Enclosure 1
Presentation Materials for Pre-Application Meeting on Hermes Material Control and Accounting
(Non-Proprietary)

Kairos Power

Material Control and Accounting for the Hermes Non-Power Reactor

NOVEMBER 2, 2023

Kairos Power's mission is to enable the world's transition to clean energy, with the ultimate goal of dramatically improving people's quality of life while protecting the environment.

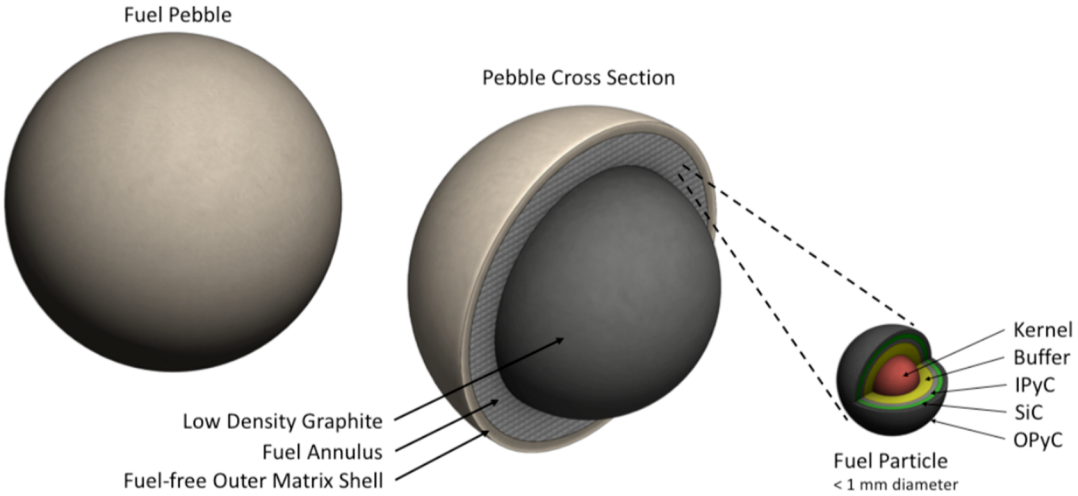
In order to achieve this mission, we must prioritize our efforts to focus on a clean energy technology that is *affordable* and *safe*

Agenda

- Provide an overview of the Kairos Power Fluoride-Cooled, High-Temperature Reactor (KP-FHR)
- Overview of regulations and guidance applicable to a test reactor facility
- Walk through draft Material Control and Accounting (MCA) Plan for Hermes
- Discussion of dilution factors
- Discussion of NMMSS reporting
- Summary and Next Steps

