

The non-design regulations in Table B-1 and B-2 were reviewed for applicability and are presented at the part level for all parts except Part 50, 51, and 52. The non-design regulations are primarily program and process and in most cases are specific to an activity. So, if the activity is performed, most if not all of the requirements within the part are applicable.

3.2 REGULATORY GUIDANCE

As discussed previously regulatory guidance is not a requirement but may provide useful information to meet a requirement. Regulatory guides and standard review plans were reviewed for relevance to the design of the KP-FHR and discussed below.

3.2.1 Regulatory Guides

Regulatory Guides (RG) are issued by NRC to provide guidance to licensees and applicants on implementing specific parts of regulations, techniques used by the NRC staff in evaluating specific problems or postulated accidents, and data needed by NRC staff for review of applications. A review was conducted of NRC Regulatory Guides applicable to reactor plants to determine which ones are relevant to the design of the KP-FHR technology. Regulatory Guides are issued by the staff in the following Divisions:

1. Power Reactors
2. Research and Test Reactors
3. Fuels and Materials Facilities
4. Environmental and Siting
5. Materials and Plant Protection
6. Products
7. Transportation
8. Occupational Health
9. Antitrust and Financial Review
10. General

The review only considered Regulatory Guides from Divisions 1, 2, 4, 5, 8, and 9 as other division Regulatory Guides are specifically not applicable (e.g., Division 3 Regulatory Guides are specifically applicable to fuel and material facilities). There are six Regulatory Guides in Division 2 and there is a comparable Regulatory Guide in Division 1 for each of the Division 2 Regulatory Guides. The guidance in the Division 2 RGs is considered to be bounded by the guidance in Division 1 and these are not evaluated further. Division 3 RGs are not considered applicable to the design because the KP-FHR is not a fuels or material facility. Similarly, Division 6 and 7 RGs are not considered applicable because they apply to products and to transportation, neither of which establish guidance to the KP-FHR.

Much of the guidance in Division 1 RGs are based on LWR technology and were concluded to have limited applicability for design or review of the KP-FHR. The details of the screening review are not included in this report. However, Table C-1 provides a list of the regulatory guides that were considered technology neutral guidance to meet associated regulations. These regulatory guides are mainly in seismic, security, and radiation protection, i.e. topic areas that are generally technology neutral to LWRs. Note the evaluation of regulatory guides was performed at the document level rather than individual regulatory positions taken within the document. Future license applications and licensing reports for the KP-FHR design will address how the applicable regulatory requirements are satisfied and the degree to which individual regulatory guide positions are used to demonstrate that conformance.

3.2.2 Standard Review Plans

The NRC has developed a number of standard review plans (SRP) for staff use in reviewing proposed licensing actions. These licensing actions may relate to constructing, operating, or decommissioning a

nuclear facility or possessing, using, storing, or transporting nuclear materials or waste. Consideration of applicable SRP content is relevant to establishing the framework for design and licensing of the KP-FHR because the SRP is intended to be a comprehensive and integrated document that provides the NRC reviewer with guidance that describes methods or approaches that the staff has found acceptable for meeting NRC requirements. However, the SRP contain guidance and compliance with an SRP is not required to be met by applicants. Alternative approaches which comply with regulations may be proposed by applicants.

Two SRP are identified for relevance to the review of reactor plant designs: NUREG-0800 and NUREG-1537. Based on their stated scope and purpose, neither of these SRPs is directly applicable to the KP-FHR. Nevertheless, Kairos Power reviewed these SRPs for insights as discussed below.

3.2.2.1 NUREG-0800

NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition” (Reference 5), has been used to conduct reviews of nuclear plants since 1975. The regulations in 10 CFR 50.34(h) require that LWR applications include an evaluation of the facility against the SRP in effect 6 months prior to the date of the application. Because the KP-FHR is a non-LWR technology, this regulation is not applicable (See Section 3.1.1). A significant revision of this SRP was issued in March 2007. Revisions to subsections of the SRP were subsequently issued and maintained for use by the staff and public. NUREG-0800 has two parts; Part 1 is the LWR Edition and Part 2 is the LWR Small Modular Reactor Edition. At this time, Part 2 contains a design specific review standard for the NuScale SMR. Both editions are specific to LWRs and this guidance is not directly applicable to non-LWRs.

While some portions of NUREG-0800 (typically those portions not related to the nuclear steam supply system) could be used for the KP-FHR, the majority of this SRP is not directly applicable. A review of NUREG-0800 Chapter 4, “Reactor,” by Oak Ridge National Laboratory (Reference 6) demonstrated that significant changes were necessary for the existing LWR guidance to be applied to non-LWR designs such as sodium fast reactors and MHTGRs. A detailed review of NUREG-0800 Chapter 5, “Reactor Coolant System and Connected Systems,” by Kairos Power similarly concluded that approximately only one-third of the existing LWR acceptance criteria were relevant to the KP-FHR design. Likewise, a review of Chapter 6, “Engineered Safety Features," produced similar results of low applicability primarily due to substantial technology differences between LWRs and the KP-FHR.

