

KP-NRC-2211-002

Enclosure 1
Presentation Slides for the November 30, 2022
ACRS Full Committee Briefing



Kairos Power

KP-FHR Fuel Qualification Methodology Topical Report

ACRS FULL COMMITTEE MEETING

NOVEMBER 30

2022

OPEN SESSION

Fuel Qualification Scope/Applicability

- “Qualified fuel” is defined as fuel for which *reasonable assurance* exists that the fuel, fabricated in accordance with its specification, will perform as described in the safety analysis (NUREG-2246)
- Fuel qualification methodology is applicable to KP-FHRs
 - Test and power reactors
 - Qualification is subject to the methodology and limitations described in topical report
- Demonstration of qualification will be documented in safety analysis report documents as part of a licensing application under Part 50 or Part 52

Fuel Qualification Methodology

- U.S. and International Experience
 - Foundation of TRISO fuel particle technology
- Kairos Fuel Pebble and Particle PIRT
 - The fuel element PIRT is used to identify high priority phenomena for investigation in the fuel qualification program
- Fuel Specification, Manufacturing, and Quality Control through Inspection
 - Fuel specification equivalent to the AGR program
 - Fuel Manufacturing Development Program (e.g. pebble pressed at pressures comparable to AGR compacts)
- Fuel Qualification Envelope
 - Operation is within the bounds of existing AGR TRISO particle qualification envelope
 - If not, an irradiation test is needed to expand the operational envelope
 - Large temperature margins exist between AGR data and the KP-FHR designs for both test and power reactor

Fuel Qualification Methodology *(continued)*

- **Fuel Pebble Laboratory Qualification Testing**
 - Pebble laboratory testing program will ensure that pebbles protect the particles from physical damage and interaction with Flibe
 - Pebbles tested for compression, impact, wear, infiltration, buoyancy, and compatibility with air and Flibe
- **Fuel Irradiation Qualification Testing**
 - A method is included for future irradiation test of a statistically significant number of TRISO fuel particles at conditions beyond the bounds of existing AGR irradiation test data to support a wider operational envelope
- **Fuel Performance Model**
 - Physics based models in KP-BISON are a quantifiable representation of fuel knowledge used for core design and source term analysis
- **Fuel In-Service Surveillance Program**
 - Pebbles inspected multiple times for damage and burnup during lifetime
 - Cover gas and Flibe monitored for radioactivity
 - Destructive PIE for both the test and initial power KP-FHR

Questions from the Subcommittee Meeting

- There were two questions from the Subcommittee Meeting that we would like to address in more detail
 - Presence of transition metals in the Flibe and their effect on the SiC layer
 - Pebble Irradiation Program

Presence of Transition Metals in the Flibe

- Laboratory testing program described in the topical report will demonstrate that infiltration into the fuel region does not occur
- Flibe has to infiltrate to the fuel annulus to bring transition metal fluorides to TRISO
- It is not credible to have metallic transition metals to transport to TRISO because they are solids, which is different than AGR where metallic elements were liquids or gases
- Particle temperatures for KP-FHR fuel are well below AGR irradiation temperatures where Ni attack was observed (~500°C lower)
- Because of the low operating temperatures, any detrimental effects are expected to progress slowly
- TRISO failures would be observable by fission product monitoring in the gas and coolant spaces for the reactor and limited by the technical specification circulating activity limit

Pebble Irradiation Testing for the Hermes Test Reactor

- The KP-FHR fuel qualification methodology ensures fuel meets the reasonable assurance criteria for qualification AND there is no safety concern due to the Flibe being an additional separate barrier to the release of radionuclides
- The AGR program extensively irradiation tested TRISO fuel particles that define the fuel qualification envelope for KP-FHRs
- Kairos Power is developing the pebble and particle manufacturing which ensures high quality fuel which is demonstrated through inspection to be in compliance with the fuel specification
- Defense-in-depth – TRISO fuel particles + Flibe coolant
 - Irradiation testing cited in subcommittee meeting for prior precedent fuel designs were all for HTGRs which have higher normal operating and accident temperatures
- Fuel in-service surveillance and monitoring activity in the cover gas and coolant during operations provides further assurance fuel does not present a challenge to public health and safety

Pebble Irradiation Testing for the Test Reactor *(continued)*

- The Hermes test reactor will provide important confirmation of the technology to support the deployment of a Kairos Power commercial power reactor
 - Hermes is a full integral test of the Kairos fuel for a power reactor
- The licensing of test reactors is provided significant latitude in the Atomic Energy Act (AEA):
 - *“In issuing licenses under this subsection of the AEA , the Commission shall impose the minimum amount of such regulations to fulfill its obligations under the act.” (AEA Section 104b)*
 - *“The Commission is directed to impose only such minimum amount of regulation of the licensee as the Commission finds will permit the Commission to fulfill its obligations under this Act to promote the common defense and security and to protect the health and safety of the public and will permit the conduct of widespread and diverse research and development.” (AEA Section 104c)*
- The extensive TRISO particle irradiation testing performed under the DOE AGR program along with the Kairos Power laboratory qualification program of the fuel pebble design and the defense-in-depth provided by radionuclide retention in the Flibe coolant provides reasonable assurance of the protection of public health and safety consistent with the AEA