ADVANCED REACTOR SAFEGUARDS & SECURITY

MC&A for Molten Salt Reactors

April 2026

PRESENTED BY Karen Hogue, Oak Ridge National Laboratory

OAK RIDGE National Laboratory | U.S. DEPARTMENT OF ENERGY

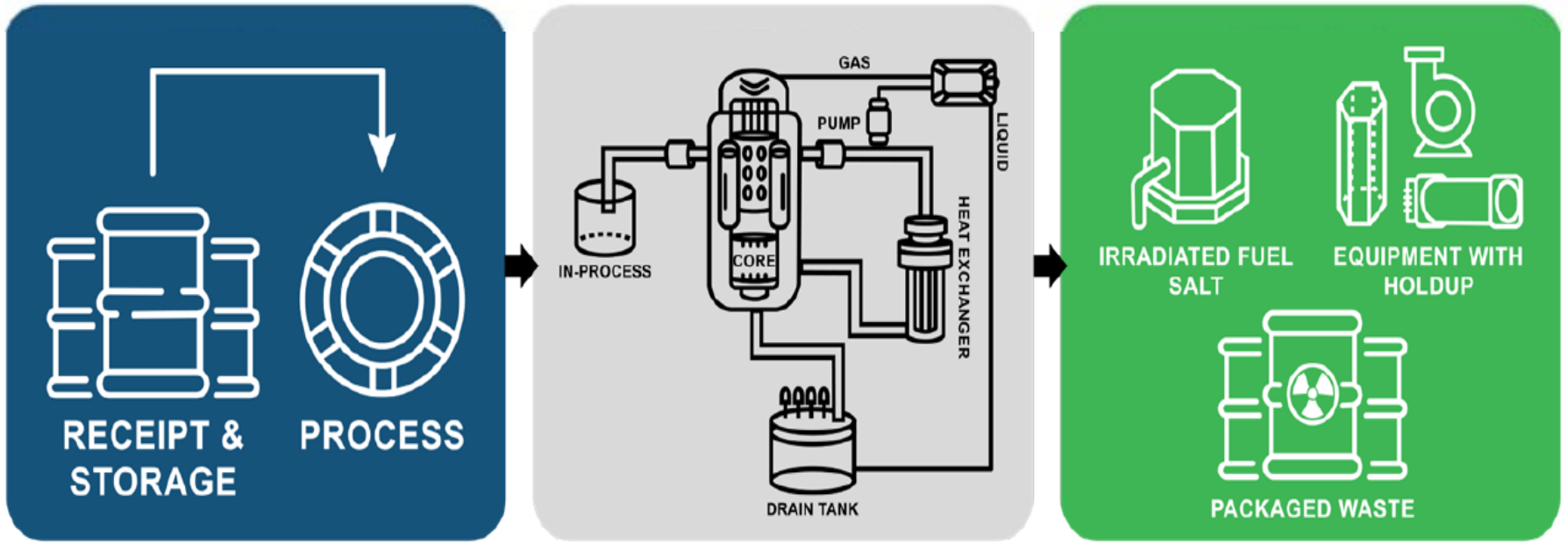
Material Control and Accounting for MSRs

- The ARSS program provide R&D to support vendors (and the NRC indirectly) with MC&A approaches to satisfy licensing and authorization requirements.
- MC&A requirements for any reactor that utilizes solid fuel assemblies or compacts relies on item accounting and declaration of inventories from reactor physics codes.
- MC&A requirements for other facilities that have Special Nuclear Material in bulk form rely on periodic inventories through measurements and material balance evaluations.
- Liquid-fueled MSRs are both reactors and bulk facilities.

MC&A for Liquid Fueled Molten Salt Reactors

- Publications:
  - Planning for MC&A in Liquid-Fueled MSRs
  - Control Boundary Approach
  - Diversion Path Analysis

- "Traditional" nuclear material accounting outside of the reactor; control (monitoring for theft) from the reactor



Periodic inventories performed, IDs and SEIDs calculated
(follows Part 74 requirements)

Monitoring performed in specific locations to detect diversion

Periodic inventories performed, IDs and SEIDs calculated
(follows Part 74 requirements)

