

MPACT Annual Review Meeting
June 26-28, 2023

Presented by Ammon Williams

Safeguards & Security by Design (SSBD) of an Electrorefiner (ER)

**Joint Project with MPACT & MRWFD in
collaboration with INL, SNL, ANL, & LANL**

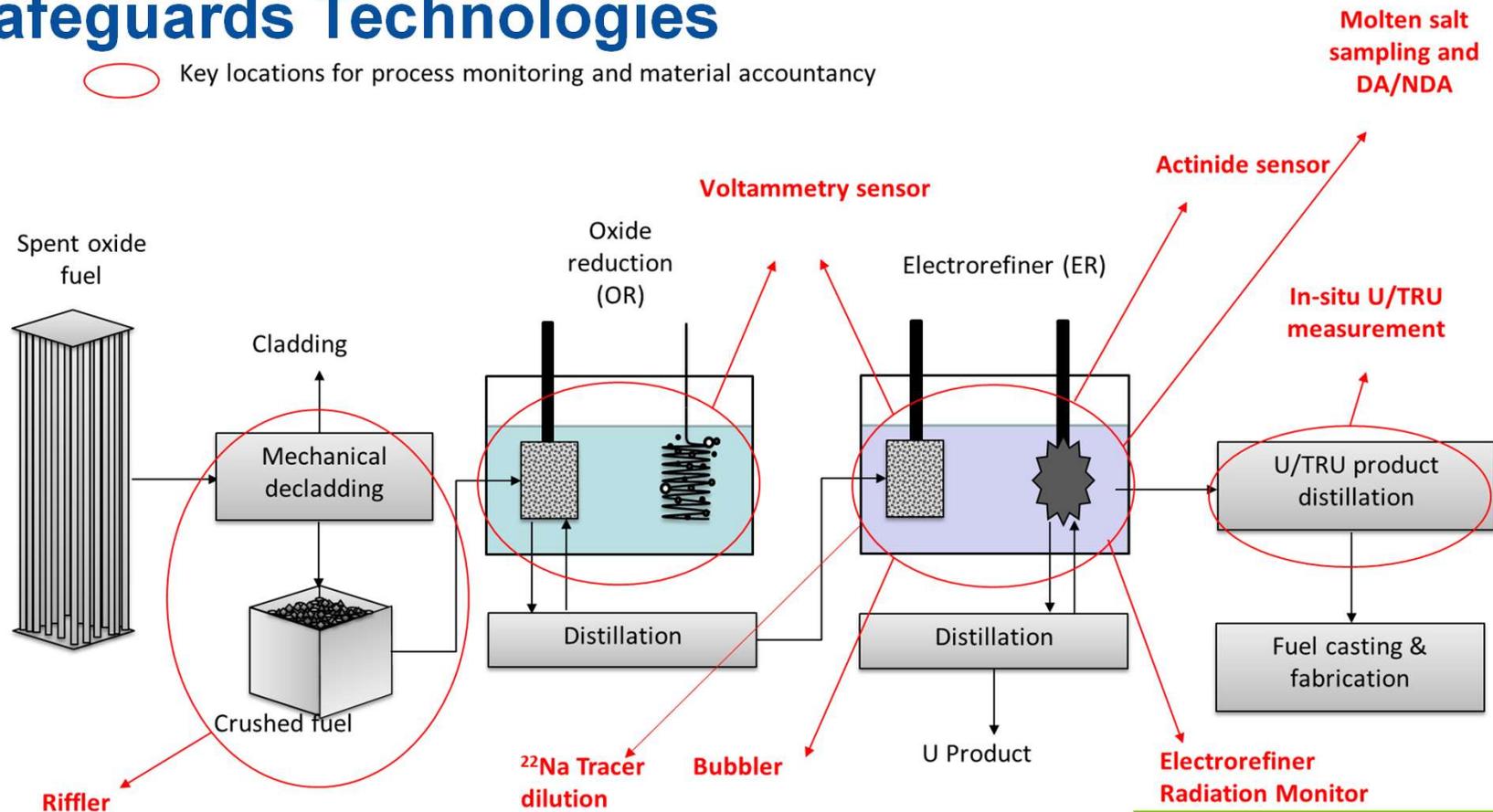
INL/MIS-23-73138

Project Overview: FY23

- **Scope:** MPACT and MRWFD have agreed to jointly perform a SSBD exercise on the redesign of an ER
- **FY23 Objectives:**
 1. Identify potential SSBD ER design elements based on previous work
 2. Incorporate elements into an ER redesign
 3. Evaluate process and domestic safeguards improvements from these design changes
- **FY23 Deliverables:**
 - **MPACT Milestone:** M3FT-23IN040103152-Preliminary SSBD Assessment of Electrochemical Fuel Reprocessing (*Due 9/30/2023*)
 - **MRWFD Milestone:** M3FT-23IN030401027-Develop technical and functional requirements for safeguards-by-design electrorefiner (*Completed on 5/15/2023*)