Advanced reactor technologies, such as represented by the KP-FHR, rely on simpler, passive safety strategies and are less complex than the designs on which this SRP was based. As a result, review guidance in safety significant chapters (such as fuel, reactor vessel and coolant piping, engineered safety features) of the SRP are generally not useful to support a review of the KP-FHR design. Additionally, while content in other areas might be technically relevant, the content is based on designs which rely on active support systems to accomplish safety functions and would require a level of detail and review significantly beyond what would be necessary for the low-safety significance of equivalent systems in the KP-FHR. The Kairos Power review concludes that this SRP is generally not suited to conduct a review of the KP-FHR design. Therefore, a detailed applicability of the content in this SRP to the KP-FHR is not provided in this report.

3.2.2.2 NUREG-1537

In 1996, the NRC published NUREG-1537, "Guidelines for Preparing and Reviewing Applications for the Licensing of Non-Power Reactors: Standard Review Plan and Acceptance Criteria" (Reference 7). This NUREG was issued in two parts; Part 1 provides a format and content guide for applicants, and Part 2 provides a standard review plan for NRC staff to conduct its review.

This standard review plan differs from that in NUREG-0800 in that it contains a higher level, broader set of acceptance standards that is less technology-specific. For comparison purposes, a review of acceptance criteria in NUREG-1537, Chapter 5, concludes that approximately 90% of the acceptance criteria could be used to support a review of the KP-FHR.

The Kairos Power review of NUREG-1537 concludes that this SRP, in some cases, is more suited to conduct a review on non-LWR designs. It is noted that this SRP cautions that the guidance provided may not be applicable to reactor designs with power levels greater than tens of megawatts thermal. Although the anticipated power level for the KP-FHR is significantly higher, much of the guidance in this SRP may be sufficient to conduct a review.

[[ ]] Detailed tables comparing the applicability of this SRPs is not provided in this report and Kairos Power is not requesting NRC detailed review of this SRP for use in a review of the KP-FHR as part of this report.

3.3 CONCLUSIONS

Kairos Power has reviewed and identified the relevant NRC regulations and guidance applicable to the KP-FHR technology. The review identified design-related and non-design related regulatory requirements from 10 CFR Parts 1-199 that are applicable to KP-FHR design and licensing and associated NRC Regulatory Guides that are useful for demonstrating how the design satisfies the applicable regulations.

The applicable regulatory requirements in Appendices A and B, along with the Principal Design Criteria identified separately in Reference 1, provide a comprehensive licensing framework for the design and licensing of the KP-FHR. While some of the existing NRC regulations are not directly applicable to the KP-FHR design and licensing, there are a sufficient set of applicable regulations to support the conduct of a safety review and enable a conclusion of reasonable assurance of adequate protection of public health and safety. In some instances, the existing regulation is not literally applicable to the design, however, the underlying basis or intent behind the regulation may have underlying relevance. In those cases, the results Tables A-3 and Table B-3 identify how the KP-FHR intends to address the relevant intent.

The review also concludes that the SRP guidance provided in NUREG-1537, although oriented towards smaller scale reactor designs is useful to support advanced reactor designs such as the KP-FHR.

Kairos Power requests NRC approval of the applicability determinations regarding design-related regulations in Appendix A and non-design related regulations in Appendix B for use in the KP-FHR design and licensing.

4 REFERENCES

1. Kairos Power LLC, "Principal Design Criteria for the Kairos Power Fluoride Salt-Cooled High Temperature Reactor," KP-TR-003, December 2018.
2. University of California Berkeley 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)", KP-TR-001, November 2018.
4. US Nuclear Regulatory Commission, "Guidance for Developing Principal Design Criteria for Non-Light Water Reactors," RG 1.232, Revision 0, April 2018.
5. US Nuclear Regulatory Commission, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition," NUREG-0800.
6. Oak Ridge National Laboratory, "Proposed Adaptation of the Standard Review Plan NUREG-0800, Chapter 4 (Reactor) for Sodium-Cooled Fast Reactors and Modular High-Temperature Gas-Cooled Reactors," ORNL/TM-2017/151, March 2017.
7. US Nuclear Regulatory Commission, "Guidelines for Reviewing Applications for the Licensing of Non-Power Reactors," NUREG-1537, February 1996.

Figure 1. KP-FHR Design Architecture

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APPENDIX A: DESIGN REGULATORY REQUIREMENTS IN 10 CFR

The following is a summary of the Design Related Tables in this Appendix.