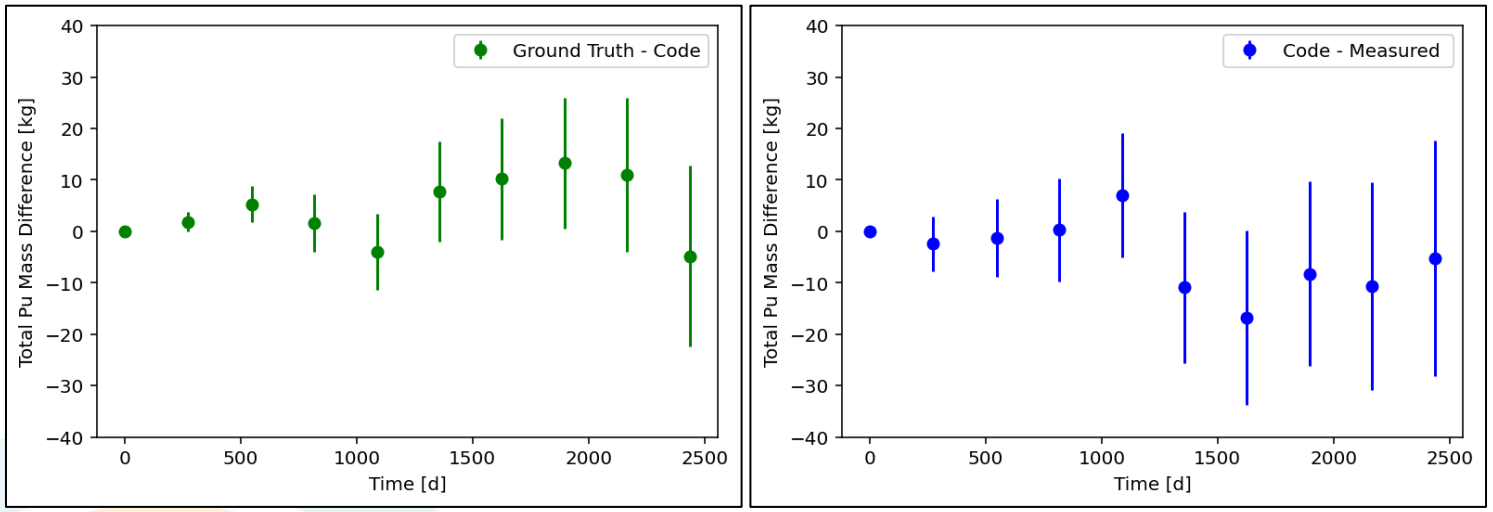
Hogue et al., ORNL Report No. ORNL/SPR-2023/3181, Jan 2024

Technical assessment on the impact of uncertainties on code predicted and measured SNM inventories

