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NRC Staff Evaluation of the KP-FHR Mechanistic Source Term Methodology, Revision 1

Michelle Hart
Senior Reactor Engineer
Office of Nuclear Reactor Regulation

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Introduction

- KP-FHR Mechanistic Source Term Methodology topical report, KP-TR-012, Revision 1 (August 2021)
- Applicable to Kairos Power fluoride salt cooled, high temperature reactor (KP-FHR) designs
  - Including a nuclear test reactor and commercial power reactors
- Methodology to develop event-specific radiological source terms and short-term atmospheric dispersion values for EAB and LPZ at distances less than 1,200 meters
  - DBAs for siting and safety analysis
  - AOOs and DBEs for use in NEI 18-04 methodology to categorize events, classify SSCs, and evaluate defense-in-depth
  - Does **not** address source terms and atmospheric dispersion for normal operation and effluents, BDBEs, or control room habitability

Staff Review Focus

- Staff review focused on the bases for models in the methodology
  - Radionuclide transport and retention in the fuel, Flibe, gas space and buildings
  - Tritium production, transport and retention
  - Aerosol formation and deposition
  - Near-field atmospheric dispersion and use of ARCON96

Mechanistic Source Term Approach

- Methodology develops MSTs by evaluating sources of radioactive materials at risk of release (MAR) and release fractions for each barrier that contains the MAR
- DBA MSTs are developed crediting only the TRISO particle and Flibe coolant radionuclide retention as the KP-FHR functional containment
- MSTs for AOOs and DBEs are developed using a more realistic accounting of radionuclide barriers
- Staff finds the MST approach acceptable because it is consistent with
  - Safety analysis regulatory requirements
  - Discussion of MSTs in SECY-93-092 and RG 1.233
  - Description of functional containment in SECY-18-0096

Vaporization of Radionuclide from Flibe

- The NRC staff finds the methodology acceptable because of conservative assumptions and KP-FHR design features

Conditions and Limitations

- Kairos Power proposed 8 limitations on use of the TR, which were acceptable to the Staff
- Includes relationships to other Kairos Power TRs under review
  - KP-FHR fuel performance methodology TR and use of KP-Bison computer code
  - KP-FHR fuel qualification methodology

Conditions and Limitations

- The Staff imposed two additional conditions and limitations
  - #9: Use of the methodology is limited to the KP-FHR design. The combination of TRISO and Flibe allows for assumptions that may not be valid for liquid-fueled MSRs.
  - #10: Applicant to provide information to justify that the calculation of tritium absorption onto graphite is not sensitive to the assumptions on tritium diffusivity and solubility in Flibe.

Changes to SE

- Changes made to the SE since issuance of Draft SE do not impact the NRC staff conclusions

Staff Conclusions

- KP-TR-012, "KP-FHR Mechanistic Source Term Methodology," Revision 1, provides an acceptable methodology for development of event-specific mechanistic source terms for use by KP-FHR designs in offsite radiological consequence analyses for AOOs, DBEs, and DBAs
- Staff approvals are subject to the Limitations and Conditions of the SE

Acronyms and Definitions

AOO	anticipated operational occurrence
ARCON96	Atmospheric Relative Concentrations in Building Wakes computer code
BDBE	beyond design basis event
DBA	design basis accident
DBE	design basis event
EAB	Exclusion Area Boundary
Flibe	salt mixture of lithium fluoride (LiF) and beryllium fluoride (BeF2)
KP-FHR	Kairos Power Fluoride-Salt Cooled High Temperature Reactor
LPZ	Low Population Zone
MAR	materials at risk for release
MSR	molten salt reactor
MST	mechanistic source term
NEI	Nuclear Energy Institute
RG	regulatory guide
SE	safety evaluation
SECY	Commission paper
SRM	staff requirements memorandum
SSCs	structures, systems, and components
TR	topical report
TRISO	Tristructural isotopic