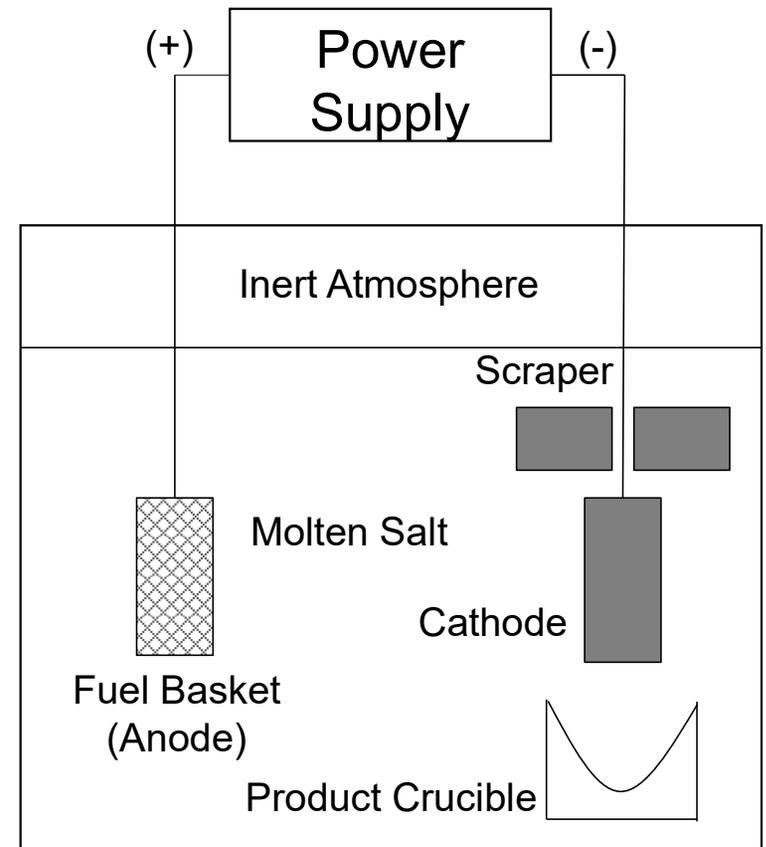
Introduction to Pyroprocessing: Approach & Safeguards Technologies

 Key locations for process monitoring and material accountability



Typical ER Operation

- Metallic fuel loaded into an anode basket and submerged in LiCl-KCl-UCl₃ salt
- Current & voltage controlled via a power supply to drive U to the cathode
- Periodically U metal is scraped from the cathode into a product crucible
- Transuranic (TRU) material is removed occasionally in a U/TRU alloy
- Salt samples are acquired to monitor U and TRU concentrations



Objective 1: Identify potential ER design elements for SSBD

- In March 2023, representatives from INL, LANL, SNL, and ANL met to brainstorm aspects of current ER concepts and designs that could benefit from a SSBD evaluation on redesign.
- The meeting resulted in the identification of:
 - ~8 hardware related aspects that could benefit from SSBD
 - ~4 operational aspects that may improve safeguards
 - Developed a prioritized list for FY23



Objective 1 Results:

List of ER Features & Operation Modes for SSBD Design

Features

- **Load cells on ER components for mass tracking**
- **Access ports into the ER for safeguards instrumentation**
 - location, size, frequency, etc.
- Salt sampling
- Scraping mechanisms
- Electrode designs
- U/TRU extraction design
- Anode residues
- Radiation measurements (neutron/gamma)

Operations

- **Atmosphere & oxidation control**
- Product consolidation after OR and before ER
- Input accountancy
- U/TRU operations

MRWFD Milestone Results

- Developed a Functional and Operational Requirements (F&OR) document
 - Outlines the design space and required operation for the designed ER
- Similar F&OR to existing ERs
- Added descriptions of each of the SSBD aspects listed
 - Conceptual designs developed for some cases