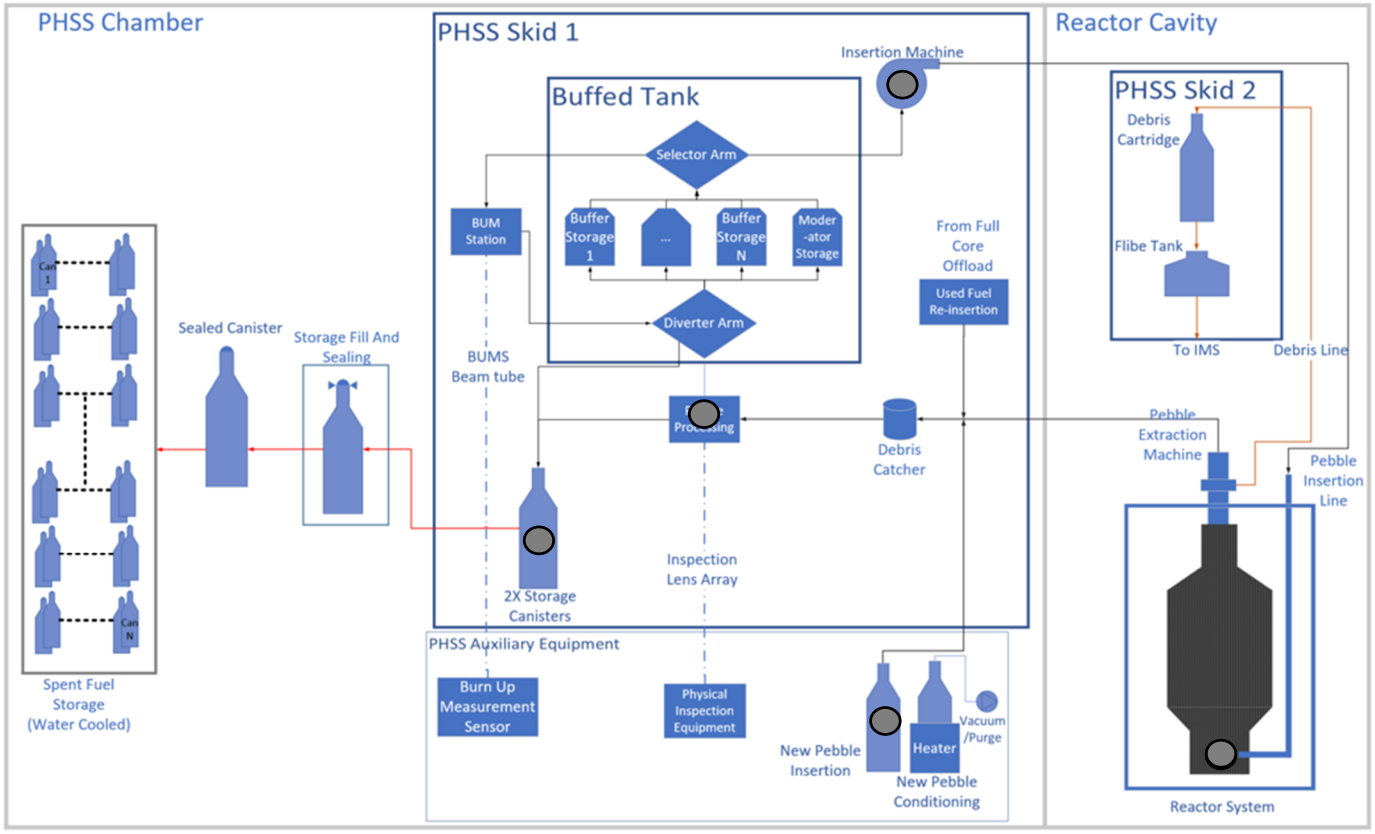
KP-FHR Fuel

- KP-FHR uses TRISO fuel particles
  - Particles embedded in fuel pebble
  - Enriched ≤ 19.75 wt%
  - 6.0 g U/pebble
- Fuel pebbles consists of three parts:
  - Fuel free outer graphite matrix shell
  - Fuel annulus
    - ~16,000 TRISO particles
  - Low density graphite core
- Graphite moderator pebbles contain no fuel
- Fuel and moderator pebbles continuously recirculated through the core
  - ~36,000 fueled and moderator pebbles in a Hermes type core
  - Total residence time of a fuel pebble is ~315 days