Table Number	Title
A-1	Design Regulatory Requirements in 10 CFR That Apply
A-2	Design Regulatory Requirements in 10 CFR That Do Not Apply
A-3	Design Regulatory Requirements in 10 CFR That Do Not Apply, but are Relevant
A-4	All Regulatory Requirements in 10 CFR That Require an Exemption

Table A-1. Design Related Regulatory Requirements in 10 CFR That Apply

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Table A-2. Design Regulatory Requirements in 10 CFR That Do Not Apply

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Table A-3. Design Regulatory Requirements in 10 CFR That Do Not Apply, but are Relevant

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Table A-4. All Regulatory Requirements in 10 CFR That Require an Exemption

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APPENDIX B: NON-DESIGN REGULATORY REQUIREMENTS IN 10 CFR

This appendix summarizes the applicability of regulations that are not related to design. These categories include Administrative, Regulatory Process, Process, and Program as described in Section 2.2. The overwhelming majority of these regulations apply to KP-FHR as would be expected. As mentioned previously, exemptions from non-design requirements are included in Table A-4.

Table Number	Title
B-1	Non-Design Regulatory Requirements in 10 CFR That Apply
B-2	Non-Design Regulatory Requirements in 10 CFR That Do Not Apply
B-3	Non-Design Regulatory Requirements in 10 CFR That Do Not Apply, but are Relevant

Table B-1. Non-Design Related Regulatory Requirements in 10 CFR That Apply

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Table B-2. Non-Design Regulatory Requirements in 10 CFR That Do Not Apply

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Table B-3. Non-Design Regulatory Requirements in 10 CFR That Do Not Apply, but are Relevant

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APPENDIX C: REGULATORY GUIDES RELEVANT TO THE KP-FHR

The following Table C-1 summarizes the Regulatory Guides that are relevant to the design and licensing for the KP-FHR.

Table C-1. Regulatory Guides Relevant to the KP-FHR

Table C-1. Regulatory Guides Relevant to the KP-FHR	
Number	Title
Regulatory Guide 1.12	Nuclear Power Plant Instrumentation for Earthquakes
Regulatory Guide 1.22	Periodic Testing of Protection System Actuation Functions (Safety Guide 22)
Regulatory Guide 1.30	Quality Assurance Requirements for the Installation, Inspection, and Testing of Instrumentation and Electric Equipment (Safety Guide 30)
Regulatory Guide 1.31	Control of Ferrite Content in Stainless Steel Weld Metal
Regulatory Guide 1.47	Bypassed and Inoperable Status Indication for Nuclear Power Plant Safety Systems
Regulatory Guide 1.59	Design Basis Floods for Nuclear Power Plants
Regulatory Guide 1.60	Design Response Spectra for Seismic Design of Nuclear Power Plants
Regulatory Guide 1.61	Damping Values for Seismic Design of Nuclear Power Plants
Regulatory Guide 1.69	Concrete Radiation Shields and Generic Shield Testing for Nuclear Power Plants
Regulatory Guide 1.76	Design-Basis Tornado and Tornado Missiles for Nuclear Power Plants
Regulatory Guide 1.78	Evaluating the Habitability of a Nuclear Power Plant Control Room During a Postulated Hazardous Chemical Release
Regulatory Guide 1.87	Guidance for Construction of Class 1 Components in Elevated-Temperature Reactors
Regulatory Guide 1.92	Combining Modal Responses and Spatial Components in Seismic Response Analysis
Regulatory Guide 1.97	Criteria for Accident Monitoring Instrumentation for Nuclear Power Plants
Regulatory Guide 1.102	Flood Protection for Nuclear Power Plants
Regulatory Guide 1.105	Setpoints for Safety-Related Instrumentation
Regulatory Guide 1.115	Protection Against Low-Trajectory Turbine Missiles
Regulatory Guide 1.145	Atmospheric Dispersion Models for Potential Accident Consequence Assessments at Nuclear Power Plants
Regulatory Guide 1.152	Criteria for Use of Computers in Safety Systems of Nuclear Power Plants
Regulatory Guide 1.153	Criteria for Safety Systems (12/85)
Regulatory Guide 1.168	Verification, Validation, Reviews, and Audits for Digital Computer Software Used in Safety Systems of Nuclear Power Plants
Regulatory Guide 1.169	Configuration Management Plans for Digital Computer Software Used in Safety Systems of Nuclear Power Plants
Regulatory Guide 1.170	Test Documentation for Digital Computer Software Used in Safety Systems of Nuclear Power Plants