Document ID: FOR-892
Revision ID: 0
Effective Date: 05/15/23

Functional and Operational Requirements

SAFEGUARDS-BY- DESIGN ELECTROREFINER

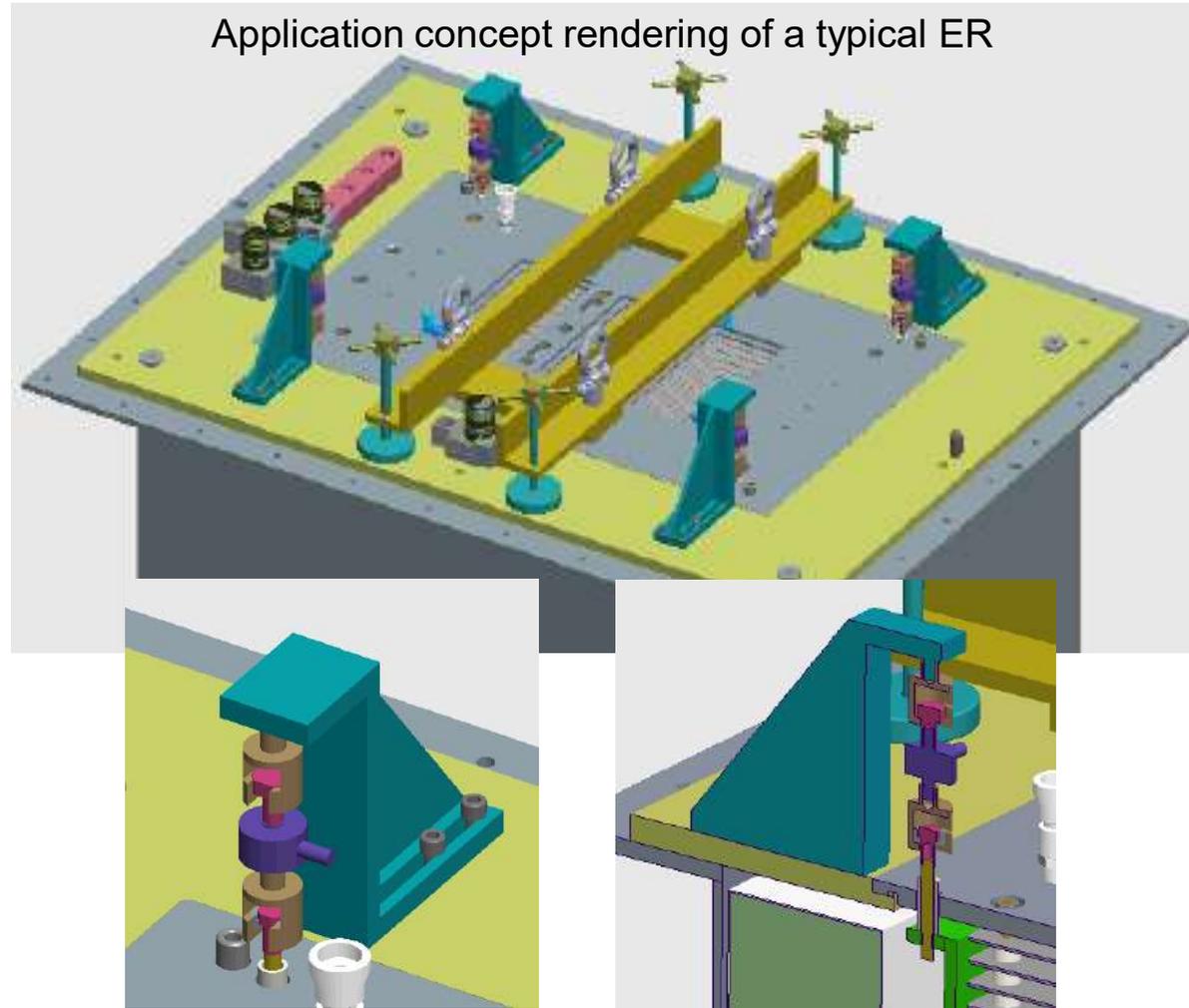


The INL is a U.S. Department of Energy National Laboratory
operated by Battelle Energy Alliance.

Crucible Load Cells

- Ability to track the total mass of material in the ER
- Four load cells
 - One on each corner
- Passes through the head plate (supporting equipment) and attaches directly to the crucible
- Maintenance operations to replace individual load cells possible
- Will require an algorithm to monitor all four load cells and generate a single mass number

Application concept rendering of a typical ER



Remaining Focus for FY23

- Explore & potentially draft a Fundamental Nuclear Material Control (FNMC) Plan for an ER
 - Engage with SMEs with experience writing FNMCs
 - Generic or SPYRE ER?
- Continue to work with MRWFD group to design hardware concepts that can improve safeguards
 - Access ports and instrumentation
 - Atmosphere control
- Perform an evaluation of the improvements from the design changes

Scope for FY24?

- Continue working on FY23 hardware design aspects to improve safeguards or select additional hardware features to focus on from the generated list
- Look more in-depth at operational aspects of the ER that could improve safeguards

Questions?



Idaho National Laboratory

Battelle Energy Alliance manages INL for the U.S. Department of Energy's Office of Nuclear Energy. INL is the nation's center for nuclear energy research and development, and also performs research in each of DOE's strategic goal areas: energy, national security, science and the environment.

WWW.INL.GOV