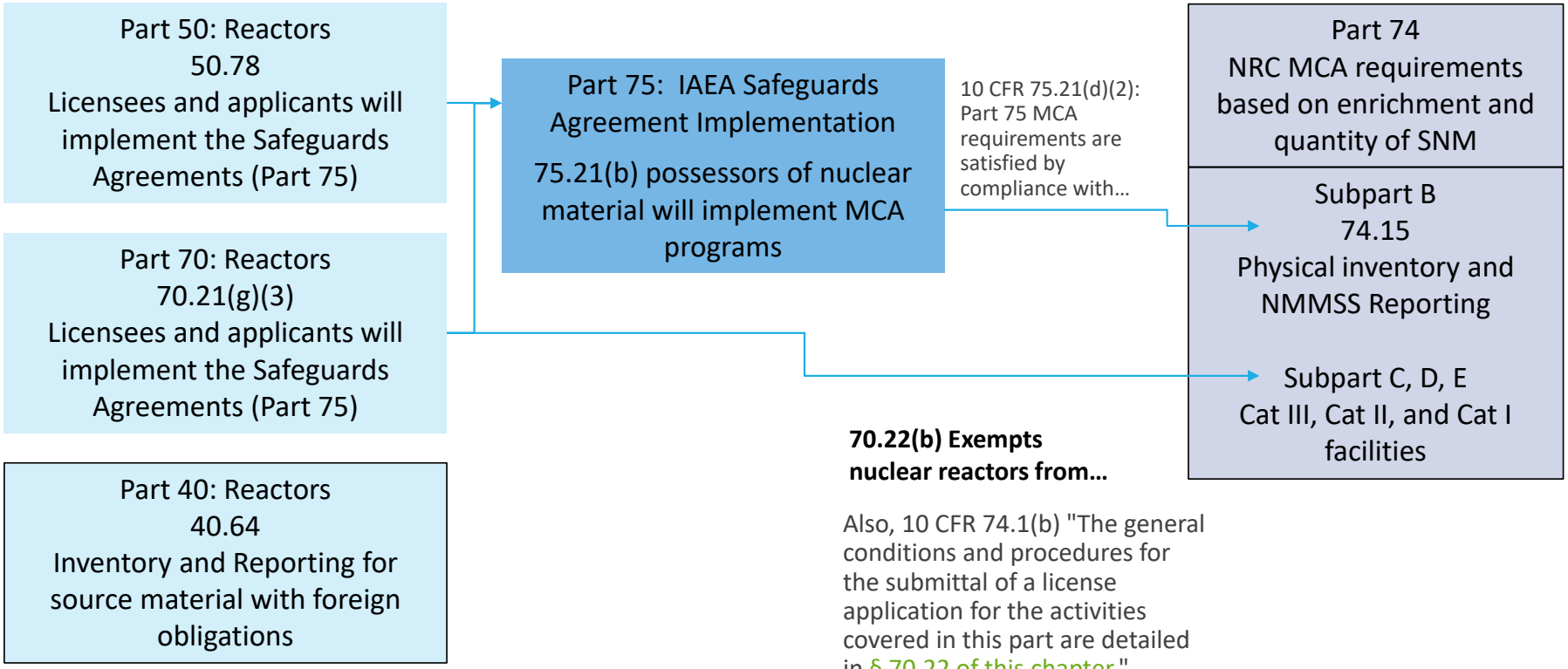


Pebble Handling and Storage System Overview

- Three main fuel areas
  - New Fuel Storage
  - In-circulation Fuel
  - Spent Fuel Storage



Regulations for Hermes Material Control and Accounting (MCA)



Overview of the MCA Plan for Hermes

- Objective: Detect and protect against theft or diversion of special nuclear material (SNM) and source material.
  - HALEU, natural uranium, depleted uranium
- Activities at the facility: receipt, storage, use, and preparation for transport of reportable materials
- Format and content:
  - Primary Guidance: Regulatory Guide (RG) 5.29, “Special Nuclear Material Control and Accounting Systems for Nuclear Power Plants”
  - Additional sections and guidance to account for areas of the facility that will use bulk accounting areas
- Plan focuses on regulatory compliance with implementation details in internal procedures