Table C-1. Regulatory Guides Relevant to the KP-FHR	
Number	Title
Regulatory Guide 1.171	Software Unit Testing for Digital Computer Software Used in Safety Systems of Nuclear Power Plants
Regulatory Guide 1.172	Software Requirement Specifications for Digital Computer Software and Complex Electronics Used in Safety Systems of Nuclear Power Plants
Regulatory Guide 1.173	Developing Software Life Cycle Processes for Digital Computer Software Used in Safety Systems of Nuclear Power Plants
Regulatory Guide 1.118	Periodic Testing of Electric Power and Protection Systems
Regulatory Guide 1.122	Development of Floor Design Response Spectra for Seismic Design of Floor-Supported Equipment or Components
Regulatory Guide 1.125	Physical Models for Design and Operation of Hydraulic Structures and Systems for Nuclear Power Plants
Regulatory Guide 1.128	Installation Design and Installation of Vented Lead-Acid Storage Batteries for Nuclear Power Plants
Regulatory Guide 1.129	Maintenance, Testing, and Replacement of Vented Lead-Acid Storage Batteries for Nuclear Power Plants
Regulatory Guide 1.151	Instrument Sensing Lines
Regulatory Guide 1.156	Qualification of Connection Assemblies for Nuclear Power Plants
Regulatory Guide 1.180	Guidelines for Evaluating Electromagnetic and Radio-Frequency Interference in Safety-Related Instrumentation and Control Systems
Regulatory Guide 1.189	Fire Protection for Nuclear Power Plants
Regulatory Guide 1.199	Anchoring Components and Structural Supports in Concrete
Regulatory Guide 1.203	Transient and Accident Analysis Methods
Regulatory Guide 1.204	Guidelines for Lightning Protection of Nuclear Power Plants
Regulatory Guide 1.209	Guidelines for Environmental Qualification of Safety-Related Computer-Based Instrumentation and Control Systems in Nuclear Power Plants
Regulatory Guide 1.210	Qualification of Safety-Related Battery Chargers and Inverters for Nuclear Power Plants
Regulatory Guide 1.211	Qualification of Safety-Related Cables and Field Splices for Nuclear Power Plants
Regulatory Guide 1.212	Sizing of Large Lead-Acid Storage Batteries
Regulatory Guide 1.213	Qualification of Safety-Related Motor Control Centers for Nuclear Power Plants
Regulatory Guide 1.214	Response Strategies for Potential Aircraft Threats
Regulatory Guide 1.221	Design-Basis Hurricane and Hurricane Missiles for Nuclear Power Plants
Regulatory Guide 1.232	Developing Principal Design Criteria for Non-Light Water Reactors
Regulatory Guide 4.21	Minimization of Contamination and Radioactive Waste Generation: Life-Cycle Planning
Regulatory Guide 5.7	Entry/Exit Control for Protected Areas, Vital Areas, and Material Access Areas
Regulatory Guide 5.27	Special Nuclear Material Doorway Monitors
Regulatory Guide 5.44	Perimeter Intrusion Alarm Systems
Regulatory Guide 5.71	Cyber Security Programs for Nuclear Facilities

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 Power"), and as such I have been authorized by Kairos Power to review information sought to be withheld from public disclosure in connection with the development, testing, licensing, and deployment of the Kairos Power reactor and its associated structures, systems, and components, and to apply for its withholding from public disclosure on behalf of Kairos Power.
2. The information sought to be withheld, in its entirety, is contained in Kairos Power's 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 Power in designating information as a trade secret, privileged, or as confidential commercial or financial information. Some examples of information Kairos Power considers proprietary and eligible for withholding under §2.390(a)(4) include:
    a. Information which discloses process, method, or apparatus details, including supporting data and analyses, where prevention of its use by Kairos Power competitors without license or contract from Kairos Power 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, and/or assurance of quality;
    c. Information which reveals cost or price information, production capacities, budget levels, or commercial strategies of Kairos Power, its customers, its partners, or its suppliers;
    d. Information which reveals aspects of past, present, or future Kairos Power or customer funded development plans or programs, of potential commercial value to Kairos Power;
    e. Information which discloses patentable subject matter for which it may be desirable to obtain patent protection; and/or
    f. Information obtained through Kairos Power 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. Information contained in Enclosure 1 to this letter contains details of Kairos Power's regulatory and development strategies intended to support NRC staff review. These strategies include aspects of Kairos Power's planning that could provide a competitor with a commercial advantage if the information were to be revealed publicly.

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 Power.

   b. The information is of a type customarily held in confidence by Kairos Power and not customarily disclosed to the public. Kairos Power 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 Power 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 Power, 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 Power and has great value in that it will assist Kairos Power 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 Power.

   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 Power of a competitive advantage.

   h. Unrestricted disclosure would jeopardize the position of Kairos Power 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: January 23, 2019

Peter Hastings
Vice President, Regulatory Affairs and Quality