- **Four MSR designs modeled**

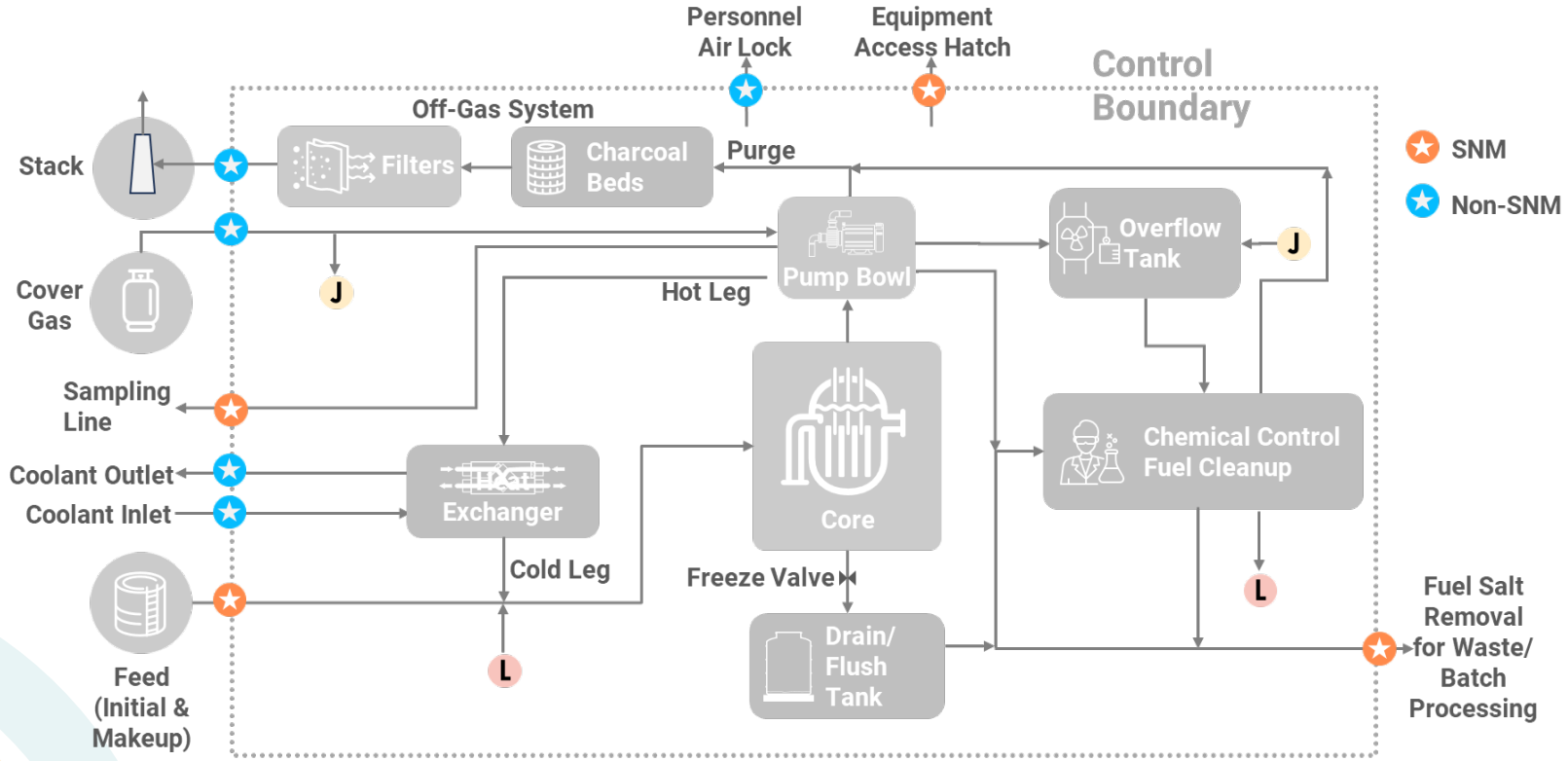
Parameter	Molten Salt Breeder Reactor variant	Molten Salt Demonstration Reactor variant	180 MW_{th} Nominal Molten Chloride Fast Spectrum Reactor (NMCFSR)	1200 MW_{th} NMCFSR
Power (MW_{th})	2,250	750	180	1200
Initial fuel salt (mole %)	$LiF–BeF_2–UF_4$ (60–30–10)	$LiF–BeF_2–UF_4$ (67–28–5)	$NaCl–UCl_3$ (66.7–33.3)	$NaCl–UCl_3$ (66.7–33.3)
Initial salt ^{235}U enrichment (wt.%)	2.29	2	13.3	11.7
Makeup salt ^{235}U enrichment (wt.%)	5	5	19.75	No makeup salt used
Length of reactor operations simulated (years)	4	7	7	7

Technical assessment on the impact of uncertainties on code predicted and measured SNM inventories (continued)



- Simulated differences in SNM inventories between code predicted and measured values, considering uncertainties
- Plot shows nominal MCFSR (180 MWth) using estimated uncertainties
  - Assumed ground truth –SCALE/TRITON simulation results
  - 8% relative uncertainty used for code predicted values
  - 5% relative uncertainty used for measured values
- Potential for differences in predicted vs. measured Pu inventories based on uncertainties

High-Level MC&A Control Boundary Concept



Shah et al., ORNL Report No. ORNL/SPR-2024/3555, Sept 2024

Acknowledgements

These slides include technical contributions from individuals at Oak Ridge National Laboratory including Sunil Chirayath, Manit Shah, Thomas DeGuire, Donny Hartanto, and Richard Reed.

Thank You!

Open reports are posted to the program website:

https://energy.sandia.gov/arss

For additional information:

Karen Hogue, Senior R&D Staff Scientist (ORNL) hoguekk@ornl.gov
Ben Cipiti, National Technical Director (SNL) bbcipit@sandia.gov
Dan Warner, Federal Program Manager daniel.warner@nuclear.energy.gov