Application of Guidance

Guidance	Guidance Relevant to	Application to Hermes MCA Plan
RG 5.29 "Special Nuclear Material Control and Accounting Systems for Nuclear Power Plants"	LWRs Cat III Material	Format and level of detail Item accounting methods
ANSI 15.8-2009 "Material Control Systems – Special Nuclear Material Control and Accounting Systems for Nuclear Power Plants"	LWRs Cat III Material Items Broken rods	Format and level of detail Item accounting methods/areas Engineering judgement methods
NUREG-2159 "Acceptable Standard Format and Content for the Fundamental Nuclear Material Control Plan Required for Special Nuclear Material of Moderate Strategic Significance"	Fuel Fab Facilities Cat II material Bulk material Material in Containers	Bulk accounting methods/areas: Measurement systems, measurement control systems, statistics
NUREG/CR-4604 "Statistical Methods for Nuclear Material Management"	Inventory	Material balance reporting
RG 5.80 "Pressure-Sensitive and Tamper-Indicating Device Seals for Material Control and Accounting of Special Nuclear Material"	Material in Containers	Fresh fuel intake and storage, fresh and spent fuel transportation

Plan Table of Contents

Chapters 1 and 2

- Performance Objectives
  - Reference: 10 CFR Part 74, NUREG-2159
  - Target Quantities
  - Investigating Differences
  - Evaluate Significance
  - Aid in Investigation and Recovery
- Summary of the program
  - Reference: ANSI 15.8-2009, Section 5
  - Procedures
  - Configuration Control
  - Corrective Action Program
- Management Structure
  - Reference: ANSI 15.8-2009, Section 4
  - Contractor Oversight
  - Reportable Material Control – functional roles
  - MCA Accounting Group – functional independence between custodians and reporting/recordkeeping
  - Reportable Material Accounting – independence and overchecks

Chapter 3 Designation of Areas and Custodians

- Reference: NUREG-2159 and ANSI 15.8-2009
- Single MBA with internal areas designated that are either: permanent, temporary, or transfer areas
- Areas defined to:
  - Minimize occurrence of and facilitate resolution of MCA anomalies
  - Limit potential losses
  - Control access to reportable material
- Acceptance criteria in internal procedures
- Custodians assigned for each control area
  - Overchecks and independence between custodians

Item Control Areas

- Control of fuel assemblies from ANSI 15.8-2009 is analogous to the control of canisters at the facility.
  - Reportable materials in containers with unique identifiers

ANSI 15.8-2009 Section	MCA Plan Content (Chapter 4)
7.2	Physical design features and administrative controls
7.3	Authorizations for movement of material at the facility, recordkeeping, and overchecks
7.4	Identifying non-reportable material
7.5	Defining items through inventory and seals

Bulk Control Areas

- Control of damaged fuel assembly cladding from ANSI 15.8-2009 is analogous to the control of pebbles outside canisters at the facility
  - Reportable materials outside container, no unique identifiers per pebble
- Control access to reportable material, administrative controls when direct access is necessary for operations, maintenance, or post-irradiation examination
- Description of measurement systems and procedures
- Measurement control program
- Reference: NUREG-2159, Chapters 4 and 5, more information on later slides

Measurement Systems and Procedures

- Measurements for material entering or leaving a bulk control area.
- Procedure acceptance criteria

NUREG 2159, Revision 1	MCA Plan Content (Chapter 5)
4.1	Measurement system description including measurement types and key measurement points
4.4	Application of fresh fuel shipping inventory measurements
4.2	Description of measurement devices and measurement controls
4.3	Description of measurement uncertainties for non-destructive measurement techniques
4.4	Configuration control of measurement procedures
4.6	Description of procedures for receipts, movements, removals, and inventories of reportable material

Measurement Control

- Internal procedures establish controls for the quality of measurement systems to ensure that loss, theft, or diversion is not masked by bias or excessing random error

NUREG 2159, Revision 1	MCA Plan Content (Chapter 6)
5.1	Roles and responsibilities related to measurement control
5.2	Determining random error for a material balance reporting period
5.3	Use of current data
5.4	Monitoring quality of measurement devices and systems
5.5	Sampling procedures
5.6	Standard Error of the Inventory Difference (SEID) objectives
5.7	Procedure acceptance criteria

Statistics (Chapter 7)

- Statistical analyses will be used in the measurement control system to compute isotopic composition and to support investigation of differences between physical inventories and book inventories
- ANSI 15.8-2009 – methods to compute isotopic compositions in internal procedures
  - Reliability of the calculation methods for active inventory (AI) and SEID
  - Sources of and affect of uncertainties on AI and SEID
  - Potential biases
  - Consider NUREG 2159 and NUREG/CR 4604 “Statistical Methods for Nuclear Material Management”
  - Methods acceptance criteria

Chapter 8 Physical Inventory

- Describes methods for conducting physical inventory for item and bulk control areas
- Physical inventory every 12 months – consistent with 10 CFR 74.19
- Consistent with ANSI 15.8-2009, Section 8.3.5, for non-fuel SNM at the site
- Describes investigating and resolution of discrepancies between the physical inventory and the book inventory
- Material balance reporting consistent with 10 CFR 74.13
- Recordkeeping

Chapter 9 Tamper-Safing

- Locations where seals are applied
- Selection of TIDs – Consistent with RG 5.80, Section 2.4
- Storage and control of unused seals
- Recordkeeping
- Acceptance criteria – consistent with NUREG 2159, Section 11.4

Chapter 10 Receipts/Shipments of Reportable Material

- Reference: ANSI 15.8-2009, Section 6 and Section 10
- Roles and responsibilities
- Records review, reporting, and recordkeeping
- Handling of discrepancies
- Description of how internal procedures will support compliance with 10 CFR 73.67(g)
- Nuclear Material Transaction Reporting consistent with 10 CFR 74.15

* Note: 10 CFR 73.67(g) rather than 10 CFR 73.67(e) because the received materials are expected to be highly dilute Category II SNM or source material

Chapter 11 Reporting and Recordkeeping

- References: 10 CFR 74.19(a) and ANSI 15.8-2009, Section 11
- Records will also support compliance with 10 CFR 72, as applicable
- Description of the types of records that will be maintained
  - Consistent with 10 CFR Part 74, Subpart B
  - TID records consistent with NUREG 2159, Section 12.2
- Description of records retention periods
  - Superseded procedures, TID information, receipt and disposal of reportable material

Chapters 12 and 13

PROGRAM ASSESSMENT AND REVIEW

- Review of the program will be consistent with ANSI 15.8-2009, Section 12.
- Description of the conduct of reviews and documentation
- Independently reviewed no less than once every 24 months.
- Self-Assessments no less than once every 12 months

PHYSICAL SECURITY

- Protection consistent with ANSI 15.8-2009, Section 13
  - Physical security plan and implementing procedures
  - Compliance with 10 CFR 73.67(f) and (g)

Dilution

- NRC issued a draft regulatory basis stating that dilute SNM is less attractive as a theft target.
  - Rulemaking for Enhanced Security of Special Nuclear Material Regulatory Basis Document. (nrc.gov)
  - Large volumes of material make it easier for law enforcement to detect subsequent processing
  - The form of the dilute material affects the sophistication of processing by adversaries
  - Enrichment is not viewed as feasible for non-state actors
- NRC recently approved an exemption request that used the concepts from the regulatory basis.
  - Application of Category III material protections in storage areas at a fuel fabrication facility for HALEU pebbles in canisters.
- Pebble matrix material and coatings are not readily separable from the fuel particles
- Pebbles in canisters that are welded shut expected to have a dilution factor of <1%

Reporting to NMMSS

- Currently NMMSS does not define codes that would be needed for NRC reporting of pebble fuel with HALEU
- Further coordination between Kairos Power, NMMSS and NRC is needed to align on reporting expectations.

Summary

- Kairos Power drafted a Material Control and Accounting Plan which would be submitted with the Operating License Application for the Hermes test reactor.
  - Consistent with 10 CFR 74, Subpart B
  - Consistent with RG 5.60, ANSI 15.8-2009, and other guidance documents, as discussed
- Next Steps
  - Further coordination about NMMSS reporting codes and expectations
  - Additional engagement as needed regarding application of dilution concepts to MCA and physical security.